1st International Conference on Quality Engineering and Management

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September 14-16, 2014

University of Minho, Guimarães, Portugal

A better world with Quality!

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PAPERS INDEX

FOREWORD

Welcome to the 1st International Conference on Quality Engineering and Management!

For the first time we are promoting the **International Conference on Quality Engineering and Management**, taking place at the School of Engineering of the University of Minho, in the historic city of Guimarães, Portugal.

This event combines two areas that are not usually brought together: Quality Engineering and Quality Management. We hope that the results of our effort will translate into a successful venture, to be repeated on a periodic basis, making gradually of this conference an important scientific event in the field of Quality.

As was our aim, since the beginning, the conference covers different topics related to Quality Management and Quality Engineering, including Standards, Continuous Improvement, Supply Chain Quality Management, Management Systems Integration, Six Sigma, Quality Tools, Quality Management in Higher Education, Quality Management in Services and Total Quality Management.

Approximately 100 papers have been submitted and almost 80 were accepted for presentation, after review from the Conference Scientific Committee. Additionally, some of these papers were selected by the Scientific Committee to be published in a special issue of the International Journal of Quality and Reliability Management (SCOPUS indexed journal). Papers accepted correspond to authors from all around the world, with 20 countries represented at this level. Therefore, a warm acknowledgment to all speakers and authors is well deserved. The success of this first edition derives from their efforts and participation!

We would like to thank all of our four keynote speakers, who will be with us during the two days of the event: A. Parasuraman, Greg Watson, Ton van der Wiele and Jens Dahlgaard. We have here the chance to listen to their contributions and new research development insights, coming from some of the most influent current Quality Academicians.

Many thanks also to all the excellent work carried out by the Scientific Committee during the papers selection process.

We must acknowledge as well the institutional support received from the School of Engineering of the University of Minho, Portuguese Association for Quality, University of Coimbra, University of Girona, International University of Catalunya, Algoritmi Research Centre, Portuguese Institute for Quality, Cempalavras, American Society for Quality, European Organization for Quality, Brazilian Association of Production Engineering and Brazilian Society of Quality and Excellence in Management.

Let's take advantage of this great opportunity and make with your contributions an event with Quality, shared and built by such a top level group of participants!

Welcome to Guimarães, where your presence in the birth of this conference is of critical importance. We hope to see you again here at Guimarães in 2016, for the 2nd International Conference on Quality Engineering and Management!

Thank you all!

University of Minho, September 14, 2014.

Conference Co-founders

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SUBMITTED PAPERS

Making Quality Management Attractive for Small and Medium Sized Enterprises

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ABSTRACT

Purpose. Small and Medium Enterprises (SME's) account for a large part of the economy. However, methods and standards in Quality Management are developed with large organizations in mind. The purpose of this paper is to show that alternative approaches, suitable for SME's can be developed.

Design/methodology/approach. Looking at elements from ISO standards on Quality Management and Six Sigma, we show how difficult it is to interpret and implement them for SME's. A test was performed to evaluate the complexity of the language and terms used in ISO 9001. From that recommendations were formulated to improve the standard. The ISO 13053-1 standard was used to evaluate the "standardized" implementation of Six Sigma. Alternative approaches are defined for medium sized companies.

Findings. The terms used in ISO standards require specialized knowledge. A certifiable standard should be achievable by any organization that is legitimately in business. In its current form this is not the case. Implementing Six Sigma according to the original guidelines makes it unattainable for medium sized companies.

Practical implications. Making Quality Management methods more adapted to the needs of SME's will have an impact on the application of Quality. It will help SME's to perform better and increase competitiveness

Originality/value. This paper's value lies in an appeal to the Quality World to think critically about the language and terminology we use, making our valuable methods less accessible to the outside world.

Keywords: SME, terminology, accessibility, complexity, standards

Paper type: Viewpoint

INTRODUCTION

In Belgium about two thirds of the people work in organizations with less than 50 employees and about 8 out of 10 organizations have less than 10 employees. However, most methods and standards in Quality Management are developed with large to very large organizations in mind. As specialists in Quality Management we sometimes forget how difficult it is for our customers, especially in SME organizations, to understand what we are talking about.

HOW UNDERSTANDABLE IS ISO 9001:2008?

The original intent of the ISO 9001 standard was to give a customer the basic confidence that a supplier had the capability to fulfil his requirements. Over the years we have seen a change where the focus on fulfilling requirements has shifted towards fulfilling general quality management principles. One could say that the standard now attempts to move towards an “Excellence Model Light”. Personally I do not think that this is the right way to go, but leaving this aside, the standard still is the basic introduction for organizations that want to strengthen and structure their quality efforts.

As such, it should be attainable for all organizations that are legally in business and care about their customers. This includes a lot of small and medium sized organizations. But to be able to apply a document one must at least be able to understand it. To evaluate this, a small test was performed with students and the list of publications of ISO TC 176 was examined

Evaluation of the readability of ISO 9001:2008. Standards are written by a group of people that are selected based on their knowledge of the subject, in short: specialists. But the disadvantage of having specialists prepare a document is that the non-specialists, in this case the customers of that document, have a hard time understanding it. It is remarkable that a standard that is written on Quality Management, emphasizing the importance of customers, takes so little notice of its own customers.

In my view the major problem is that the ISO 9001 standard is not written so that it can be understood by the majority of the people in an organization, but so that it can be understood by the Quality Manager of the organization. He or she is seen as the customer of the document. That has serious consequences on the application of it. First of all, in small organizations there is no Quality Manager that can devote all his time to studying this document. So the application of all these good ideas is lower than could be. But it also has a negative effect in larger organizations because it is immediately seen as the system of the Quality Manager. It is not owned by the organization and as such not lived by the organization. Passing the audits becomes the major concern for management.

As the owner of a small company I want to improve quality and so I buy the ISO 9001:2008 standard. This will cost me 113 € and I will have to read a 27 page document to know what I will need to do. However, reading this document I will soon run in to terms that I have difficulty with understanding. In fact, ISO itself recognizes this by creating an abundance of additional, explanatory standards. When I look at this list and I buy the additional standards that are directly related to terms stated in the requirements of the ISO 9001:2008 standard, I end up with an additional expenditure of 930 € and 270 extra pages to read. This is already an indication of how complex we have made basic quality.

We must also understand that by using a complex terminology we alienate us from many people in an organization. This will be handled in some detail in paragraph 4.

In order to check how understandable the standard is, I developed a small test (see appendix). This test contains both questions on the terminology and words used, but also looks at possible interpretation errors. The test was given to a group of 109 professional bachelor students in hotel management and nutrition and diet (see acknowledgement).

These are people that later might start their own company or that could be managing an organization. Off course, they have no experience in Quality Management and are by no means specialists. The results are given in table 1, the maximum score is 20.

Table 1: Results of test

	Hotel Management	**Nutrition - Diet**	**Total**
Number of students	46	63	109
Average score	9.2	8.8	9.0
Number <10	26	41	67
% < 10	57	65	61

As can be seen in table 2 the majority of the students could not reach half of the required points. The concepts explained in ISO 9001:2008 are simple concepts and common sense. They should be understandable to a large audience.

And in reality it is even worse than that. For some of the questions I doubted myself what was the correct answer and when looking at discussion fora on the internet it was clear that there was a lot of discussion among the community of quality management specialists about certain terminology. The most typical example was §7.6.a where it is said that "…measuring equipment shall be calibrated or verified or both …". It is very difficult to find an explanation as to what the difference would be between calibration and verification and even more difficult to understand when and why one would do both.

What can be done? It is clear that the standard, in its current form, requires the interpretation of a specialist and that even then there can be a lot of discussion. Just look at all the discussions that occur during audits. I would encourage people involved in the Quality world to focus more on explaining the standard in common language. To actually avoid using the terms in the standard because very few people seem to understand them. However, if you use more common words to explain the concepts behind it, everybody understands this. So why don't we use that common language directly? This document should be and could be a motivation for people in small and medium sized organizations to start with structured quality management. It should create enthusiasm for quality. It does not at the moment.

So in the long term it is important that members of ISO TC 176, that do a tremendous job, keep their customer in mind: the person that will have to use the documents that they create and that hopefully will not be a quality specialist. If we want to increase the impact of quality in the world, we need to talk to the ones that are not yet convinced in a language that they can understand. There is a lot of feedback foreseen already and the public has a bigger say, but Quality is too important to just leave it to Quality specialists. Why not add communications and language specialists as part of the evaluation team? This will obviously mean a major change to the standard, but it is an effort worth taking if it can lead to the application of sound quality principles in more organizations.

MAKING SIX SIGMA ATTRACTIVE FOR SME'S

If we consider ISO 9001 to be an entry level to Quality Management then, within the methodologies developed, Six Sigma could be seen as placed at the high end from a complexity point of view. It is almost natural that new methodologies are being developed within larger corporations as they have the means and the experience to do that. However, this often makes these methodologies less accessible for smaller organizations. In the same way as methods developed in production are sometimes difficult to interpret for service organisations.

Classical we try to "translate" the methodology to a smaller organization but keep on using the same terms. It is clear that this translation is needed but I also think that we should try and grasp the fundamentals of a method and have them already implemented into an organization. These fundamentals are generally not that difficult to understand and can be implemented in the way best suited to the organization. This could mean that we do not even speak of Six Sigma but still have the company apply the basics of the methodology. This requires more than just translating, it is all about adapting to the environment rather than adopting a prescribed standard.

The essentials. So what could any organization, no matter how small, learn from Six Sigma in such a way that it can be applied to good use in that organization?

The essential elements of Six Sigma are data driven and structured problem solving. Off course, the entire toolbox of Six Sigma is directed at solving complex to very complex problems. But one way in which the owner of a small company could profit from Six Sigma is by applying these two essential elements that anyone can learn in half a day: always see if there is data available that can help you understand and solve the problem and whatever problem is brought to your attention, ask the following questions:

- What is the problem exactly?
- How big is it?
- What do you think is causing it?
- What can we do about it?
- And how can we prevent this from happening again?

This is off course the classical Define - Measure - Analyse - Improve - Control cycle from Six Sigma, but asking these simple questions will help many owners of small companies. First of all it forces them to evaluate the importance of problems. The biggest mistake I see being made by leaders of small organizations is to try and tackle everything, leaving insufficient time for the important things. Entrepreneurs are enthusiastic, hardworking people. This is also their weakest point. Once it has been decided that it is worth investigating, asking the bearer of the problem what he thinks can be done, will avoid the very often seen "upwards delegation".

The prime role of a leader must be to make his people stronger. The only way to do that is by turning them into problem solvers. Applying these simple rules, without any tools, will gradually transform the people from problem reporters to problem solvers. This will in term allow the owner / leader / manager to focus on these problems that do require his attention.

One could say that this has as such nothing to do with Six Sigma, but it is an example of how we need to focus on truly essential elements of methods and making sure they are applied in a consistent way. The quality world all too often wants to develop very interesting and complex methodologies that are suited for very special cases, but the basics of quality lie in simple things. Applying these simple things to a much larger part of our economy could prove to be the most interesting quality investment ever.

Adapting Implementation Rules. One step further is the application of Six Sigma in medium sized organizations by adapting the implementation structure and methodology. Classical Six Sigma implementation creates a rather heavy structure with project champions, Master and ordinary Black Belts, Green Belts, etc. It also involves a major training program that is obviously rather costly. ISO 13053 part 1 and 2, offer guidelines for such an implementation. The underlying assumption is that the organization will be implementing a “Six Sigma program”. But is that what organizations want to do with it? Is that what they need? Not necessarily.

Over the years I have worked with many organizations on Six Sigma and in function of the objectives of the organizations many different implementations have followed. The most simple one is not to implement but just to do. The CEO knows about Six Sigma, spots a problem that requires a deeper approach and hires a Black Belt to lead the internal project team. No training (except on the spot), no structure, no Belts, but the problem solved. And if you only have one such a problem a year this is the most efficient way of working.

Other organizations just wanted to raise the problem solving capacity of their people and organized a Green Belt training, but without calling it Green Belt and leaving out all the typical Six Sigma terminology (no sigma scale of quality for instance or belts).

Another adaptation, and at this point in time probably the most used and best suited Six Sigma implementation for medium sized organizations (100 – 500 employees), is to change the implementation from top-down to much more bottom-up. Having full time Black Belts is too expensive for many organizations anyway, so it is much better to start by training a group of Green Belts. This allows the organization to tackle problems in different areas of the company. Applying the Pareto principle will show that the Green Belt toolbox (containing 20% of the Black Belt tools) is capable of solving 80% of the problems. In time, one of these Green Belts could be further trained to the level of Black Belt, but only if needed (Vandenbrande, 2005).

Other adaptations are to reduce the number of Green and Black Belts compared to “standardized” numbers and to adapt the toolbox to the industry. This latter element is extremely important when applying the methodology to service organizations. Just some ideas that could help you make the content better adapted to your needs:

- In a transactional environment not all statistical techniques are relevant. Evaluate what can add value to your organization
- Try to use graphical methods as much as possible. Very often the statistics just confirm what you already can see on the graph.
- A smaller toolbox that is intensely used will have more impact on the organization than an extensive one that never gets applied.

MAKING QUALITY MORE ATTRACTIVE TO EVERYONE

Finally I want to point out a major problem that Quality Management is facing in all organizations and that is increasing with time. There seems to be a growing gap between what people experience as being quality and what quality management is advocating it to be.

The main difference is that Quality Management uses an “economized” vision on quality, but that is not what people generally feel as being Quality. If we want to keep motivating people for Quality we will have to adapt and start thinking again much more in terms of intrinsic quality and of happiness of employees. Our approach to people must change with much more emphasis on the positive, rather than always focusing on the negative.

Just a few tips on what you can do to create a more positive perception of Quality Management by the people in the organization:

- Have projects on removing employee frustrations
- Focus on intrinsic quality and beauty
- Decorate the offices
- Add “How to handle congratulations” to your procedures.
- Be positive in all you do

CONCLUSIONS

So far, the application of Quality management tools and practices in SME’s has been too limited. To change this will require a change from the Quality Management community. This change is all about understanding customer expectations and adaptability to customer needs. The very fundamentals of Quality.

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Benefits of implementing Service Management Standard ISO 20000

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ABSTRACT

Purpose. This paper explores the benefits perceived by organisations with certified ISO 20000 service management systems. It intends to propose a classification of benefits and test the relationship between that classification and general satisfaction of the standard.

Design/methodology/approach. The study is based on 105 responses to a survey on ISO-20000-certified organisations in Spain. After a descriptive analysis of the sample, a structural equation model is presented to test the hypothesis presented.

Findings. According to the model, ISO 20000 benefits can be divided between internal and external benefits. The variables that best define each type of benefit are identified. Moreover, those factors are proven to be related to general satisfaction with ISO 20000 certification and the existing correlation between internal and external benefits.

Originality/value. In light of the fact that there are few quantitative studies in the field of IT service management, this paper contributes to a better understanding of the benefits related to its application. Conversely, this paper shows how to apply the classification of internal and external benefits in the case of ISO 20000 and proposes a model of causality between those benefits and satisfaction.

Keywords: ISO 20000; ITIL; Management standards; SEM.

Article Classification: Research paper

INTRODUCTION

Most of the benefits obtained from information technology (IT) result not only from the technology itself but also from the services that can be built using it. In recent years, the perception of IT organisations as technology providers has evolved to a perception of IT organisations as service-centred providers (Bitner, 2001; Cherbakov et al., 2005). Furthermore, several factors, such as an IT service's ubiquity, pervasivity, dependency and the investments involved (Ong and Chen, 2013), create a need to industrialise IT services.

This industrialisation process makes it necessary to establish formal management techniques. In recent years, a field known as Information Management Service Management (ITSM) has been developed to manage IT services (Winniford et al., 2009; Iden and Eikebrokk, 2013).

In the ITSM field, many frameworks, good practice codes, models and standards have been developed (Cater-Steel, 2009). Among these instruments, ISO 20000 is the only international standard that defines the requirements for a service management system. It has proven to be a powerful tool for those looking for quality service management, whether they are IT-sector enterprises, IT departments or internal providers within any type of organisation or eventually, other types of service-oriented organisations.

However, until now, ISO 20000 has been somewhat eclipsed by ITIL (Information Technology Infrastructure Library), or at least, the two have been frequently confused. ITIL (OGC, 2011) is the most diffuse and predominant standard in ITSM and thus, the imaginary overlap between the two could be interpreted for both as either a benefit or a drawback. In particular, with respect to research, someone aware of their overlap and differences should be able to interpret which results can be shared and which are specific to ITIL or ISO 20000.

Regardless, although the two standards have common factors (Dugmore and Taylor, 2008), their very natures are quite different. ITIL is a collection of good practices, whereas ISO 20000 takes the form of a service-management-system standard. Accordingly, no organisation can declare compliance with ITIL while claiming ISO 20000.

Moreover, as with other management standards, organisations that implement a management system according to ISO 20000 can rely on external entities to certify their compliance. Those external, independent entities, known as certifiers, formerly issued certificates. These certificates are significant when studying the impact of the standard because certified organisations have tangible evidence of having applied the standard and operated the management system. This does not mean that an organisation cannot achieve the same benefits without certification or by applying a different approach to the use of this standard, save for those benefits specific to the prestige of the certification seal and its market recognition.

Factors such as the relative youth of the standard and the aforementioned lack of visibility have led to a lack of specific research on ISO 20000. Although there has been a considerable amount of research in the field of ITSM, very little has focused on ISO 20000. Thus, the standard's current level of maturity and its foreseeable impact should encourage a more detailed study, as presented here.

ISO 20000 OVERVIEW

The ISO 20000 standard is composed of a series of documents. The first document, formally known as ISO/IEC 20000-1 (ISO/IEC, 2011), is the only part that establishes requirements for a service management system, and therefore, these are the only ones that require compliance to obtain certification.

The rest of the documents, even though they are very valuable and helpful for implementing the standard, can be considered complementary (ISO/IEC, 2010, 2012, 2013a, 2013b, 2013c). This is the reason why the first part is frequently considered as the entire standard, as is done in this study. The current (2011) version of the standard represents the first revision since the 2005 former version, which was adapted from the pre-existing British standard BS-15000.

The contents of the standard may seem familiar in their general form to those used to other quality management standards, for example, ISO 9001 (Piskar and Dolinsek, 2006), while containing more detailed, specific requirements, given that the objects to be managed are services. Although the origin of the standard is rooted in an intention to manage IT services, the current version contains no impediment to using it for other types of services (Agrasala, 2013).

The text body of the first part of the standard (ISO/IEC, 2011) is structured into chapters and clauses, including general management-system requirements, the requirements to deploy and retire new or changed services and four groups of processes, for a total of thirteen processes that are designed to manage service level, reporting, continuity and availability, budgeting and accounting, capacity, information security, business relationship, suppliers, incidents and service requests, problems, changes, configuration and finally, release and deployment (Cots and Casadesús, 2013).

OBJECTIVES AND HYPOTHESIS

In the field of ITSM (Gacenga et al., 2010; Marrone and Kolbe, 2011; Iden and Eikebrokk, 2013) and in the general study of management standards, there are only a few papers focused specifically on the benefits of ISO 20000 certification, namely Disterer (2009), Disester (2012), Cots (2012) and Cots and Casadesús (2014). All of those papers use research approaches that were previously validated by studies of other management system—specifically, the most widespread systems, which are ISO 9001 and ISO 14001 (Casadesús et al., 2001; Casadesús and Karapetrovic, 2005; Heras et al., 2006; Piskar and Dolinsek, 2006; Psomas et al., 2011).

However, previous studies show that ISO 20000's diffusion slope is quick and that this standard has reached the maturity stage more quickly than previous, more general standards (Llach et al., 2011; Marimon et al., 2011; Cots and Casadesús, 2014). This enables and encourages an exploration of the benefits of ISO 20000, which the previous literature has not analysed, and renders an approach to ISO 20000 certification a valuable contribution.

Consequently, the objective of this research is to better understand the benefits of ISO 20000 implementation and their relation to the general satisfaction with this standard. First, as a contribution to understanding the impact of ISO 20000, in this research the definition of certification benefits and their classification into internal and external benefits leverage previous studies on management systems, as adapted and conformed to ISO 20000. Second, beyond the descriptive analysis on the perception of ISO 20000 implementation benefits, this research aims to find the hidden factors that contribute to the perceived benefits. With this objective, this paper collects the opinions of those who have real experience with ISO 20000 implementation and certification and analyses the possible relationship between these benefits and general satisfaction with ISO 20000 certification.

According to these objectives, this research can be structured in the following hypotheses:

H1: ISO 20000 implementation has internal benefits.

H2: ISO 20000 implementation has external benefits.

H3: ISO 20000's internal benefits have a positive impact on satisfaction.

H4: ISO 20000's external benefits have a positive impact on satisfaction.

H5: ISO 20000's internal and external benefits are correlated.

METHODOLOGY

The research presented here is based on data gathered from a survey administered between May and July of 2013 to all of the known and contactable ISO-20000-certified companies in Spain.

To design the survey questionnaire, in addition to information describing each organisation assessed, we compiled from the literature a list of concepts related to motivations, key success factors, benefits and integration. The actual questions, specifically those related to benefits, were adapted from previous works on other management standards, specifically those of Buttle (1997), Corbett et al. (2003) and Disterer (2012). Each question was formed using a common introductory sentence plus a specific question about how ISO-20000 certification contributed to obtain various defined benefits. To verify the tool, a pilot test was conducted with 9 experts (3 academics and 6 practitioners) and then revised based on their contributions.

Another issue involved building a list of participants. The uncertainty in the number of organisations to survey was due to the lack of an official register of certificates. Unfortunately, no register of certificate was available either in Spain or globally. For this study, a list of ISO-20000-certification registers was constructed and (to a large extent) verified by starting with an unofficial list, then conducting an exhaustive Internet search (including search engines and social networks) and finally soliciting help from several consulting firms and support from the Spanish chapter of the itSMF (IT Service Management Forum). This process provided us with confidence that the number of certified organisations in Spain was close to 186 at the time of the survey. We attempted to contact the organisations through every means possible, but generally by attempting to obtain an email address, which we did for 149 organisations, and that was the number of surveys that ultimately were sent.

One hundred and five valid responses were collected, each from a qualified individual in one of the selected organisations. A descriptive analysis of the data gathered is presented in the results section, specifically focusing on the benefits archived. However, a complete descriptive analysis of the study is available in our final research report (Cots, 2014).

The methodology used to assess the aforementioned hypotheses is based on structural equation modelling (SEM). SEM analysis is a multivariate statistical technique that is broadly used in the literature, which aims to explain causality based on covariance analysis. The analysis is split into two steps. The first aim is to validate a scale to assess the benefits of implementing the standard. Once that is established, the second step analyses the extent to which the benefits are antecedents of satisfaction in using the standard.

Once the first step was concluded and the dimensions of the benefits were established, hypotheses H1 and H2 were analysed. The final three hypotheses were tested in the second step, in which a model in which the benefits dimensions are antecedents of satisfaction was analysed, again using an SEM technique. The main limitations of this study, which are very common in this type of research, were the specificities of the Spanish certification market, the size of the sample and the overlap in benefits arising out of the standard versus benefits arising out of the certification itself.

With respect to the first limitation, we note that the Spanish ISO-20000-certification market was encouraged through public funding. "Avanza" and "Avanza2", two now-complete public programs, provided qualified companies with an opportunity to become certified at no cost. Although the funding source should have only a small impact on the benefits obtained, it is clear that public funding may have affected the composition of the certified population because it is likely that some organisations would not have sought certification if they had been required to assume its cost. Moreover, the existence of public funding provided consulting firms with a powerful argument to sell certification projects.

The size of the study's sample is a consequence of its scope. Although Spain is a country with a high concentration of certified organisations (Cots and Casadesús, 2014) and the response rate was high, the total number of certificates in Spain is obviously limited. Anyway, according to Iacobucci (2010), when cites to Anderson and Gerbing (1984) "three or more indicators per factor, a sample size of 100 will usually be sufficient for convergence", going even further when noting: "It is of some comfort that SEM models can perform well, even with small samples (e.g., 50 to 100). The vague, folklore rule of thumb considering requisite sample size, e.g., "n>200" can be conservative, and is surely simplistic." (Iacobucci, 2010. Taking that into consideration, and being obvious that bigger sample sizes are always better when it comes to SEM analysis, a sample of 105 should be enough to perform the analysis and to take the results into consideration.

Another obvious limitation is that all of the participating organisations were certified; thus, there was no way to distinguish between the benefits obtained from the standard and those obtained from the certification itself. Whether a particular benefit can be obtained without certification depends on the nature of that benefit. Obviously, it is not necessary to obtain a certification to derive the benefits of the use of the standard; however, use of the standard provided the study with certainty. We chose to accept this trade-off.

FINDINGS

The above-mentioned survey provided us with the ability to study the benefits of certification and its relationship with motivations and general satisfaction. Thus, first there is a description of the characteristics of the participating organisations. Second, an exploratory factor analysis was conducted and a confirmatory model of benefits was created to determine latent factors. Finally, a more complete model was created to test the relation between those factors and general satisfaction with the implementation of ISO 20000.

Description of the sample. Most of the participating organisations, as is reasonable to expect, belong to the IT sector (85%). The sector with the second-largest number of certificates is that of science and technology (7%). The third-most-important sector is education (3%) and the rest are singular cases, as shown in Table 1. Consistent with the prevalence of IT companies highlighted, in the majority of those companies, the IT department represents over half of the total employees. In 18% of those companies, nearly all of the employees belonged to the IT department.

Another relevant characteristic to classify the participating companies would be to know whether they offer consulting or training on ISO 20000, as is the case for 32% of those companies. It should be taken into account that this characteristic could influence the intent to answer based on financial interests, which would most likely project optimistic views. However, the fact that a company provides services related to ISO 20000 and simultaneously provides certified services should not be surprising; indeed, in the early stages of the development of the market for a certification, it is even natural. Moreover, this activity means that in many cases, respondents in this group have greater knowledge of and experience with the standard and therefore, can make especially valuable contributions and have well-founded opinions.

Company or organisation ownership reveals that the vast majority of the participating companies are privately owned, with only 7% having public ownership.

With respect to company size, the companies were categorised solely by number of employees, partially following the criteria of the European Commission's Recommendation 2003/361/EC. Thus, companies with fewer than 10 employees were classified as micro-enterprises; those with fewer than 50 employees were classified as small businesses; those with 50 to 250 employees were classified as medium; and those with more than 250 employees were classified as large.

It was also interesting to assess the number of IT-department employees. This data, taken as a proportion of total company employees, provides an estimate of the weight of the IT department and thus, of the scope of the standard inside the company. This led us to classify IT departments as follows: minor, if fewer than 10% of employees worked in that department; significant, if the IT department's personnel exceeded the 10% but did not reach half of the employees; "major or controlling" if the IT department's exceeded 50% but did not reach 95%; and finally, for IT department personnel constituted more than 95% of the company, the entire organisation was considered to relate to IT (whole-company).

To learn the details of companies' certification, we first analysed the year of initial certification and what version of the standard was obtained (either the first, 2005 version or the 2011 version). It is observed that the number of certified companies increases until 2010, when the trend reverses, with a decline beginning in 2011 and 2012. These results are consistent with previous, worldwide studies (Cots and Casadesús, 2014). As mentioned above, a specific Spanish characteristic is the existence of public campaigns, which in the past have provided grants for obtaining ISO 20000 certificates. The impact of these campaigns was so great at the time that companies that used them represented a majority of the sample (60%). The drastic reduction of subsidies in recent years may also be a key factor explaining the reduction in the number of certificates issued in Spain beginning in 2011 and creates a mystery as to the long-term sustainability of obtained certifications. It is interesting to know that although there is no contrasting evidence, 89% of respondents consider their company certificate to remain valid, and only 11% do not maintain it.

Table 1 - Sample characteristics

Sector		
	IT	84.8%
	Science and technology	7.6%
	Education/universities	2.9%
	Transportation	1%
	Energy	1%
	Industry/manufacturing	1%
	Financial services/ insurance	1%
	Distributions	1%

Number of employees		
	<10	21%
	10-40	44%
	50-250	18%
	>250	17%
Employees in IT department		
	<10%	21%
	10%-49%	21%
	50%-95%	40%
	>95%	18%
Offering consultancy or training on ISO 20000		
	Yes	32%
	No	68%
Ownership		
	Public	7%
	Private	93%
Users of services under certification scope		
	External clients	67%
	Other organisations	47%
	Internal users	57%
Used public grant to certify		
	Yes	60%
	No	40%
Implementation project cost		
	<501€	9%
	501€-3,000€	12%
	3,001€-6,000€	7%
	6,001€-18,000€	28%
	18,001€-60,000€	29%
	>60,000€	16%

The average duration of an implementation project is 8.29 months, with projects ranging from 2 to 24 months and the most common duration lasting 6 months. In any case, relatively few projects last longer than one year.

Analysing the cost of implementation projects and also the recurring or maintenance cost, it is noteworthy that the response rate for these questions was by far the lowest in the study, with only 69 valid responses. It is interesting to see that 54% of organisations report having dedicated less than 500€ to the purchase of tools, most likely either because these tools were already owned at the time of project implementation or because the organisations used tools that were free or practically so. 25% used tools that cost more than 500€ but less than 3,000€, which, together with the previous cases, shows that in 79% of cases that can be considered, the cost of tools was reduced. Conversely, the number of companies that invested in costly tools is not negligible.

With respect to the total cost of implementation, grouping the companies that declare a project cost, including tools, of lower than 3,000€ (21%) seems to prove that it is possible to implement ISO 20000 and obtain certification at a cost lower than previous standards (Karapetrovic et al., 2010). Conversely, 45% of companies declare more than 18,000€ as the cost of implementation. Finally, with respect to maintenance costs, the pattern is repeated: 45% of companies spend more than 6,000€ per year on the management system (including tools), whereas another 45% invest virtually nothing (less than 500€).

Finally, the lack of similar data and studies in the ITSM field makes it very difficult to determine the representativeness of the sample at a global level, even when it includes a majority of Spanish organisations. The mere existence of public grants could make a difference in the Spanish market compared with others.

ISO 20000 BENEFITS

To analyse the perceived benefits of ISO-20000 certification, a list of 14 questions was presented to each respondent. All of the questions were composed of a common introduction and a series of concepts, shown in Table 2.

Each respondent was asked to qualify his level of agreement to each sentence according to a Likert scale ranging from 1 (“not at all”) to 5 (“absolutely”). It is important to note that although 3 is the medium value between 1 and 5, it should be interpreted as a medium perception of a particular benefit, not as a neutral opinion. It was expected that if no benefit was perceived, a respondent would have answered 1.

Table 2 aggregates the descriptive and SEM analyses for each variable, including the following: a label to quickly identify the variable, the corresponding concept to the question asked, the mean and the typical deviation from the collected responses. The table is sorted by the mean, with the motivation having the highest degree of agreement at the top to easily show the order of respondents’ perception of the benefits. It can be observed that most means (11 on 14) are above level 3 (labelled as “average”) with typical deviations between 0.91 and 1.23. Because the highest mean is 3.71 and the lowest is 2.81, all of the proposed benefits are positive.

One could consider that not all benefits appear within the same time frame and not all of the participating organisations had operated their management systems for the same length of time. Our results are the product of this detected heterogeneity, and the sample size is not big enough to segment to establish different patterns depending on the years of ISO-20000 implementation. This could be a good point for a future wider study.

Assessment of the benefit scale. Until now, all of the benefits assessed have been valued as equivalents (except for their levels of "perception" or consensus), but it is clear that not all of them contribute in the same way or give the same weight to satisfaction in implementing ISO 20000.

The first step of the assessment is the exploratory factor analysis (EFA). The scale was analysed in accordance with the Kaiser-Guttman rule (Loehlin, 2004), selecting two as the number of nontrivial factors given that the eigenvalue for the second factor was above the 1.0 cut-off (1.74) whereas its value for the third was below (0.93). This leads us to propose the existence of two latent factors for ISO 20000 benefits.

Once this two-factor distribution has been established, Table 2 shows the variable's loading on each factor. The variables with a loading above 0.7 on one factor were selected as clearly contributing to the factor explanation. This analysis excluded 3 variables from either factor for not loading enough on either of them, leaving 11 variables: 8 explaining one factor and 3 explaining the other. According to these findings, the first factor is explained by: B.Std, B.Inc, B.Rec, B.Contl, B.Plan, B.Prof, B.Knol and B.Cult. In turn, only three items load on the second factor: B.Comp, B.Mrkt and B.Exig. The reliability of these two factors was then assessed. The composite reliability indicators greatly exceed the threshold value of 0.7, confirming internal consistency. For each scale, the average variance extracted (AVE) estimate is higher than 0.50.

Based on the variables that explain each factor, it is feasible to identify those variables as internal and external benefits coherent with the literature's existing classification for benefits provided by other standards (Tsiotras and Gotzamani, 1996; Casadesús et al., 2001). Mapping the first factor to internal benefits and the second to external benefits, and having evaluated consistency, **H1** and **H2** are accepted: It is clear that ISO-20000 implementation produces internal and external benefits, just like the implementation of other management standards.

Table 2 - ISO 20000 Benefits

				EFA		CFA			
				Internal Benefits	External Benefits	Internal Benefits		External Benefits	
Benefits	**Label**	**Mean**	**σ**	Loada	Load[a]	Stand Loadb	t-value	Stand Load[b]	t-value
Marketing argument, confidence and/or reputation	B.MRKT	3.71	0.95		0.80			0.74	7.62
Improved services through continuous-improvement method	B.CONTI	3.68	0.96	0.73		0.77	6.90		
Impulse standardisation, increased uniformity and consistency of processes and services	B.STD	3.67	0.92	0.71		0.68			
Increased ability to plan and control	B.PLAN	3.51	0.97	0.74		0.72	6.55		
Satisficing a present or future exigency of clients or regulators	B.EXIG	3.51	1.12		0.81			0.69	7.09
Increase in user and client orientation and satisfaction	B.SATISF	3.49	1.02	0.60	0.49				
Competitive advantage	B.COMP	3.48	1.22		0.89			0.90	
Making staff aware and/or establishing a quality culture	B.CULT	3.44	0.97	0.72		0.64	5.91		
Improving the capacity to recover from an incident, error or catastrophic events	B.REC	3.37	1.03	0.78		0.81	7.27		
Reducing incidents, errors and deviations	B.INC	3.23	1.02	0.82		0.80	7.20		
Enabling retention of knowledge and /or the introduction of new staff	B.KNOL	3.10	0.96	0.79		0.78	7.01		
Establishing audits	B.AUDIT	2.98	0.99	0.61	0.31				
Reducing costs, increasing benefits or improving productivity	B.PROF	2.97	1.07	0.71		0.68	6.20		
Increasing staff motivation	B.MOTIV	2.81	0.98	0.69					
	Cronbach's alpha					0.90		0.82	
	Composite reliability					0.91		0.83	
	Average variance extracted (AVE)					0.55		0.61	

EFA, exploratory factor analysis; CFA, confirmatory factory analysis.

a Cells in blank are loads below 0.3.

b All significant at p-value=0.01.

Causal Model. Once the latent variables have been determined, the model proposed, as presented in Figure 1, includes the directly measured global satisfaction variable, allowing testing of H3, H4 and H5. The results are presented in Table 3. The indices of goodness of fit vouch for the conclusions drawn from it: the Satorra-Bentler scaled chi-square is 60.60 on 52 degrees of freedom and its associated probability value is 0.194; the comparative fit index (CFI) is 0.981; and the root mean-square error of approximation (RMSEA) is 0.041. Together, these results allow us to relay the analysis and accept H3, H4 and H5. Consequently, this analysis shows that the internal and external benefits of ISO 20000 have a positive impact on satisfaction while making it possible to detect a clear, positive relation between internal and external benefits.

Table 3 - Standardised solution of causal model

			Coefficient	**t-value**
H3	Path	Internal Benefits->Satisfaction	0.37	3.56
H4	Path	External Benefits->Satisfaction	0.39	3.87
H5	Correlation	Internal and External Benefits	0.43	3.31

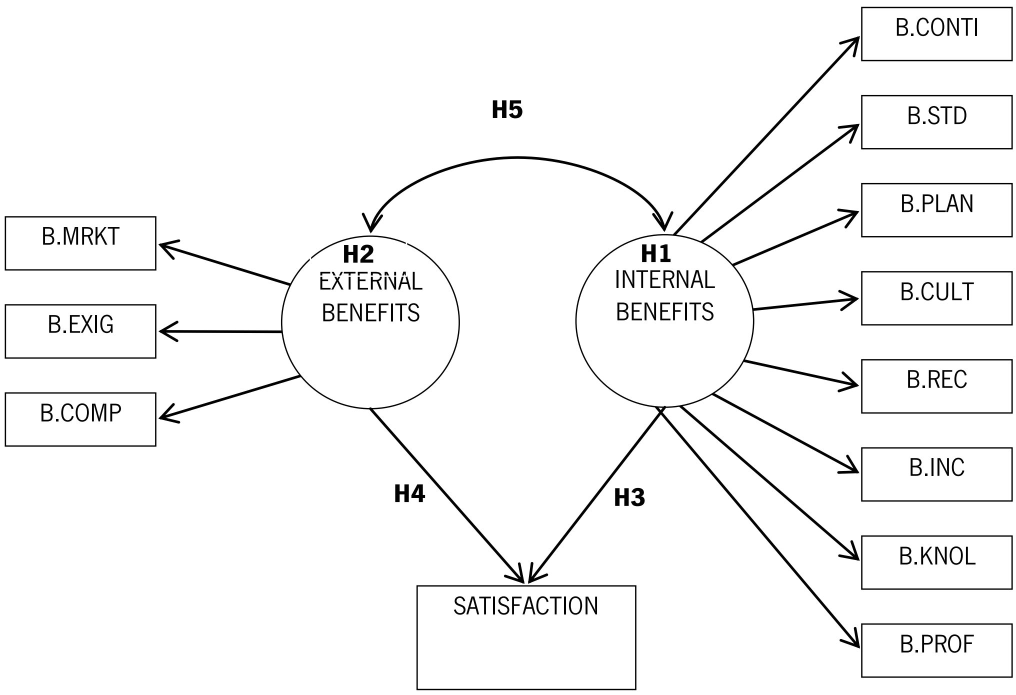

Figure 1 - Causal model

CONCLUSIONS

In addition to the characteristics of the sample of Spanish organisations that have certified their service-management systems according ISO 20000 in Spain, which can be more or less similar to those in other countries, this research is the first to arrive at certain conclusions in a brand new field: the benefits of implementing ISO 20000.

First, the order of agreement in the list of benefits itself provides evidence of the benefits that are clearly perceived, enabling those interested to advance the positive results of certification. It is relevant to underline that the majority of the analysed concepts are perceived as benefits of the implementation of the standard. The results are clearly positive.

Second, it is feasible to classify the benefits of ISO 20000 into internal and external categories and to identify variables that best describe those benefits. Namely, external benefits can be defined, considering their importance order as marketing benefits, responding to customers and their exigencies, and obtaining a competitive advantage. In parallel, internal benefits can be defined from more to less important, as improving services, supporting service standardisation, increasing the ability to plan and control, establishing a quality culture, improving the capacity to recover from an accident, reducing incidents and enabling the retention of an organisation's knowledge.

Finally, this research shows that internal and external benefits make an important contribution to satisfaction, facilitating the interpretation of more relevant benefits and showing which of those benefits have a greater impact on satisfaction. The expected correlation between internal and external benefits verifies that frequently, benefits are not isolated and organisations that perceive one type of benefit frequently also perceive others; consequently, such organisations obtain satisfaction from ISO 20000 implementation and certification.

Conversely, even in light of this study's limitations and exercising necessary caution, our results on the benefits of ISO 20000 could be, to some extent, considered as generic benefits of ITSM techniques (for example, as with ITIL), and thus, more investigation of this field should be conducted.

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Diffusion and efficiency of ISO 9001 in Portugal: a qualitative and quantitative study from a holistic theoretical perspective

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ABSTRACT

Purpose. The aim of this paper is to analyse the diffusion and efficiency of ISO 9001 on different sectors of activity

Design/methodology/approach. For that purpose, a holistic an integrative theoretical approach was based on the scope of the Contingency theory, the Institutional theory and the Resources-Based View (RBV). This theorethical perspective was used in a broad empirical study, using a qualitative and quantitative methodology, concerning Portuguese companies from different sectors of activity.

Findings. According to the findings from both perspectives, a ranked combination of the named theoretical frame was constructed.

Research limitations/implications. As to the analysis of the efficiency of ISO 9000, one of the limitations of this study lays in the consideration of just two sectors of activity, and another relates to its domestic geographical placement.

Practical implications. This study used the ISO 9001 structure for the interviews and this has revealed very useful for the organizations to grasp the matters inquired.

Originality/value. A relevant contribution to the state of art is achieved through the considered theoretical scope of analysis

Keywords: ISO 9001, performance, efficiency, effectiveness, institutional theory, contingency theory, RBV

Article Classification: Research paper

INTRODUCTION

Within the Quality Management (QM) paradigm, ISO 9001 is arguably the most influential contribution that there has been to date. The purpose of this paper is to measure the efficiency of ISO 9001 on management, and furthermore, its association with the organization financial performance, under a holistic theoretical approach. So, the paper is arranged as follows: the introduction (1), the holistic theoretical framework from literature review (2), the methodology steps and data observation (3) and at last the conclusions (4).

THEORETICAL FRAMEWORK UPON LITERATURE REVIEW

The holistic theoretical framework consists of the Contingency theory, the Institutional theory and the Resources-Based View.

Contingency theory argues that there is no ideal or optimal way to manage. Wiio and Golhaber (1993) refer contingency related to leadership and Fiedler (1992) says that it is connected to the human resources. Vroom (1988) selects the motivation and involvement of the employees but Smith (1984) refers that the standards of behavior translate some power. In brief, Somsuk (2010) refers it as combination of ideas about the environment of the organizations permanently in adjustments to its subsystems. Adversely inside the organization lies the institutional theory that considers the norms, rules, regulations, procedures and routines as the structure of the organization (Scott 1995). Companies many times seek legitimacy through processes of isomorphism. This becomes a kind of benchmarking (O'Connor *et al*. 2004). Coercive isomorphism is a form of coercion by a third party (State, Trade Unions, clients or suppliers) while the normative relates to the standards across the classes of professionals (Levitt and Nass 1989; Chua and Petty 1999; Lowrey 2005; Leiter 2005). Under an efficiency inspiration RBV theory suggests that the organizations use specialized resources (Wernerfelt 1984) based on knowledge (knowledge based) or based on power (competence based from Hamel and Prahalad 1994). Somsuk (2010) subdivided it into explicit knowledge - information and tacit knowledge - expertise. Teece et al. (1994) and Dirickx and Cool (1989) mentioned the dynamic capacity for change. Thus, business strategy of any organization depends on the resources that are skills (Oliver 1997) and its ability to keep routine production over time (Wernerfelt 1984).

Under the umbrella of these theoretical perspectives the purpose of this paper is to reinforce the state of art as to quality and performance, after Haversjo (2000), Casadesus *et al*. (2008), Chong and Rundus (2004), Martinez and Jimenez (2008), Furtado (2002), Pereira (2005), Ribeiro (2007) and Sampaio (2008) authors who considered that there is some kind of relation between quality and performance.

METHODOLOGICAL APPROACH

The methodological approach will consist of a qualitative perspective and a quantitative perspective.

Qualitative perspective. The methodological approach is a case study (Yin 2009). Initial research questions motivated literature review which enabled some propositions; the interconnection of the literature propositions (assertions) lead to a theoretical model of analysis. A criteria for results interpretation was considered. Data concern the information got through semi structured interviews achieved in the defined sample (units of analysis). Results will be evaluated according to the defined theoretical criteria enabling conclusions.

Research questions, issues and assertions

The initial research questions motivated the literature review defined as issues (Table 3.1). From them propositions arise which contribute for the assertions (a1-a10) construction.

Table 3.1 Issues of content and related assertions

ISSUES	ASSERTIONS
Organisation and quality	a1 - the structure of ISO 9001 certified organisations may be more enhanced a2 - ISO 9001 may contribute to a culture reinforcement
ISO 9001 implementation process	a3 - after ISO 9001certification organisations may develop better management practices a4 - with quality certification organisations may register a more motivated human structure a5 - with ISO 9001 quality there is a greater customer loyalty
The effects of ISO 9001 implementation	Non-financial a6 - a large part of quality certifications is driven by the market a7 - the focus of quality must come from top management
The effects of ISO 9001 implementation	Financial *(Immediate)* a8 - costs related to quality may be significant a9 - good practices of management may create conditions for a good management performance *(Mediate)* a- 10 a good management performance can lead to a good financial result

a1-a2 organisations with a lean structure (Kanter 1989) are more likely to implement a quality management system. Dale (1999) argues that these have implemented procedures and Wiio (1993) says that this is something very institutional. So, ISO 9001 certification helps organisations to have a defined structure – a1 (Schein, 1992). Kotter and Heskett (1992) and Lindby *et al.* (1999) suggest that organisations culturally more open are better hosts for quality. It seems that afterwards there is a reinforcement of a quality culture - a2.

a3-a5 top management should involve the employees of the organisation (Mac Adam and Oneill 1999; Kaplan and Norton 1992) who should have a prior knowledge on quality and an ability for change (Dillard and Tinker, 1996). Quality process effects result in expenditures which should be considered an intangible assets (Kaplan and Norton 2001; Heskett *et al.* 1994). Best management practices should emerge - a3. Quality certified organisations may show a more motivated human structure and continuous improvement is a natural event - a4. From this quality process (Crosby 1979; Feigenbaum 1991; Dean and Bowen 1994) a greater customer loyalty will emerge - a5.

a6-a10 some authors argue it, as a competitive advantage (Porter 1987; Senge 1994; Basu 1997; Stern 2001), the market (Oakland and Tanna, 2007) or a customers demand (Zairi 1996), leading to -a6. But quality must come from the top - a7. Expenditure on quality should be handled carefully (Yang 2008, Yang 2008; Shirley 1997) - a8. Good quality management practices may create conditions for a good management performance - a9; the motivation and involvement of the top of the hierarchy (Zairi 1996; Weldeghiorgis 2004; Kaplan and Norton 1992; Walsh 2006) may contribute to a good financial result - a10.

Assertions inter relation under a theoretical scope

Three different management theories: institutional, contingency and resources based view (RBV) will be considered and the logical connection between the assertions are present in figure 1.

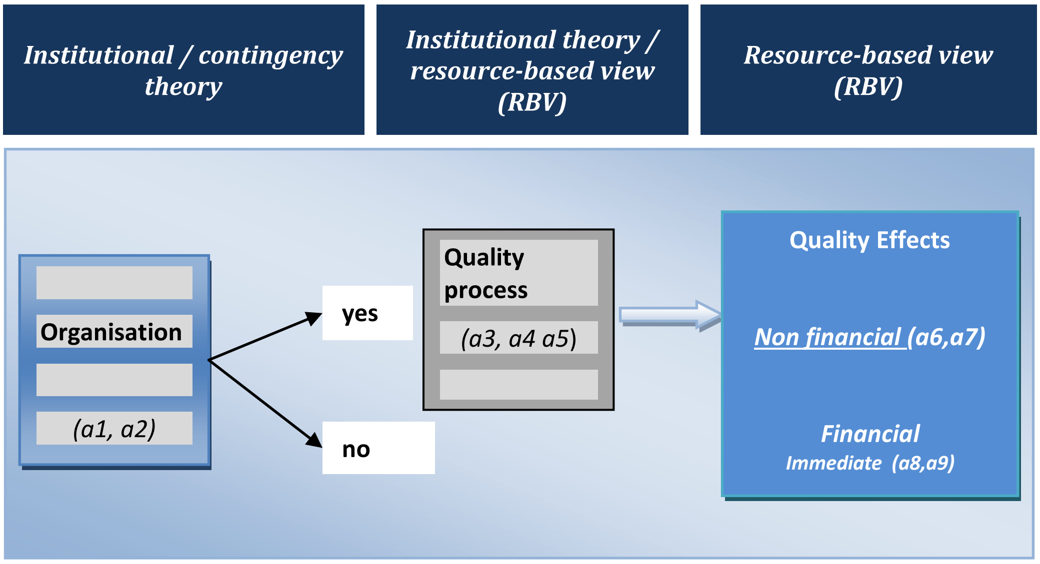

Figure 1 Theoretical approach of the Model of Analysis

Institutional and/or contingency theory (a1- a2): the organisational structure is connected to the cultural nature and these elements may be of an institutional or of a contingent nature.

Institutional theory/RBV (a3 - a5): after ISO 9001 certification, organisations can develop better management practices and a more motivated human structure both will result in greater customer loyalty. These facilities are of an institutional or of a resource perspective.

Resources View - RBV (a6 - a10): a large part of quality certification is driven by the market and the focus of quality should come from top management. The financial effects are a consequence. Costs related to the quality may be significant but its good practices may create conditions for a good management performance.

This model of analysis will be evaluated through the following criteria.

Criteria for results comprehension

From the institutional (Scott 1995; Oliver 1997) to the contingency (Wiio 1993) or to the resources-based view RBV (Wernerfelt 1984). In Figure 2, the different circles intend to interpret the results highlighted considering their greater or lesser extent, according to the degree of frequency in which the term is used.

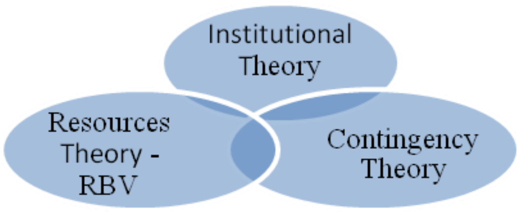

Figure 2 - Criteria for interpreting results

This will allow defining the sequential positioning of theories through the size of the representative image. The intersection of theories means a double or triple simultaneous theoretical interpretation.

Profile of the units of analysis and means of analysis

From the Portuguese website of stock exchange companies CMVM (accessed on February 25, 2010) the financial elements relating to listed companies ISO 9001 certified, were taken. These organisations belong also to Euronext being classified by an ICB acronym meaning – industry classification benchmark. ICB is a detailed and comprehensive structure for the sectors and respective industry, facilitating the comparison across companies through the economic activity classification. The following sectors will be considered: ICB 2350 – Construction (where two companies will be selected) and ICB 5330 – Food and retail (where two companies will be selected). In addition, it was also considered a sector without ISO 9001 certification – ICB 5550, concerning "media" where two companies were selected.

Interviews were developed according to a guide (in two versions for quality certified and not quality certified companies) prepared according to the logical sequence of subjects formatted in the ISO 9001 structure and based on the abovementioned Model of Analysis. Its topics contents were the result of the framework of assertions (a1: a10) created upon literature propositions. Therefore, it is essential to address its key points, identified in 4.5.6.7.8.[c] and related assertions:

Table 3.2 ISO 9001 contents and related assertions

Quality Management System (4)	QMS	a1; a5
Management Commitment (5)	MC	a2; a3; a7
Resource Management (6)	RM	a4; a8
Product Realisation (7)	P/S	a6
Measurement, analysis and improvement (8)	MAI	a9; a10

All assertions listed from one to ninth, concern nonfinancial performance and the tenth assertion concerns financial performance. From these the questions for the interview emerged and enabling the construction of the guide that was specifically applied in the following companies.

ISO 9001 certified Companies

<u>*Company 1 and Company 2*</u>

ICB 5330 - Food and Retail: Food and retail: this ICB in Euronext list, obtained in May 2010, reaches a global value of 12,247,000 Euros, where Company 1 contributes with an income of 6,894,000 Euros, representing 56% of that value, and Company 2 with 5,353,000 Euros, representing the remaining 44%.

cFrom ISO 9001 standard points 1 to 3 of the ISO 9001 Standard are respectively: 1. Fundamental concepts of its application, 2. Regulatory framework and 3. Terms and definitions that are not relevant or fundamental for the present research aim.

Company 3 and Company 4

ICB 2350 - Construction: Company 3 and Company 4 - In the construction sector, which, (from *Euronext,* May 2010) recorded a global value of 7,524,000 Euros in 2008, Company 3, with a turnover of 1,868,000 Euros, represents about 25% and Company 4, with 835,000,000 Euros, represents about 11%.

ISO 9001 non-certified companies

In these companies, as there is not a "cut off" element concerning quality certification, because they are not ISO 9001 certified.

Company 5 and Company 6

ICB 5550 - In 2008 the media industry (from Euronext, May 2010) totalled 1,439,000 Euros, where Company 5 records 270,000 Euros income and represents 19% of that amount, and Company 6, with 122,000 Euros, represents 8%.

Results from the qualitative perspective

From the achieved interviews results were positioned face to the initial research questions and enabled interesting findings as Table 3.3 summarizes.

Table 3.3 Findings from qualitative analysis

INITIAL RESEARCH QUESTIONS	FINDINGS
Characteristics and reasons that explain the choice of ISO 9001 quality in the organizations	The market and the size of organization as well as culture are good and steady reasons
Income and expenses associated to the quality process	Usually accounting department of companies can identify them but are not used as a management tool
The register of costs related to quality certification as an intangible assets	No interviewee considered this as somehow important for management
Effects of ISO 9001 implementation on management	If organizations do not possess and ISO 9001 they will not be in market, so, no competitiveness for them
Quality management performance	Usually the policy and objectives of quality help the management through the establishment of good practices

The cross case analysis of results of the interviews were inserted in the theoretical scope according to the defined criteria. The resources theory (RBV) is the more relevant: Knowledge based (Prahalad and Hamel 1990) and dynamic capability models (Teece *et al.* 1994; Dirickx and Cool 1989). As to the institutional theory - mimetic, opinions confirm that the control tools existing in the organisation are mostly associated to the quality process (Levitt and Nass 1989; Chua and Petty 1999; Lowrey 2005; Leiter 2005). Shellhorn (2007) meaning that anything to be managed should be measured. ISO 9001 is an institutional artifact. But all the rules and procedures may be changed due to unexpectable events (contingency of the market).

Former conclusions – about qualitative analysis. It was interesting to note, from the interviews data analysis, that not-certified ISO 9001 companies were those advocating more strongly the connection about quality and performance (perhaps because they did not start such a process...). For ISO certified companies the explanation of their choice was *ad contrario* saying that a non quality certification would become a competitive disadvantage. As a final conclusion one could say when ISO 9001 efficiency is relevant it means that companies have a devoted belief in/on quality.

Quantitative perspective. A quantitative analysis – OLS, multivariate analysis and an econometric model will be achieved in order to reinforce the results from the qualitative perspective. The relevant hypotheses of analysis were:

Table 3.4 Hypotheses and models of analysis for the quantitative perspective

HYPOTHESES	MODEL
H1 - ISO 9001 through its implementation, can contribute to higher productivity and increased business value defined in terms of GAV	AE1: GAV = Function (ISO certification, control variables)
H2 - The increase on sales occurred in certified organizations can be associated to ISO 9001	AE2: Sales = Function (ISO certification, control variables)

A descriptive statistical analysis was done as the construction and the food sector having as source of information a database published in Exame Magazine (nowadays Expresso Publishing) compiling financial indicators for the 500 Biggest and Best Business (this was published in 2009). Information included national companies from which the following parts were taken: Global sales (internal and external), results - operating and net staff costs, Assets, Gross Added Value - GAV, personnel attached. The information was gathered per sector analysis. Within these sectors of activities, for the period 2002 to 2009, companies having (or not) ISO 9001 quality certification were identified.

Data was obtained during the period 2002 to 2009[d], and referred to the sectors of Construction and Agricultural - food (agro-food) industry in which representations from both agro industry and food distribution are present. Together these sectors form a representative critical mass of the food area. This sector shows a high level of certification, reaching 52% in 2002 and 71% in 2009. The construction sector shows a significant growth in recent years, representing about 85% in 2009, a value well above the average ones recorded in Europe.

In the descriptive analysis two outcome variables were also included corresponding to alternative proxies: one for financial performance and another for non-financial performance (productivity). In the context of estimating the impact of certification on performance it was defined a model that was based on a regression of Gross Added Value (as a proxy of the non-financial performance) and Sales

d Guia de empresas certificadas. Edição (2009) Cem Palavras.

(as a proxy of financial performance).The variables of the sample were defined according to the assumptions and the ones belonging to the econometric model were summarized in the table below.

Table 3.5 Definition of the variables

Variable	Definition	Unit
$Sales_{it}$	Annual sales value i, year t	Million Euros
GAV_{it}	Gross Added Value i, year t	Euros
Current $profits_{it}$	Annual operational balance for company i, being the difference between operational income and expenses in period t.	Euros
Net $profits_{it}$	Net profit of company i, being the difference between income and expenses, including operational profits the financial charges and the extraordinary results, in year t.	Euros
Certification ISO_{it}	Binary variable identifying if company i, is certified (assuming value 1) or not (assuming value 0) in year t.	Certified company=1 Non certified company=0
$Asset_{it}$	Set upon f factors of the company i – able to generate financial inflows – year t	Euros
$Productivity_{it}$	Work apparent productivity: ratio between GAV and the number of employees	Euros

A descriptive analysis elaborated from the database elaborated by sector of activity was done. After identifying the sectors of activity with a major relevance of ISO certification – a brief description of the sample will follow.

In the construction sector and considering the 52 (N) firms on the database referred to, only 16 (31%) held ISO certification in 2002. This number has evolved considerably in recent years, standing, in 2009, 44 companies (85%). The temporal analysis (T) is 8 years (2002-2009). This data set constituted a panel data with a sample size (N * T) of 416 observations (52 * 8). However, the used database had some information gaps that forced the resizing of the panel. Considering the dependent variables to be used in the model and the non- existence of 123 observations for the variable sales, these observations were taken out in the econometric analysis. However, it was necessary to remove from the sample 52 observations resulting from the unavailability of data for the year 2007 (missing in the database considered). Thus, the original panel data was reconfigured in an unbalanced panel with about 241 observations.

The sample concerning the sector of the agro-food industry includes a total of 38 companies with observations in the period 2002 to 2009, setting up a panel data with 304 observations. However, and similarly to what happened in the construction sector, the erroneous information in the database eliminated 144 observations. Of those eliminated observations, 38 were a result of lack of data for all companies in the sample, for the year 2007. Thus, the unbalanced panel data results in 157 valid observations included. In 2002, about 52% of the sample (n = 20) were certified, this proportion rising to 71% in 2009, with about 27 companies certified.

This study will focus on the econometric analysis. It was possible to construct an unbalanced panel data with about 52 companies in the construction sector and 38 companies in the agro-industry for a period of eight years (in construction, the sample size will be approximately 52x8 = 416 and agro-industry sample size will be approximately 38x8 = 304). However, in some years the financial information was not available what reduced the size of the actual sample values shown in the tables of results and drew together an unbalanced[e] panel data. Therefore, in the research an unbalanced panel was used since it does not involve significant changes in the theoretical model[f]. Moreover, the software used (LIMDEP) allows to treat the absence of information as such and not as a zero. The fact of working with a panel of data allows the use of multivariate regression methods more complex than the simple OLS (Ordinary Least Squares Method) or the pooled OLS (Greene, 2003)[g]. In brief, we carried out the following: *Pool OLS, Fixed Effects Model (FEM), Random Effects Model (REM)* but from these only one was adopted. As before mentioned, OLS pool method in practice results from its application to a sample juxtaposed for various periods. The methods FEM and REM (which, in their estimation, consider the temporal evolution of the causal relationship in each individual) conduct to more efficient estimates, if there are, indeed, effects of group that capture the idiosyncratic characteristics.

In this research it is expected that there is no correlation between the observed and intrinsic component of the company and any of the explanatory variables. Thus the fixed effect model will be used. There are a set of statistical procedures and tests that contribute to a greater security in the decision making. Thus, the first test of statistical analysis implemented in this practice is the F-test or global significance that seeks to infer the statistical significance of the artificially set of dummies created to capture the individual-specific effects in panel data. The null hypothesis assumes that these dummies are zero and, as such, there would be no statistically significant idiosyncratic characteristics that should be taken into account in the estimation process. In case of rejection of this null hypothesis, this implies that there are indeed effects of group and thus FEM outlays more efficient estimators. In addition one might consider also the test of the Lagrange Multiplier (LM). Similarly to the F test, this test considers the analysis of the significance of the dummy model compared to the method underlying the REM (where there is no correlation between the individual-specific component and the independent variables which leads to an estimated transformed model different from the FEM). Finally, to test if whether $a_{ir\ \mathrm{or}}$ w_t are correlated or not, with the explanatory variables and thus opt for the method FEM or REM, the Hausman test was performed. The Hausman test compares the fixed effects model with the random effects model, assuming as a null hypothesis that the component is not observed and specific to each individual and did not correlate with the regressors of the model (Hausman, 1978; Park, 2006). If there is evidence of correlation, the null hypothesis is rejected and one should opt for the fixed effects model because the random effects model would produce inconsistent estimators. If the null hypothesis is not rejected, then it is preferable to adopt the random-effects model because it leads to consistent estimators and more efficient than the ones obtained by the method of fixed effects (Greene, 2003). In this analysis there are theoretical reasons that support the choice of the fixed effects model - statistical tests. Accordingly, and given the restrictions imposed by the available data, it is not possible to model a complete listing that captures all these structural effects. Usually idiosyncratic aspects are captured by the effects of group, something that allows to identify the individual characteristics of each company and which favor the choice of FEM or REM.

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e Alternatively, we could have used a balanced panel. A panel of this kind implies that there is complete information for all the observations considered in this case would only be possible by eliminating some of the observations.

f For further details, check Greene (2003, pp. 289-290).

g As in this case, the non-availability of data over a long period discourages the use of methods of time series analysis as the GMM – Generalized Moment Method (Greene, 2003).

Considering the eventual inefficiency of the model, the probability of correlation between the non-stocastic component of the error and any of the independent variables, would result in the non-validity of the statistical inference.

Thus, a more conservative and safe approach was undertaken, selecting a method that cannot produce more efficient estimators and therefore allow statistical inference. Moreover, as already mentioned, the statistical means intended to assist in this choice, mainly Hausman – test, have a high overall statistical test, indicating that for significance levels usually taken as a reference, the fixed effects model is in fact preferable and it shall be used in the estimates of the models in this research.

The theoretical hypotheses

It is recalled that in the present investigation the influence of ISO 9001 on the performance of the organization is to be evaluated. A model of regression considering GAV (as a proxy of management performance and non-financial performance) and Sales (as a proxy of financial performance) was defined. Thus, the generic models presented - (1) and (2) – are respectively

$$AE1: \quad GAV_{it} = Z_i^{'}\alpha + \beta_1 ISO_{it} + X_{it}'\theta + \nu_{it} \quad (1)$$

$$AE2: \quad Sales_{it} = Z_i^{'}\alpha + \beta_1 ISO_{it} + X_{it}'\theta + \nu_{it} \quad (2)$$

Based on the models above described several sub-models were estimated, using alternative control variables, in order to disguise the possible overestimation of the impact of ISO and a further evidence as to the robustness of the results. To evaluate the non-financial performance of ISO 9001, a regression was made on three versions of model (1) trying to capture the impact of certification on Gross Added Value (GAV) and / or productivity (GAV / Workers), controlling the scale of operation of enterprises measured by the assets.

$$AE1-Mod.1: \quad VAB_{it} = \beta_0 + \beta_1 ISO_{it} \quad (1.1)$$

$$AE1-Mod.2: \quad GAV_{it} = \beta_0 + \beta_1 ISO_{it} + \beta_2 Assets \quad (1,2)$$

$$AE1-Mod.3: \quad \mathrm{Pr}oductivity_{it} = \beta_0 + \beta_1 ISO_{it} + \beta_2 Assets + \beta_3 Sales \quad (1.3)$$

Theoretically, it is expected that the impact of ISO 9001 is positive, whether as to GAV or as to productivity. It is also expected that GAV and productivity are higher in large scale organizations because they have size to be more productive. So, it is expected that the assets has a positive impact on the GAV and productivity due to a larger scale of operation which would enable bigger economies of scale and an accrued ability to create value. Similarly, to assess the financial performance of ISO 9001, a regression on three versions of the model (2) was considered in order to capture the impact of certification on the volume of sales and assets controlled by the company's productivity. It is expected that companies with a larger scale of operation and, consequently, greater production capacity, have larger sales volume, as well as productivity should have a positive impact on the company's competitiveness.

In order to estimate the effects of ISO 9001 certification on the performance of an organization, other regression models were considered:

$$AE2-Mod\,1: \quad Sales_{it} = \beta_0 + \beta_1 ISO_{it} \quad (2.1)$$

$$AE2-Mod\,2: \quad Sales_{it} = \beta_0 + \beta_1 ISO_{it} + \beta_2 Assets \quad (2.2)$$

$$AE2 - Mod3: \quad Sales_{it} = \beta_0 + \beta_1 ISO_{it} + \beta_2 Assets_{it} + \beta_3 \mathrm{Pr}oductivity_{it} \quad (2.3)$$

As concerns testing hypotheses, it is well known from literature that certification should influence positively the market and it is expected that the estimate for β1 is positive for both sectors.

In model 2.3 it was included in addition to the assets, the productivity which means a way of evaluating the efficiency of enterprises and the extent to which the assets could induce workers' productivity. It has been tested as well whether this could also influence the volume of sales reflecting a higher added value.

Using the two samples (sectors of activity) as a source, the method of fixed effects selected on the basis of the taken theoretical assumptions and on the findings of the achieved statistical tests (Hausman, LM, and F), results are as follows.

Latter Conclusions – about quantitative analysis. In brief and according to the theoretical scope it can be argued: as to RBV - Sales and Gross added Value and Sales and Assets are correlated variables as well as it seems true for the statistical analysis. As to the Institutional perspective one can say that the best the organization is ruled the best the performance indicators arise and as to the Contingent perspective one must refer the market because a company cannot be predict its vision for sure.

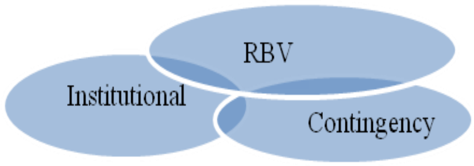
Table 3.6 Hypothesis of investigation and associated results

H1 - ISO 9001 IMPLEMENTATION MAY CONTRIBUTE, TO A BETTER PRODUCTIVITY AND ACCRUED BUSINESS VALUE (DEFINED IN TERMS OF GROSS ADDED VALUE - GAV)	**H2 – SALES ACCRUALS IN CERTIFIED COMPANIES CAN BE ASSOCIATED TO ISO 9001**
On a correlation basis it can be said:	On a correlation basis it can be said:
There is a strong correlation in quality certified companies between GAV and Sales and between Sales and the assets	There is a strong correlation in quality certified companies between GAV and Sales and between Sales and the assets
Statistics analysis revealed that the average values of Sales and GAV in ISO 9001 certified companies were bigger than sector average; mainly as to companies belonging to the food industry	Statistics analysis revealed that there is a positive association between sales value and quality certification. Sales values, in ISO 9001 certified companies – in both sectors of activity , were bigger than the sector average
The econometric model refers that the effect on management performance, in ISO 9001 certified companies, measured through GAV and productivity, was not significant.	The econometric model reveals that the effect of ISO 9001 on sales was more significant in food sector than in the construction one

Notes: GAV – Gross Added Value

FINAL GLOBAL CONCLUSION

A major conclusion from the empirical study of this research puts forward a need for ISO 9001 certification, as a resource for companies in order to persist in the market. After all, ISO 9001 is placed in the organizations' environment, under the scope of a theoretical holistic umbrella made up of resources inserted under an institutional perspective, which may be changed at any time by unforeseen events included in the contingent of the present times. The fact of a large company not being certified is an evidence of a competitive disadvantage. According to the evaluation criteria we get the following figure:



This way one could look at ISO itself as a resource (RBV) that implies the good use of many other resources in the organizations (human and material) providing for some rules and procedures about management (institutional) in order to face a dynamic market (contingent).

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Laboratory Management considerations when working with Nano-Engineered Materials

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PURPOSE OF THE RESEARCH

Nanotechnology is said to be an innovative and novel way to address the world's future needs. However, there is limited knowledge on the behaviour of nano-engineered (NEM) materials even though their use is widespread.

The context of this study is Quality Management (QM). This study was undertaken to seek the extent to which QM practices were adopted during the research and development and manufacture of NEM. It is purely exploratory and draws on the literature from research and technical guidelines in the field on risk management.

Due to the limited literature related to QM in this field this paper aimed to establish suitable quality management steps that could be adopted by a laboratory to monitor, measure and control its activities when working with nano-engineered materials. It attempts to show both the quality management (in terms of systems) and the quality technical (laboratory practise) activities that should be undertaken to achieve this.

Delgado (2010) reported that in 2006 the following nano-materials were already being used in consumer goods: carbon (34%), silver (30%), silica (17%), titanium oxide (9%), zinc oxide (9%) and cerium oxide (1%).

The behaviour of NEMs during its lifecycle and post lifecycle and its effects are of particular importance due to the fact that these potential effects are largely unknown (SABS: 12885, 2008). Of concern is that presently, monitoring, measurement and control and assurance are based on research and development (R & D) knowledge and supplier data sheets.

In most instances NEMs are managed in accordance with the behaviour of their bulk counterparts but little is known about whether their behaviour is similar (Thomas et. al; 2006). Delgado (2010) cites Poland et.al that carbon nanotubes exposed to rats' abdominal cavity resembled the pathogenicity of that of asbestos. To prevent the negative views as was the case from the emergence of past novel products and in an attempt to learn from the poor perceptions of the public to genetically modified (GM) foods and to prevent similar repercussions from the use of asbestos, NEM manufacturers, scientists and users should understand the material to pre-emit their possible undesirable effects. Therefore, an understanding of the effects of NEM to fauna and flora are equally important (Delgado, 2010).

Already studies have suggested that exposure to nanoparticles in laboratory tests and in products in the market have had adverse effects on animals and consumers respectively (Delgado, 2010; Sass et.al; 2006). Examples cited were as follows: lung inflammation, granulomas, brain cell damage, precancerous lesions, consumer intoxication with bathroom products, death and pulmonary disease from exposure to NEM paint, to name a few.

Quality management and engineering has the ability to monitor, measure, control and assure the use of NEM. This can be supported by Tolmachev (2012) who proposes the importance of understanding product quality in gaining an understanding of its behaviour to provide control accordingly. Thomas et.al (2006) suggested the establishment of suitable data collection, detection, monitoring, control and remediation structures specifically for NEM. Vladimir et. al (2009) proposed that the OECD – GLP provides a suitable structure to manage the safety of chemicals and data analysis to encourage global uniformity in practice.

RESEARCH APPROACH

Due to the novelty of this focus area, this study adopted a qualitative paradigm, an interpretivist strategy and was stimulated by the inductive reasoning from the calls for consistency and uniformity of practice. In considering the limited knowledge in this field, this research sought related technical reports, relevant research papers and material data sheets to determine the current focus, and research related to NEMs. Thereafter, a series of interviews (12) were conducted with international leading organisations and researchers who are either fully engaged with manufacturing or are in R and D in NEM to establish if there was a match between the findings from literature and actual practise in industry. Face validity was administered by an expert in nanotechnology. The reliability of the study was based on credibility, dependability, trustworthiness and transferability of information. The latter was achieved by a comparison between multiple articles and feedback received from the interviewees above, and was deemed comprehensive and appropriate to meet the needs and deficiencies in the field, respectively.

FINDINGS

Findings from literature indicated that the outcome of most of the research papers were in the same quandary which primarily related to unknown behaviour of NEM throughout its lifecycle, its potential toxicity, its effects on flora and fauna and lack of standardisation of practice, guidelines and legislation.

Findings from the interviewees suggested that all the analysis related NEM is currently being conducted in accordance with material data sheets and test methods for related bulk material. All the manufacturing laboratories indicated that they are in preparations for seeking ISO 17025:2005 certification. None of the interviewees indicated knowledge of prescriptions to OECD Good Laboratory Practices (GLP) by researchers and licencing bodies. In noting the number of NEM products on the market it brings considerations as to what criteria were followed by these establishments if GLP and ISO 17025 were not adopted during their development of NEMs. Other findings from both literature and interviews were very specific for mechanisms to establish monitoring, measuring, quality control and quality assurance. There was no evidence of standard practice in the development of a particular type of NEM between the various establishments even though they may have been making similar products and controls adopted were based largely on the experience of the technical individuals and the materials data sheet. Therefore it was decided that this study present steps indicating typical QA protocols to advise similar establishments of minimum practice that should be followed if they desire quality test data and have no accreditation and/or do not follow GLP.

LIMITATIONS OF THE RESEARCH

Work with NEM is in its infancy and due to its potential applications is very confidential. Therefore, the findings of this study cannot be generalised to all R and D laboratories and manufacturers of NEM and is applicable only to the interviewees and their organisations which formed part of this study.

Developmental work and discussion based on findings. The developmental work in this study draws from various established quality management systems and shows their possible integration and relationship to NEM.

In considering the actual industry practice from the findings above, this study discusses components required for achieving quality test data. Even though an organisation may comply with ISO 17025, ISO 9001, HACCP, ISO22 000, upon investigation of the OECD GLP Directive 88/320/EEC and a typical management system above, it was found that certain requirements from the OECD GLP were not accounted for in any of the management systems. Hence it was decided to use ISO 17025 in the context of this study. Therefore Figure 1 below will show the similarities of the requirements of OECD –GLP and ISO 17025.

The suite of management systems mentioned in Figure 1 may not be prescribed by licencing bodies for NEM but have been selected for the purposes of this study.An organisation need not subcribe to all the management systems mentioned but should follow GLP in combination with any of the other systems mentioned above.

According to the OECD and its member states, methods for testing and assessing bulk chemicals can be deemed suitable for NEM however consideration and adjustements must be given to the uniqueness of the NEM (www.oecd.org/env/ehs/nanosafety/nano%20 brochure, 2010). The selection of the combination of management systems will depend on the sector of the organisation, for example, if it is laboratory testing (GLP +ISO 17025) or food and beverage manufacturer (GLP+ ISO 9001 or ISO 22 000), among others.

It is worth noting that both GLP and ISO 17025 systems are very similar according to their requirements but their applications may differ significantly. For example, it appears that GLP is more appropriate for R and D laboratories because they conduct work exclusively in its novelty stages and ISO 17025 appears to be more inclined to laboratories were commercialisation and more customer interaction is required. This distinction became evident from the scope of the following requirements: “study plan” and “study director” (GLP) and “contract review”, “subcontracting”, “purchasing”, “complaints”, “non-conforming products” and “service to customer” (ISO 17025), respectively.

Because the Management Requirements for ISO 9001, ISO 17025, ISO 22 000 and ISO 14001 are so similar, integration between these management systems with GLP is conceivable and only the Technical Requirements of the GLP can be included and applied to demonstrate robust quality data. A suitable model to demonstrate the integration of GLP and ISO 17025 is currently in its developmental stage and was not adequately tested when this publication went to print.

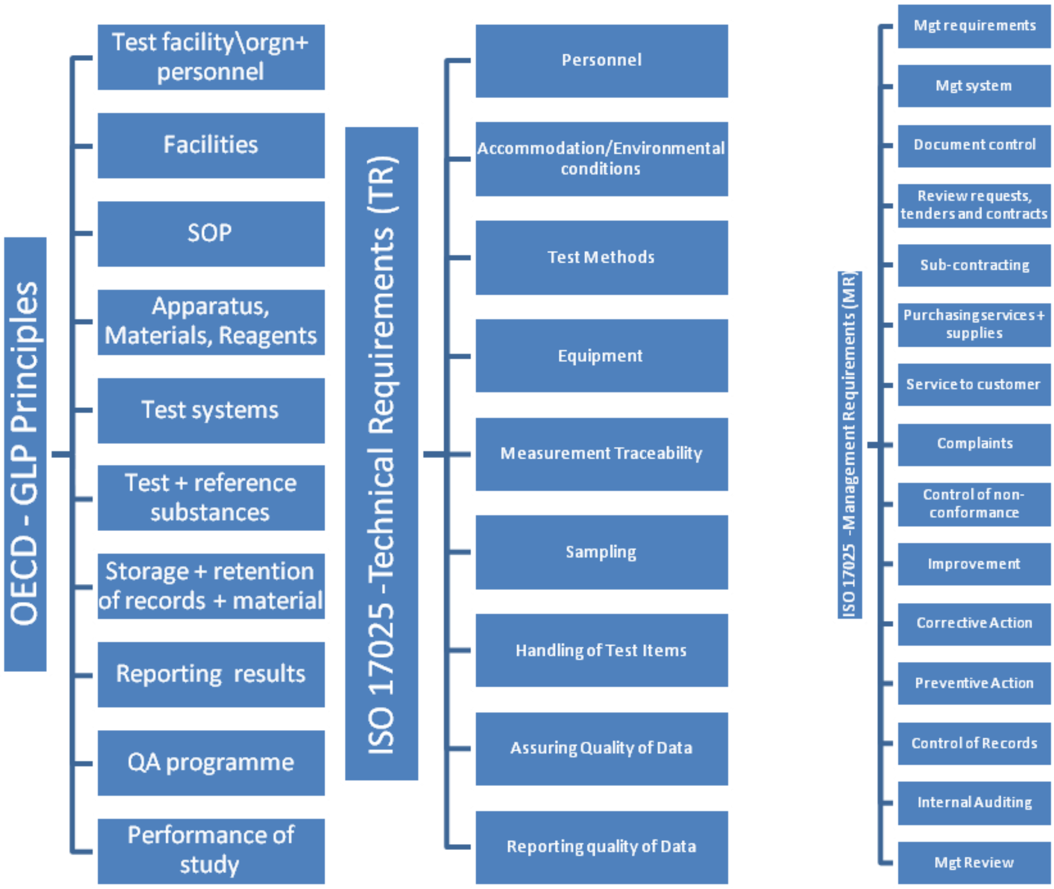


Figure 1: Activities to consider for Good laboratory practices (Adapted from OECD: GLP and ISO 17025: 2005)

Figure 1 shows the similarities between the GLP principles and ISO 17025. This is particularly evident ranging from "test facility/organisation" to "reporting results" (GLP) and "accommodation/environment", "personnel" to "reporting the quality of data" [ISO 17025- Technical Requirements (TR)]. Noteworthy is that the principle "test facility/org" (GLP) is more prescriptive about the environment for the test and important aspects may be overlooked if an establishment only follows the requirement "accommodation/environment" (ISO 17025-TR). It appears that certain aspects of the principles "QA programme" and "performance of study" are somewhat covered in the management requirements, "management system" and "document control", however the management of the tests and experiments in the principle of "performance of study" is more prescriptive than the management controls required in ISO 17025. Similar findings were evident on comparisons made between other principles and requirements. Therefore, from this study it was established that there was a place for both these management systems in the development of NEMs and the selection of the most appropriate ones will depend on the nature of the laboratory or organisation.

Furthermore, from the findings of the study and due to the novelty of NEM and the limited quality related background of the developers and manufacturers, such conversations around the selection of appropriate control systems is deemed neceassary.

Adherence to GLP or ISO 17025 will inadvertently enable an organisation to comply within the components of figure 1. However, not all organisations or laboratories are accredited to ISO 17025 and comply with GLP principles, hence it was decided that a simple series of models be developed so that such establishments can comply with a reasonable and acceptable means to determine the quality of their data.This will also facilitate uniformity of practice within the organisation and create an understanding of practise to other outside organisations.

Consequently, figure 2 was developed from a consolidation of activities recommended from various published research technical papers and publications regarding NEMs. It covers the steps that could be undertaken during the varies stages from sampling, choosing or developing appropriate test methods, showing assurance and robustness of data while adhering to sound practices.

Although the activities included in the schematics below may be considered routine for a quality practitioner, it may not necessarily be the same to an individual from outside the quality fraternity who is conducting tests in NEMs, and was therefore deemed necessary in the context of the title of this publication.

In the light of there being minimal standardisation protocols regarding NEM the rationale for the selection of the components in Figure 2, 3 and 4 will be necessary and will be discussed briefly as an understanding of these models might be necessary for individuals working with NEM and who are from outside the quality fraternity.

It was found that the quality assurance (QA) regarding the NEM should be evaluated and communicated to all stakeholders for a better understanding of activities and to facilitate unity of purpose within the establishment. These include, the laboratory would have to establish a means to sufficiently measure the parameter under investigation and then decide the possible uncertainty related to the data. These were specifically highlighted and stressed upon in ISO 13212 and by Tolmachev 2012 and have therefore been added as the point of departure for this series of models. Other factors highlighted were integrity, transparency, credibility and confidence of data. The importance of these parameters is self- explanatory to all fraternities and has therefore not been elaborated.

Due to the size and versatility of NEMs, their soluabilities vary. This variation makes more soluable NEMs dangerous because of the increased surface area. Also the small particle size decreases the ignition energy and therefore makes the NEM more combustible (ISO 12885). The type of equipment or apparatus selected is therefore important too. Furthermore, due to the factors above, the large particle size distribution, the wide application of NEMs and particularly its unknown effects, equipment and apparatus should be easily potable, be inexpensive and provide real-time results and have therefore been included for consideration. Hence, particular mention to an understanding of exposures, stability and traceability and their associated activities has been made.

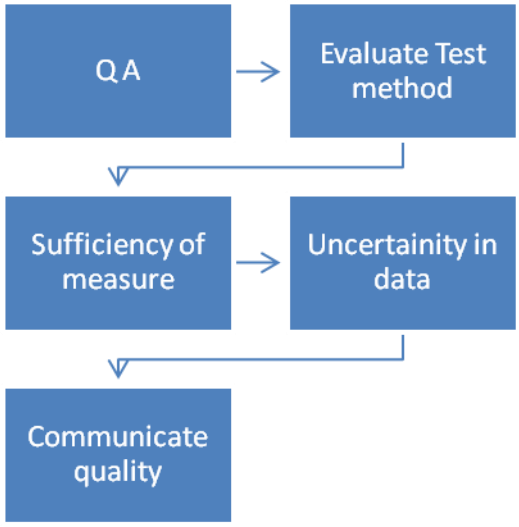
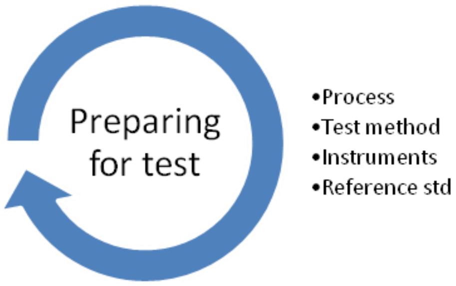


Figure 2: Overview of quality assurance in NEM



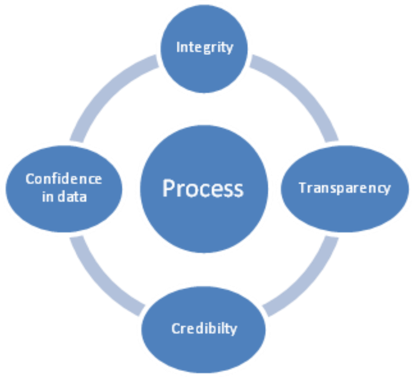


Figure 3: Preparation for selecting test method

Figure 4: Factors in a test process

Figure 2 , figure 3 and figure 4 allows for both the management and technical requirements of QA data to be considered.

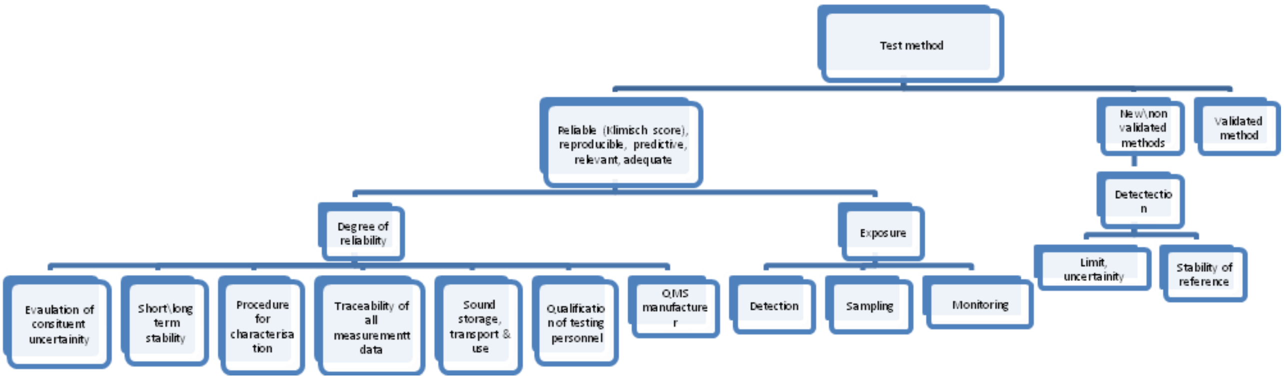


Figure 5: Considerations in test method (Adapted by researcher from ISO 13121, Tolmachev 2012)

From the figure above considerations related to the study plan and its efficacy have been accommodated.

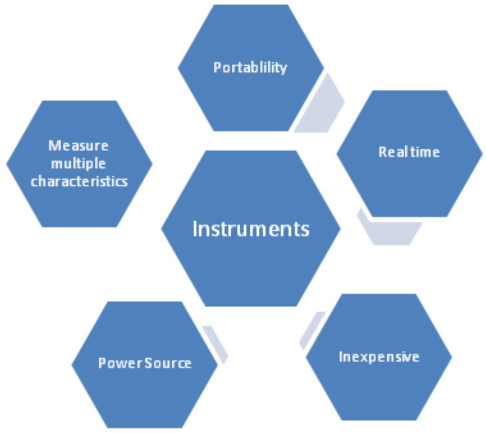


Figure 6: Requirements for test equipment and instruments (ISO 12885)

Figure 6 covers some of the factors that should be considered when choosing equipment /instruments for NEMs.

PRACTICAL IMPLICATIONS

The importance of standards was suggested by Delgado (2010) because he believes that without it individuals may develop their own perceptions on working with NEMs and this may not necessarily support the manufacturing organisation.

Adherence to these steps will ensure that results are credible and consistent and that customers and consumers can be confident of their product.

All the schematic models developed in this study dovetail to support each other to ensure that the quality of data is managed appropriately. It is hoped that this study brings to light the absence or scarcity of QM practices in selected NEM interactions and serves as is a useful source of information to help users, manufacturers and organisations to establish good quality practice in their attempt to manage their activities associated with NEM.

ORIGINALITY AND VALUE OF THE STUDY

This paper presents original work. At the time of this publication no known quality standard was found. This study developed the schematic models based purely on literature and interviews conducted during the preparation of this research.

The study can be deemed valuable because of the following benefits that can be derived from adherence to the schematic models above: establish policies and procedures to manage NEM, produce test results that are credible, sound, reliable and accurate to boost customer and consumer confidence, harmonise the use of SHEQ standards, ability to regulate and control processes on supplier chain nationally and internationally, facilitate conformity testing and cross border trade and acceptance, be binding to manufacturers and users, develop technical competence, help to determine proprietary risk and latent or immediate hazard, align poorer countries, uniformity of practice, provides a systematic way to co-ordinate and interact with NEM and aids in communication. Ichimura (2010) affirms that guidelines and standard practices for certification of NEM developed not only standardise practice but will also manage the negative impacts that may emerge.

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Reasons, benefits and difficulties associated with ISO 9001 certification for sugar and ethanol companies

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ABSTRACT

Purpose. With increasing business competitiveness, companies have sought to adapt their processes and / or products to worldwide established quality standards in order to achieve a greater share of consumers having as favorable aspect the quality assurance of the products and/or services provided. It was observed that companies of different sizes have different challenges regarding the certification however, the degree of difficulty is the same for all of them. The objective of this paper is to verify the reasons for the implementation of ISO 9001, the obstacles encountered during the implementation, the benefits arising from the use of the quality management system and the degree of difficulty to implement this standard.

Design/methodology/approach. This work was developed based on a survey involving companies certified with ISO 9001:2008 from the productive sector of sugar, ethanol and derivatives of sugarcane, located in all Brazilian states.

Findings. It was observed that companies of different sizes have different challenges regarding the certification however the degree of difficulty is the same for all of them.

Originality/value. Thus, we believe that expected results represent a very important contribution to examining the reasons, benefits and difficulties of the ISO 9001 to both, the companies and certification bodies, and to researchers.

Keywords: NBR ISO 9001, sugar, ethanol.

Article Classification: Research paper

INTRODUCTION

The national policy, described by the Brasil (2011), for the production of sugarcane is oriented on the sustainable expansion of the culture, based on economic, environmental and social criteria. The Agro-Ecological Zoning of Sugarcane Program (ZAEcana) regulates the planting of sugarcane, taking into consideration the environment and the region's economic aptitude. From a thorough study, the best planting areas are stipulated based on the types of climate, soil, biomass and irrigation requirements. A timetable is also planned, for gradual reduction, by 2017, of the burning of sugarcane in areas where harvesting is mechanized, prohibiting the planting in the Amazon, Pantanal, in the Upper Paraguay River Basin (BAP) and in areas with native vegetation. The national sugar and ethanol sector is a reference for other producing countries.

The sugarcane is produced in nearly the entire country, 60% in Sao Paulo. The other producing areas are Parana, Triangulo Mineiro and Zona da Mata Nordestina. World leader in the production of sugarcane ethanol, Brazil has the availability of arable land for sugarcane planting, without prejudice to other foods, production technology and distribution structure. The country mastered the whole cycle of ethanol production, from the high-productivity farming to the installation of equipment for the distilleries that are producing this biofuel, from the fermentation of the juice extracted from sugarcane.

Every organization would like to improve their operation, if that means a steady increase in its market share, reducing costs, and managing risks more effectively, improving customer satisfaction and corporate image. A quality management system provides a structure to monitor and improve performance in any area you choose.

According to Debnath et al. (2010) and Kim (2009), the quality management system ISO 9001, proposed by the International Organization for Standardization (ISO) in 1987, represents the first international standard for the development of a quality management system and it is used by nearly 1.1 million organizations in more than 180 countries (ISO, 2013). This system helps all kinds of organizations wishing to demonstrate the ability to consistently deliver a high quality product, greater customer satisfaction, increased staff motivation and continual improvement. According to Sampaio, Saraiva e Rodrigues (2011) the ISO 9001 certification is considered one of the most effective tools used today for improving Quality Management System (QMS). Given the strong growth of using these standards, a great interest from companies regarding this practice has been observed (Sampaio, Saraiva e Rodrigues, 2011).

Since ISO 9001 gained popularity, many authors attempted to understand its effects on businesses and in the world, such as: Aggelogiannopoulos, Drosinos and Athanasopoulos (2007), Sampaio, Saraiva and Rodrigues (2009); Saizarbitoria, Casadesús, Marimón (2011), Sampaio, Saraiva and Rodrigues (2011), Alonso-Almeida, Marimon e Bernardo (2013).

This article aims to identify the benefits, reasons, obstacles and difficulty level that companies of this sector had to implement and certify their Quality Management System in accordance with ISO 9001:2008, correlated with the number of employees and the time to get certified.

The work is justified since the Brazilian agricultural productive sector has developed increasingly; giving the country a major rise in exports of their products and not being identified similar studies for this sector.

The cultivation of sugarcane is the third largest agricultural activity in terms of production area and gross value produced, losing only to soybeans and corn that are the major crops of the country, and in 2006 the crop had a gross value of about 19 billion reais, according to the Brasil (2011). Since this sector is highly productive and profitable, the search for new markets becomes a determining factor for further growth. Thus, it is necessary to invest in quality management systems, because the market has become more demanding and more critical of the quality of products.

Because of this need, the use of systems recognized worldwide has led companies to implement ISO 9001 in their production process. Therefore, the identification of obstacles encountered during implementation, the benefits generated by the use of the quality management system and the degree of difficulty to implement this standard in companies of the sugar and ethanol sector are needed by the importance of this sector to the country, and the fact that other sugar and ethanol companies are still not certified.

The study was conducted in three stages. The first consisted of a literature review on the sugar and ethanol industry and the quality management system ISO 9001. This stage has been proved as of great importance to the implementation of a QMS, as well as the importance of the sugarcane culture in the national economy.

In the second stage, a survey was carried out on sugarcane companies that have the QMS certified in ISO 9001:2008, which could participate in the field-research. Besides that, the questionnaire of Bhuiyan and Alam (2005) was chosen to perform the data collection. In the third stage, the compilation and analysis of data was performed.

THEORETICAL FRAME OF REFERENCE

Sugar and ethanol sector. Introduced in the colonial period, the sugarcane became one of the main cultures of the Brazilian economy. Brazil is not only the largest producer of sugarcane. It is also the first in the world in the production of sugar and ethanol and conquers, increasingly, the foreign market with the use of biofuel as an alternative energy. Responsible for more than half of the sugar traded in the world, the country should achieve an average rate of increase in production of 3.25% until 2018/19, and harvest 47.34 million tons of the product, which corresponds to an increase of 14.6 million tonnes compared to the period of 2007/2008. For exports, the expected volume for 2019 is 32.6 million tons, according to the Brasil (2011).

To Scopinho (2000), in the mid-80s, a new phase of the productive restructuring process began in the sugar and ethanol sector in Brazil. On one hand, under the neoliberalism influence, the State failed to regulate more directly the sugar and ethanol economy; the cut of subsidies and stimulus programs to encourage the production and commercialization forced it to dispute spaces in domestic and foreign markets, increasingly competitive in these times of economic globalization. On the other hand, social movements reacted more strongly against the abuses that have been committed by the sugar and ethanol companies, especially with regard to the exploitation of the environment and workers.

According to Paulillo and Soares (2008), governments, as funder and promoter of development, acting more discreetly in providing supplies to the sector, has forced companies to seek new investments. Given that the options of the domestic credit market, with high interest rates and fees, have not favored the development of the sector. The biofuel companies have sought alternatives; among the most quoted is the capital market, since there is a great need for investment to meet the growing demand for sugar, ethanol and biodiesel. However the sugarcane and ethanol sector is traditionally dominated by family businesses which have hampered the acceptance of the industry in the capital market, besides being a new industry and full of uncertainties. However these companies have adopted a system of corporate governance, which has given more credibility and confidence to the sector, a fact that is being observed in the Sao Paulo Stock Exchange (BOVESPA).

ISO 9001 Standard. The ISO 9001 certification is considered one of the best and most effective tools used for guidance of a Quality Management System. Given the strong growth of these patterns, a great interest from enterprises as regards this practice has been observed (Rodrigues, Saraiva and Sampaio, 2011).

To Levine and Toffel (2010), implementing a quality management system in accordance with ISO 9001 implies suiting operational procedures documentation, training, internal audit and corrective action procedures, in addition to requiring that the procedures to improve existing processes, be also implemented.

The basis of the model proposed by ISO 9001 consists of three key aspects: customer satisfaction, which says that a quality system is only effective if it ensures full customer satisfaction; the continuous improvement, in which the organization needs to demonstrate that it has processes for continual improvement of the effectiveness of its quality management system; and finally the focus on processes, which directs the company to a more systemic and correct view of their activities, seeing the organization horizontally.

Reasons e benefits

According to Heras et al. (2008), the conclusions regarding the effectiveness of ISO 9001 in the industrial sector have been diverse, that's because some studies claim that its implementation is something beneficial for organizations, while in other studies, there are doubts about this conclusion.

To Rusjan and Alic (2010), these internally motivated companies, strive to maintain an effective and efficient QMS, and not just to get the certification. Such companies are not only interested in the formal aspect of the standard and its requirements to be met in order to be certified, but also the recommendations of satisfaction for continuous improvement established by ISO. These recommendations become especially important for those organizations that are involved in showing the basic principles of quality management, which represent the proper and efficient basis of the implementation of a QMS, showing that companies have understood the spirit behind the requirements of the standard.

It should be emphasized that a quality management system can contribute to the efficient performance of a company, whether it is presented effective and connected to your business strategy, because can be used in a proactive way to contend with market changes and adverse economic situations (Lam et al. (2011); Andrada, Almeida and Antón (2011)). As a result, we have a competent QMS, enabling organizational improvements, rationalization and business improvement (particularly with regard to reducing the cost of poor quality), and most importantly, an increase in income of the company following the improvements in product quality. This system contributes to achieving the goals of the business and an improvement in the overall performance of the organization. According to Magd and Curry (2003), where ISO 9001 is implemented properly, it contributes to the achievement of different business goals.

Many researchers (Leung, Chan and Lee (1999); Karapetrovic and Willborn (2001); Magd and Curry (2003); Sampaio, Saraiva and Rodrigues (2010); Alolayyan et al. (2011)) mention several types of benefits achieved by implementing the ISO or TQM (Total Quality Management), which can be grouped into four groups such as: benefits related by the customer perspective, benefits related to the internal process perspective, benefits related to learning and development perspective, and benefits related to the achievement of economic goals and better financial performance.

Obstacles and difficulties

Despite the countless benefits a correct implementation of ISO 9001 can bring, some negative aspects are encountered during the process of adapting the company. For Pinto, Carvalho and Ho (2006), the greatest difficulties in implementation are: the complexity of the operations performed by the organization, the unavailability of internal staff to conduct trainings and meetings, the preparation of relevant documents for certification, the calculation of costs and gains with the program, and the availability of leaders for the implementation.

Moreover, although many companies have a quality management system with ISO 9001 and / or other certifications, many of them face in their day-to-day life difficulties in ensuring that the system is "running", that is really in proper functioning so that it can objectively bring the quality benefits expected for their products, processes and in relation to their customers and suppliers.

RESEARCH METHOD

The survey research or survey is a method of collecting information directly with people about their ideas, feelings, health, plans, beliefs and social, educational and financial background or about the unit, company or organization they operate. A survey can be performed by using a questionnaire where one completes the information with or without assistance. This questionnaire can be sent by mail or email. The survey can be further developed through personal interviews or telephone, as Fink and Kosecoff (1998) and Forza (2002). The survey provides information on large populations with a high level of accuracy, according to Forza (2002).

The questionnaire was prepared in accordance with factors, processes, variables and scales for the ratios, barriers, benefits and level of difficulty for the implementation of ISO 9001.

The survey of sugar and ethanol companies certified with ISO 9001 was carried out through their registry on the INMETRO website, consulted in August 2010, whose contact was established through electronic mail (e-mail) and telephone from August to December 2010.

Therefore, 49 certified companies from the sugar and ethanol industry in Brazil were identified. For a confidence level of 95%, the total number of companies required for consultation is 47. Thus 47 companies were invited to participate in the survey; however 20 contributed by answering the questionnaire. So the survey counted with the participation of a sample of 40.8% relative to the total identified, as shown in Table 1.

Table 1: Sampling of the *survey*

Total of certified companies	Companies surveyed	Level of confidence	Respondent companies	Participation rate
49	47	95%	20	40,8%

After data collection, statistical analyzes were performed on the number of employees and in relation to the time to get certified.

For both data (time to obtain and number of employees), it was performed residual analyzes, number of principal components, variance analysis, determination of factors and alpha cronbrach.

DISCUSSION OF THE RESULTS

The distribution of the participating companies by size is presented in Table 2. There is a predominance of companies with over 1,000 employees, followed by companies with 201-500 employees.

Table 2: Distribution of companies by size

Companies Size	Total	%
up to 20 employees	2	10
21-50 employees	1	5
51-100 employees	2	10
100-200 employees	0	0
200-500 employees	5	25
501-1000 employees	3	15
Over 1000 employees	7	35
Total	20	100

Table 3 shows the distribution by how long the companies have been certified for. There is a predominance of companies certified for more than 5 years, representing 80% of the companies surveyed.

Table 3: Distribution of companies by time of certification

Time of ISO 9001 certification	Total	%
certified under 1 year	0	0
1 to 2 years certified	0	0
2 to 3 years certified	3	15
3 to 5 years certified	1	5
over 5 years certified	16	80
Total	20	100

The first step in data analysis was to validate the questionnaire used, so that the information obtained by respondents corresponded to reality, even being their personal opinion. To evaluate if a questionnaire has reliable variables an internal validation can be used, which refers to how well the instrument measures what it is proposed to measure, and also using the external validation, which relates in order to infer a possible situation in the population, and if the results are generalizable, according Giuffre (1997 a, b).

To determine the reliability of the questionnaire, the degree of homogeneity of the set of responses by Cronbach's alpha was calculated, since it provides internal consistency values, enabling to evaluate the scale used, as Hair JR. et. al. (2005). The internal validity indicates the conditions of application of the instrument, in this case the questionnaire.

However there is no absolute standard of values for Nunnaly and Bernstein (1994) and Hair Jr et. al. (2005) the values of Cronbach's alpha equal to or above 0.70 reflect an acceptable reliability. However, Malhotra (2006) recommends as a decision criterion for "Cronbach's alpha to be considered acceptable, indices above 0.6, and the closer to 1, the greater the reliability." In this work we calculated Cronbach's alpha using the software Minitab 15 ® and the lowest value found was 0.9498, which can be considered acceptable.

The external validation of the questionnaire is ensured by the respondents' reliability. It is known that the respondents of the questionnaire are all supervisors or employees in the area of quality management in their companies.

According to the questionnaire data, 71.42% of the respondents are supervisors, while 21.58% are employees of Quality Management (Table 4).

Table: 4 Respondents Profile

Position	%
Supervisor	71,42
Employees of Quality Management	21,58
Total	100

Therefore, it can be seen that despite the survey responses be based on the opinion of the respondents, they are reliable, since the respondents had always been involved with the Quality Management System.

It was used the method of regression "Partial Least Squares" or PLS that applies when there are: multiple dependent variables, highly correlated predictors, more predictors than observations, according to Yacoub and MacGregor (2003), Helland (1998). The PLS method reduces the number of predictors to a set of principal components. Therefore, PLS is a method which seeks to form components that capture the maximum information of the variables X and that is useful for predicting Yi, while reducing the dimensionality of the problem of regression by using a smaller number of components than original variables.

In this work, there are 55 questions (X), identified as correlated, besides the existence of more predictors than observations (55 variables issues X against 4 Yi: reasons, benefits, obstacles and difficulty level).

The correlation analysis using the PLS, calculates through the software Minitab 15 ®, uses the algorithm NIPALS (Nonlinear Iterative Partial Least Squares).

The NIPALS is an extension of the PLS used for multivariate data analysis. As in PLS, the NIPALS is used in cases where all dependent variables are provided simultaneously, according to Sena and Poppi (2004).

It was performed a correlation analysis between the number of employees and the time to get certified, transforming the discrete data into continuous, finding a P-value 0.226, and to accept this correlation it is statistically required a P-value lower than or equal to 0.05, so there is no correlation.

Firstly we performed the PLS model and a residual analysis to verify their normality. In case of abnormality of the waste, you eliminate its generating element and recalculate the model. The process is repeated until normality of the residuals is obtained and only then the analysis of the PLS results is performed. Data normality was obtained in the analysis of residues.

One major issue that arises in the Principal Component Analysis is the criterion for choosing the number of components to retain. Kim and Mueller (1978) report that the most popular methods are: Kaiser, which proposes to consider only the eigenvalues greater than one, demonstrating that these values would be the statistically significant. But this condition is not sufficient. Not all eigenvalues greater than one correspond to components with apparent significance, and the Eigenvalues Diagram : consists of observing the diagram of eigenvalues and conserving the ones situated above the break point of the fall of the curve of the function that relates the order and the eigenvalues. Thus, if two factors are associated with almost equal eigenvalues, they represent the same proportion of variability and there is no reason, a priori, to keep one and not the other. However, a strong decrease between two successive eigenvalues follows in conserving the predecessor factors in the interpretation.

Analysis of correlation between number of employees and certification time for certification reasons. Analysis of variance was performed for the correlation between company size in terms of number of employees and the time of certification having as variable the reasons that led the companies to search certification. By the P-Value found (0.069 - number of employees, and 0.239 - time to get certified) and both being greater than 0.05 there is no statistical significance for the correlation number of employees and time to get certified with the reasons for certification. Thus, a number of key components that would be required to obtain a representative sample were selected.

The stability occurs with 7 major components which represents approximately 91.36% of the analysis of variance sample.

For the 7 components the P-value lower than 0.05 only occurs to number of employees (P-value = 0.028). Thus there is a correlation between number of employees and the reasons for certification and there is no correlation between the time to get certified and the reasons for certification (P-value = 0.074). The residual Analysis is shown in Figure 1 and the residues show normality.

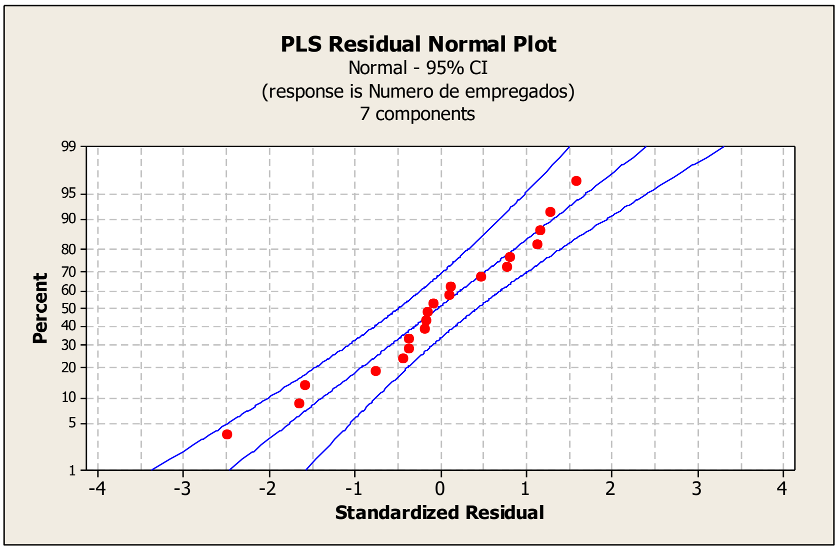

Figure 1: Normality analysis of residues by PLS.

Figure 2 identifies the variables of greater or lesser importance to achieve the result "Reasons for certification" correlating with the number of employees.

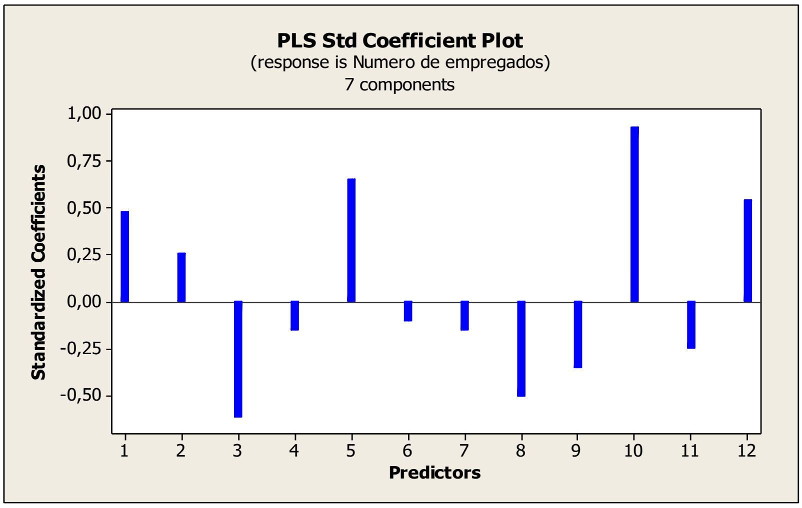

Figure 2: Identification of variables of greater and lesser importance for obtaining the result.

It is observed in Figure 2 that the variables most likely to contribute to the reasons for certification in companies with the largest number of employees are: variable 1, which assesses customers' requirements and expectations; variable 5, which assesses the potential of export market access; variable 10, which assesses the culture of the organization and discipline; variable 12, which assesses the fact of meeting the laws needed for marketing.

Still considering Figure 2, the variables most likely to contribute to the reasons for certification in companies with fewer employees are: variable 3, which assesses the company's competitive advantage; variable 8, which assesses the improvement of product quality; variable 9, which assesses the improvement in quality management.

Considering the variables, regardless of the number of employees, we have: variable 2, which assesses the competitive pressure of competitors; variable 4, which assesses the aid for export; variable 6, which assesses the approach of consultants; variable 7, which assesses the Government purchasing policy; variable 11, which assesses government funding.

In the review by Rusjan and Alic (2010), it was determined that companies seeking to implement a quality management system having internal reasons, get a better impact in increasing the companies competitiveness and administrative capacity. However, having external reasons, companies have less impact on business performance. However, it is possible to observe that for sugar and ethanol companies, both external and internal pressures are variables that contribute as reasons for certification.

Analysis of correlation between number of employees and certification time with obstacles. Analysis of variance was performed for the correlation between company size in terms of number of employees and certification time having as variable the obstacles that led the companies to search certification. By the P-Value found (0.074 - number of employees, and 0.384 - time to get certified) and both being greater than 0.05 there is no statistical significance for the correlation number of employees and time to get certified with the obstacles for certification. Thus, a number of key components that would be required to obtain a representative sample were selected.

The stability occurs with 8 major components which represents approximately 90.4% of the analysis of variance sample.

For the eight major components the P-value lower than 0.05 only occurs to number of employees (P-value = 0.022), so there is correlation between number of employees and the obstacles to certification. And there is no correlation between the time to get certified and the reasons for certification (P-Value = 0.169). The residual analysis is presented in Figure 3 and shows the normality of the residuals.

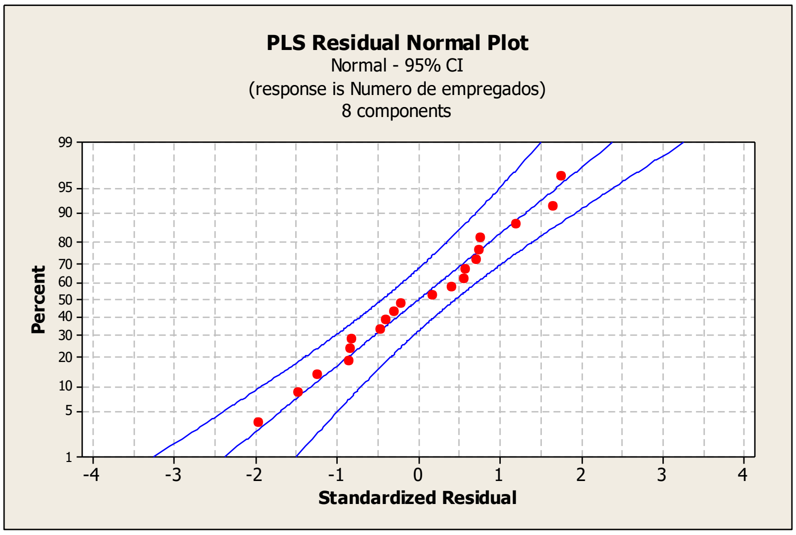

Figure 3: Normality analysis of residues by PLS.

Due to the normality of the data, the variables of greater or lesser importance to achieve the result "Obstacles to certification" can be identified, correlating with the number of employees (Figure 4).

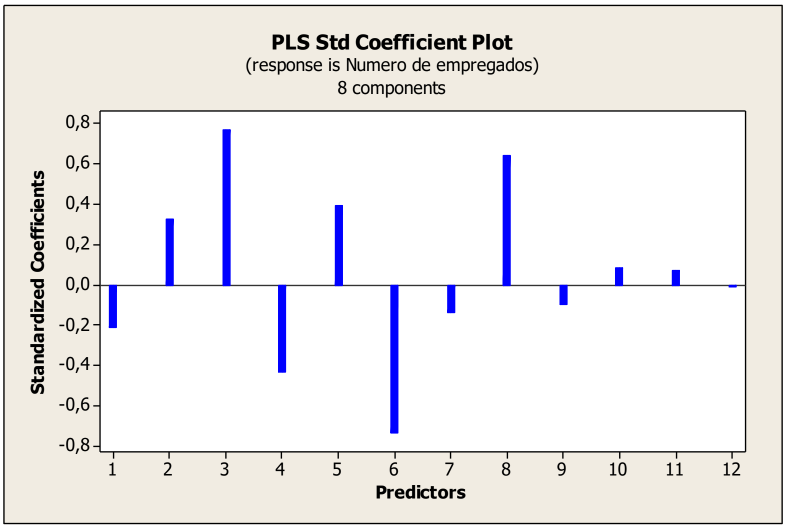

Figure 4: Identification of variables of greater and lesser importance for obtaining the result.

It is observed in Figure 4, for companies with fewer employees, the variables that most influence as obstacles are: variable 1, lack of commitment of the board of directors (Talib, Rahman and Qureshi (2011)); variable 4, high cost of preparation; variable 6, development of documentation and records. However, for companies with more employees, the variables that most influence are: variable 2, restriction of resources; variable 3, instrument calibration; variable 5, employees' resistance; variable 8, implementing the procedures defined. And as variables, regardless the number of employees, we have: variable 7, documenting the approval of processes; variable 9, misinterpretation of the standard; variable 10, training required; variable 11, not understanding the benefits of certification; variable 12, underestimating the efforts needed to develop the culture of registering.

In Saizarbitoria, Casadesús, Marimón (2011), it was identified as the main obstacles for companies: the difficulty posed by the bureaucratic demands, Motivation and involvement of the managers, Lack of adequately trained human resources and Resistance to change.

Analysis of correlation between number of employees and certification time with benefits. Analysis of variance was performed for the correlation between company size in terms of number of employees and certification time having as variable the benefits that led the companies to search certification. By P-Value found (0.044 - number of employees, and 0.239 - time to get certified) being that only the time for certification is greater than 0.05, indicating that there is no statistical significance for the correlation between time to achieve certification with obstacles to certification. Thus, a number of key components that would be required to obtain a representative sample were selected.

The stability occurs with 8 major components which represents approximately 97.48% of the analysis of variance sample.

For the eight major components the P-value lower than 0.05 only occurs to number of employees (P-value = 0.041), so there is correlation between number of employees and the benefits for certification. And there is no correlation between the time to get certified and the benefits for certification (P-Value = 0.169). The residual analysis is presented in Figure 5 and shows the normality of the residuals.

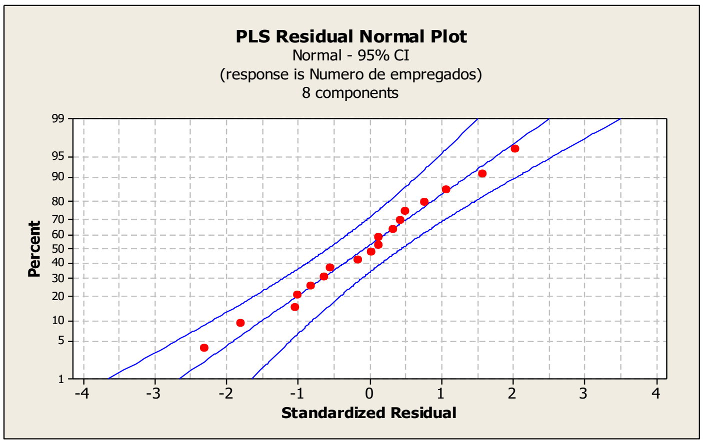

Figure 5: Normality analysis of residues by PLS.

Due to the normality of the data, the variables of greater or lesser importance to achieve the result "Benefits for certification" can be identified, correlating with the number of employees (Figure 6).

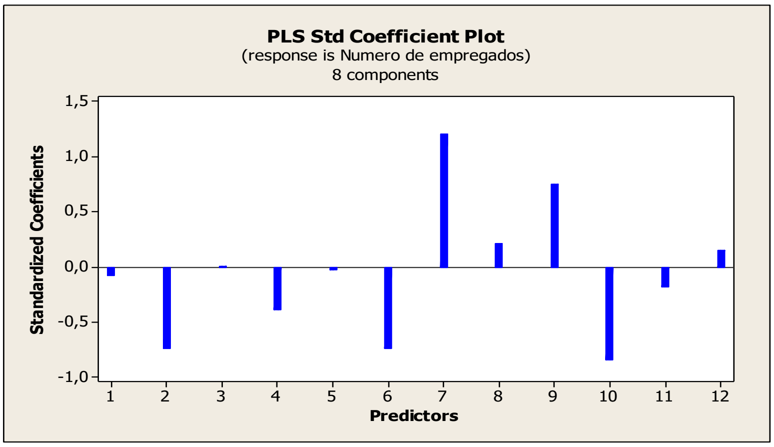

Figure 6: Identification of variables of greater and lesser importance for obtaining the result.

It is observed in figure 6, for companies with fewer employees, the variables that most influence as benefits are: variable 2, customer satisfaction; variable 4, advertising / marketing; variable 6, better standardization through documentation and record; variable 10, consistency between the organizations with regard to quality. However, for companies with more employees, the variables that most influence as benefits are: variable 7, improved customer service; variable 9, disciplined and organized work environment. And as neutral variables, i.e. regardless the number of employees, we have: variable 1, staying in business; variable 3, better market share; variable 5, improved customer confidence.

In Rusjan and Alic (2010), it was identified as the main benefits for companies to increase efficiency and business performance, divided into groups as: consumer benefits; benefits in the process; benefits in development; financial benefits. In this research on sugar and ethanol companies, all these groups of benefits were identified, and in companies with larger number of employees all four groups were important, however in companies with fewer employees the most significant groups were in relation to the benefits to consumers and the benefits in development.

Analysis of correlation between number of employees and certification time with level of difficulty. Analysis of variance was performed for the correlation between company size in terms of number of employees and certification time having as variable the benefits that led the companies to search certification. By the P-Values found (0.119 - number of employees, and 0.288 - time to get certified) being that both P-Values are greater than 0.05, indicating that there is no statistical significance for the correlation between time to achieve certification and the number of employees with the obstacles for certification. Thus, a number of key components that would be required to obtain a representative sample were selected.

The stability occurs with eight major components, which represents approximately 97.48% of the analysis of variance sample.

For the nine major components the P-value below 0.05 does not occur for both number of employees (P-value = 0.094) and for time to obtain certification (P-value = 0.203), thus there is no correlation between numbers of employees and the time to get certified with the degree of difficulty.

CONCLUSION

One can infer from the data that sugar and ethanol companies certified by ISO 9001 tend to have as more significant variables, related to the number of employees of the company, the reasons adopted for certification, the benefits of certification and the difficulties encountered. However, when considering the time to obtain certification, there was no correlation with the variables. This demonstrates that the challenges faced by companies is the same regardless of size and purpose, however it reveals that the certification promotes a great evolution in the company, making it more organized and prepared to meet the expectations of its customers.

The increased need to seek better quality in their products, the intensification of customers' demands, the organizational improvement and the increasingly frequent unification of global markets has led many companies from different sectors to seek a quality management system (QMS), in order to equate to its competitors in the market, thus gaining more space and competitiveness. However, in the sugar and ethanol companies surveyed, the factors of greater motivation to seek ISO 9001 certification are related to better interaction with the customers having in mind their expectations, the search for larger markets mainly of export, legal requirements, demonstrating that companies are interested in a constant evolution.

The release of the first review of ISO 9001 in 1987, about twenty-four years ago, demonstrates that this globally accepted system is relatively new and is constantly reviewed and improved, yet its implementation is relatively expensive and requires a great effort of companies which has become a major obstacle for them, event observed in this study.

With the constant evolution of the ISO 9001 system and the greater intensification in the search for quality management systems by companies, along with the increase of professionals involved in the area, the emergence of new variables either for reasons, obstacles or benefits becomes a possible reality. This possible reality can require a new understanding of ISO 9001 and its implementation, fact that would be interesting to be investigated in future studies.

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Identifying and solving some conceptual issues associated with the adoption of a generic service quality scale: the E-S-QUAL case

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ABSTRACT

Purpose. Service quality has come to be recognized as a strategic tool for attaining operational efficiency and is a critical determinant of business performance. However, the conceptualization and measurement of perceived service quality has proved to be a difficult concept to grasp. It has been referred to as "elusive", "unresolved" and "far from conclusive". Therefore, this paper aims to identify and discuss some key conceptual and empirical issues related to the adoption of a generic scale, such as E-S-QUAL.

Design/Methodology/Approach. A collection of 21 papers that have previously used the scale were retrieved from the leading well-known databases. A Delphi method was used and two rounds of the web survey data collection were adopted. Out of the 61 potential respondents 17 experts agreed to take part in the panel group.

Findings. The overall results showed that all the experts agreed on 42 points related to the conceptualization and empirical issues. Including for example the number of the dimensions instability are not only due to the service industry analyzed or the web user cultural profile but also to other factors such analysis methodology used across studies. There was consensus that the "Fulfillment" dimension is one of the prominent dimensions only referring to the websites that sell and deliver physical goods etc.

Originality/value. This study results increase the knowledge and the confidence that researchers and practitioners have when they use a generic scale.

Keywords: Online Service Quality, Scale Assessment, Generic Scale, E-S-QUAL, Delphi Survey

Article classification: literature review

THEORETICAL BACKGROUND, MANAGERIAL PROBLEM AND RESEARCH QUESTIONS

In the last three decades, both the conceptualization and measurement of perceived service quality have been difficult to comprehend. It has been referred to as "elusive", "unresolved" as well as "far from conclusive" (Parasuraman et al., 1988; Brady and Cronin, 2001). Yet, the existing literature points toward the considerable effort and progress that has been made in the definition of perceived service quality. According to Garvin, (1984), individual consumers have different wants or needs and as a result possess different perceptions of service quality. Thus, the user-based approach definitions start from the premise that quality "lies in the eyes of the beholder" (Garvin 1984).

It is also widely accepted that service quality depends on the outcome of an evaluation process. In that sense, Parasuraman et al. (1988) defined service quality as the difference between customer expectations of what a customer feels a company should offer, and the actual perceived service performance. According to Brady and Cronin, (2001), in the traditional services there has been considerable progress as to how service quality perceptions should be measured, but a little advance as to what should be measured. This finding is very alarming given that quality has come to be recognized as a strategic tool for attaining operational efficiency and is a critical determinant of business performance, as well as firms' long-term viability (Jain and Gupta, 2004). Moreover, quality leads to customer satisfaction, which in turn has a positive impact on customer word-of-mouth, attitudinal loyalty, and purchase intentions (Marimon et al., 2010; Yaya et al., 2011 and 2013).

Furthermore, despite the unconcluded debate on the definition of service quality, a number of efforts have been made to conceptualize scales to evaluate service quality. For example, in the traditional services, researchers and practicing managers have widely applied and valued the SERVQUAL instrument. However, numerous studies have reported growing difficulties with the use of SERVQUAL. According to Ladhari (2009), these difficulties have been related to the use of so-called difference scores (between expectations and perceptions), the ambiguity of the definition of consumer expectations, the instability of the scale over time and the unsettled dimensionality of the instrument. Accordingly, questions have been raised regarding the use of SERVQUAL as a generic measure of service quality and whether the alternative industry-specific measures of service quality should be developed for specific service settings (Dagger et al., 2007; Ladhari, 2010). Furthermore, in an increasingly competitive and changing world of online services, the management of the online services has also emerged as a strategic imperative for most companies. Therefore, it is of paramount importance that online service providers know how to improve the quality of their offer.

The extant literature indicates that there is significant confusion about how to assess e-service quality and its attributes. According to Ladhari, (2010), the number and nature of the causes influencing consumer perceptions of e-service quality in the plethora of existing studies appeared to be unclear and undefined, mainly because many of those prior service quality measures do not to take into account the entire service process. All the phases of the service should be considered, from the pre-purchase to the after-purchase. Even so, the most rigorous study reviewed (Parasuraman et al., 2005) proposes a new scale to assess the quality of the online services. The instrument is called E-S-QUAL. It appears to capture the general domain of e-service quality fairly well. In the same way as SERVQUAL, E-S-QUAL has also received considerable attention from practitioners and researchers, possibly, because the scale shows good psychometric properties to evaluate an e-service quality (Yaya et al., 2012).

Nevertheless, there is a prominent debate among practitioners and academics about the usefulness of E-S-QUAL as a generic measure to evaluate any e-service (Yaya et al., 2012). This study undertook a comprehensive review of the existing studies that had used E-S-QUAL from its publication in 2005 till 2011. It revealed that E-S-QUAL has been replicated successfully in 11 countries and a variety of service settings. Moreover, the authors also highlighted that the majority of the studies accredited the E-S-QUAL scale to be effective in capturing the core e-service quality. However, they revealed that the dimensional structure of the E-S-QUAL appears to be unstable, even within the same sector. Furthermore, the authors also observed that there were some disparities among the studies in terms of the methodology used, sample characteristics, data analysis procedures, and nomological validity, etc. The following questions were also raised about the instability of the scale dimensionality:

1. Is the instability due to non-measurable causes, sampling errors, etc.?
2. Is it due to the disparity of methodology used, the data analysis procedures used, etc.?
3. Is it because the scale is not generic but rather specific to e-services that only sell specific goods, such as for example physical goods?

Therefore, the main aim of this study is to attempt to answer some of these key questions. To accomplish this, we first identified from the previous studies some key conceptual and empirical issues in the adoption of the E-S-QUAL. Thereafter, we developed an agenda (based on the experts' opinion) of what to consider while adapting the generic instrument in the future. Furthermore, in light of rapid technology development, we also discussed whether the scale is still reliable or whether part of its components require updating.

METHODOLOGY

This study is a follow-up to research previously initiated by Yaya et al. (2012). The present investigation only focused on assessing the E-S-QUAL scale and, more specifically, to identify and characterize suspected factors that may cause its instability. In contrast to other data gathering and analysis techniques, the Delphi method was used. Evidently, the Delphi method is based on structural surveys and makes use of the intuitive information of the participants, who are mainly experts. Prior to identifying potential respondents, we exhaustively searched for papers that used E-S-QUAL in their study. The keywords searched were E-S-QUAL, website or web site or online or electronic service quality evaluation or assessment or measurement, etc. Acknowledging that the direct search may lead to some limited results, we also searched the references of the retrieved articles (Yaya et al., 2012). No conference papers were included, and only those papers published in leading well-known databases and search engines such as ScienceDirect, Emerald Insight, EBSCOhost, ABI/INFORM and Google Scholar were retained. This process yielded a total of 21 published articles since the appearance of the E-S-QUAL from 2005 to 2011 and 61 potential respondents (authors and co-authors) were identified.

The study survey was driven by a monitor group and comprises several rounds of a group of experts who were anonymous to each other and for whose subjective-intuitive prognoses a consensus was aimed at. After each survey round, a standard feedback about the statistical group judgment calculated from percentage, median and quartiles of single prognoses was given and where possible, the arguments and counterarguments of the extreme answers were fed back.

RESULTS

Data collection methodology and survey administration. In their review, Yaya et al. (2012) note that some analyzed papers that used E-S-QUAL collected data through an online survey, some of used an off-line survey and others a combination of both. In addition, various sampling method and a limited sample size were were used as well as alternative Likert-scale and different ways of phrasing the scale items. Independent of what method was used by the respondent, experts were asked to choose or advise on the most appropriate method of data collection. On the first round, no consensus was reached. One argued, “All can work, but each has pros and cons”; another thinks, “the best way is a combination of web-based surveys and interview.” All these comments were taken into consideration in the next round. At the end of the process, 77% remaining experts in the second round concluded that the best way to launch an e-service survey is using a web- or e-mail-based survey. However, the same proportion concluded that it was not advisable to complement the web- or e-mail-based survey with an off-line survey.

Moreover, 88% of respondents concluded that random sampling was the most appropriate sampling method, followed successively by convenient sampling, quota snowball sampling and experts’ collection of some specific websites. All experts agreed that the sample size must be established following the Hair et al. (1998) criterion that suggests a minimum of five observations per scale item. Alternatively, 57% of experts in the second round think that the sample size has to be larger than 200, independent of the number of items in the scale (Kelloway, 1998). Furthermore, the majority of the experts (92%) rejected anything that goes beyond the Likert-scale type. Still, no agreement was reached on if 5 or 7 points Likert-scale type was appropriate. This outcome was not surprising because it was consistent with Dawes (2008) who found that the five- and seven-point scales produced exactly the same mean score, once they were re-scaled.

Preliminary dimensionality. The review of the studies showed the majority of the studies primarily considered the four dimensions of E-S-QUAL. However, some of the studies advocated that E-S-QUAL as a whole does not capture extensive service attributes available in some retail web sites. Thus, they complemented the scale with some other dimensions or excluded some of the dimensions. The majority of the experts (81%) concluded that regardless of the type of website, and depending on the purpose of the survey and context, the scale may be complemented with additional items. Nonetheless, additional items must come from (in decreasing order): in-depth interview with web users, literature reviews, in-depth interview with researchers and finally an in-depth interview with managers. Although no consensus was reached, 58% of respondents agreed that a lower limit of at least 3 and a maximum of 8 items per dimension must be set.

Data analysis procedure for assessing factor structure. Despite the fact that researchers’ a priori assumption is that any indicator may be associated with any other factor, it was surprising to see that some of the previous studies did not perform EFA. The Delphi results indicated that most of the experts in the first round (53%) consented that the EFA must always be performed, regardless of whether any additional items were added or rejected. Moreover, given that factor loadings provided by the preliminary EFA are used to intuit the factor structure of the data, nearly all the experts (71%) also claimed that the acceptable factor loading must be set to a minimum acceptable threshold of 0.5 (Fornell and Larcker, 1981). In addition, all the experts found it very advisable that items to be retained in the purification of the scale must adhere to Wolfinbarger and Gilly, (2003) rigorous and strict criteria which are (i) item is retained when its load is 0.50 or greater and (ii) does not load greater than 0.50 on two factors. Some of the studies neglected to run an EFA, claiming that E-S-QUAL is a well-established scale. Consequently, they only performed a CFA to confirm that the indicator variables load as predicted on the expected factor. Nearly all the experts (84%) also agreed that the acceptable CFA factor loading must be greater than 0.7 (Carmines & Zeller, 1979).

Scale convergent validity. Our initial attempt to compare convergent validity methods used was difficult due to a wide variety of labels used. Therefore, regardless of the method used in their study, experts were asked to order according to their importance the most appropriate method of convergent validity. The results showed all the experts agreed that Fornell and Larker (1981)[h] must first be considered, followed by Hair et al. (1998)[i] and finally Gerbing and Anderson (1988)[j]. In addition, virtually all the experts (10 out of the 14 respondents) also assented that it was not necessary to use more than one of these methods because some of these criteria overlap. Moreover, they also assent that convergent validity must be compulsorily reported.

Scales Discriminant validity. Like the convergent validity, the studies reviewed also indicated that there were varieties of labels used and some studies did not report discriminant validity. The Delphi results showed that the majority of experts (80%) agreed that discriminant validity must always be reported. Moreover, they also agreed on the most appropriate method of discriminant validity according to their importance (in decreasing order) as follows: Fornell and Larker (1981) and Hair et al. (1998)[k]; Gerbing and Anderson (1988)[l]; Smith and Barclay, (1997)[m] and finally Loiacono et al. (2002)[n]. Nevertheless, there was no agreement on whether more than one of these methods can be used.

Reflective versus formative consideration of the E-S-QUAL dimensions. There is a high consensus among the experts that the dimensions of E-S-QUAL must be considered as reflective first order factor constructs and consequently all the items must load on their respective dimensions. Accordingly, the test of reliability must be performed on each dimension. It was not asked how to assess the reliability or internal consistency of the dimensions of the scale due to the previous consensus showed in their respective studies: a threshold of 0.70 for composite reliability (CR) (Anderson and Gerbing, 1988; Bagozzi and Yi, 1988) or Cronbach's αgreater than 0.70 (Fornell and Larcker, 1981; Nunnally and Bernstein, 1994).

The scale dimensionality. The generic E-S-QUAL scale that was proposed to assess the quality of any online service quality (Parasuraman et al., 2005) was originally composed of four dimensions. The studies reviewed exposed that the vast majority of studies has reported a number of dimensions different than 4. Additionally, the use of E-S-QUAL in several sectors raises questions about the number of dimensions and their stability from one context to another. Given that the dimensional structure of E-S-QUAL is unstable across countries and even within a given sector, experts were asked to opine on the reasons for the instability in the scale dimensionality. In the first round, a number of plausible reasons were proposed. In the subsequent round, experts were asked to discuss and rank those plausible reasons to explain the instability of the number of dimensions. The overall results showed that the experts agree that the service industry analyzed was at the top of the list, followed by

h (a) Loads exceeding 0.5 and significant and (b) AVE greater than 0.5.

i (a) High loads and significant and (b) high coefficient alpha values.

j Each indicator's estimated coefficient is significant; greater than twice its standard error.

k Inter-factor correlations are less than the square root of the AVE.

l Constraining each correlations to unity (leaving all other parameters to be free) and repeat the CFA.

m Confidence interval around the correlation between any two latent constructs does not include 1.

n The fit of two factors is better than the fit of one factor.

the cultural profile of the web users, thereafter variations in the analysis methods used across studies, then appropriateness of the analysis methods used and lastly, rapid technology development.

In addition, it was also observed that the dimension of Fulfillment, which is related to the extent to which the site's promises about order delivery and product availability are fulfilled, was ostensibly problematic. Since this time, 52 % of the published papers preliminarily disallowed from one item to the whole dimension. Therefore, experts were asked to give their thoughts about why Fulfillment was a problematic dimension. The Delphi results showed no consensus because only 50% of the experts that answered this question did not think that there is a problem on this dimension and 33 % were indecisive. On the other hand, 585 of experts agreed that Fulfillment dimension is one of the prominent dimensions of the E-SQUAL referring to the web sites that only sell physical goods.

Given that the technology related to computer, telecommunications and web sites has experienced a great development (e.g., the current generation of computers was at least three times faster than those of 8 years ago). Consequently, experts were asked to express their thoughts on the usefulness of the Efficiency dimension. It was unanimously agreed that the Efficiency dimension must not be erased. However, the majority of experts (83%) agreed that the dimension must be reviewed and improved. In contrast, no consensus was reached on if the items of Efficiency, such as EFF5 "the site loads its pages fast," or EFF 7 "This site enables me to get on to it quickly," should now migrate to the dimension of System Availability.

Fitness of the structural model. The review showed some of the indices that provide information to evaluate the fitness of data to the model such as the χ^2, χ^2/degrees of freedom, GFI and AGFI, CFI, TLI, RMR, RMSEA, etc. However, some of the reported fit indices appear to be problematic or never to have achieved adequate fit. The Delphi results indicated that nearly all the experts (at least 75% in each case) consent that the acceptable p-value of χ^2 under normal distributions must be ≥ 0.05; the Comparative Fit Index (CFI) cutoff value must be ≥ 0.90; the Goodness-of-Fit Index (GFI) cutoff value must be ≥ 0.90 and the Normed Fit Index (NFI) cutoff value must be ≥ 0.90. In addition, they also agreed that Non-normalized Fit Index (NNFI) cutoff value must be ≥ 0.90 and the Adjusted Goodness-of-Fit Index (AGFI) cutoff value must be ≥ 0.80. Finally, it was also agreed that the Bentley-Bonnet Non-normed Fit Index (BB-NFI) cutoff value must be ≥ 0.90 and that the Root Mean Square Error of Approximation (RMSEA) cutoff value must be ≤ 0.05.

However, no consensus was reached on whether the acceptable p-value of Satorra-Bentler scaled $\chi 2$ under arbitrary distributions should be ≥ 0.05; nor was it determined whether the $\chi 2$/degrees of freedom interval should be $2 \leq \chi 2/df \leq 5$, nor if Tucker-Lewis Index or Tucker Fit Index (TLI or TFI) cutoff value should be ≥ 0.90. The main reason behind the non-agreement was because between 16 to 41% of respondents said they did not know and/or have never used those indicators before. Notably, two of the respondents argued that the RMSEA threshold must be set to 0.8 instead of 0.5.

Historically, the most popular index used to assess the overall goodness of fit has been the $\chi 2$ statistic, although it is known to be biased when the sample size is large. Moreover, it offers a dichotomous decision strategy (accept /reject) for assessing the adequacy of fit. Most of the panel experts (83%) agreed that the only p-value of $\chi 2$ (under normal distributions) or the p-value of Satorra-Bentler scaled $\chi 2$ (under arbitrary distributions) is sufficient to analyze the CFA model fitness. However, 87% of the experts strongly advise using several indexes altogether to interpret fitness, principally, because the poorer power of one index can be compensated by the overall results of fit indices. Moreover, given that some of the indices are absolute fit measures, some are incremental and others are parsimonious fit measures, experts were asked to rank, according to their importance, the 3 most important fit indices. The p-value of $\chi2$ under normal distributions (or of Satorra-Bentler scaled $\chi2$ under arbitrary distributions) leaded the ranking, followed by the RMSEA and finally $\chi2/df$.

Overall Satisfaction with the scale. Experts were finally asked to evaluate their level of satisfaction and confidence with the scale. The overall results indicated that 83% of experts were satisfied with the scale as a whole. The same proportion still trusts that even with rapid technology development, the instrument is appropriate to assess e-service quality. They also agreed that the adoption of the scale in their study was easy. Likewise, 91% of experts assent that it was pleasant to use the E-S-QUAL scale in their study. In addition, 74% of experts consent that all the respondents of their study clearly understood all the items of the scale. The same percentage said that taking into account the overall value they got, the effort of using the scale was worth it. Additionally, 81% of experts confirmed they would always say positive things about the scale to other people. The same amount said they would recommend the scale to someone who seeks their advice. Nevertheless, a consensus was not reached on two points. Only 63% said they were happy with the scale performance. The same percentage said the scale would be their first choice in the future.

CONCLUSION

Quality has been recognized as an important component of the business strategy, a strong catalyst for attaining operational efficacy and as a tool to boost business performance. However, in general, the problem with management of online service quality in service firms is that quality is not easily identifiable and measurable because service quality has been defined in various ways. Drawing on those different definitions, a number of generic scales to assess service quality have been proposed. Moreover, some researchers have attempted to identify key attributes that best fit the online business environment. However, many of the proposed scales to evaluate websites do not provide a comprehensive evaluation of the service quality of the website.

There is a scale that really has succeeded both in the academic field and among practitioners: the E-S-QUAL scale developed by Parasuraman et al. (2005). It integrates four different dimensions, each one in turn composed of some items in Likert scale. It has been widely disseminated across many different countries and industry sectors (Yaya et al., 2012). Nevertheless, one of the criticisms of the scale is its applicability to different specific industries. Consequently, this provides the impetus to scrutinize from the point of view of experts whether the scale really is generically applicable across a broad spectrum of services and if the scale instability was due to chance or caused by some known/unknown factors.

The study shows some issues related to the conceptualization and empirical issues of the scale. The overall results indicated that the entire panel group of experts consents that the E-S-QUAL is a generic, valid and applicable scale across industries. In addition it has been found that the adoption of the scale in the previous studies was easy and that the respondents to the adapted scale clearly understood all the items. It was unanimously agreed that the scale instability is not due to chance. Moreover, it was concluded that the causes of instability in a number of dimensions were not only due to factors such as the service industry analyzed and the web user cultural profile; other factors, such as variations in the analysis methods used across studies and the appropriateness of the analysis methods used are also sources of variability.

Furthermore, it was consented that regardless of the case, both EFA and CFA must always be performed. In addition, a lower limit of at least 3 items and a maximum of 8 per dimension must be set. Moreover, it was concluded that it was always necessary to perform and report the convergent and discriminant validity of the scale. The experts also concluded that Fulfillment dimension is one of the prominent dimensions only referring to the websites selling physical goods. In addition, because of the rapid development of the telecommunication technology, it was agreed that Efficiency dimension must be improved and updated. Nevertheless, no consensus was reached on whether items such as EFF 5 “the site loads its pages faster” or EFF 7 “This site enables me to get on to it quickly” must now be moved to System Availability as a consequence of the rapid development of the telecommunication technology. Overall, the findings of this study provide managers with valuable insights into how to assess customers’ perception of online service quality based on the E-S-QUAL scale. Furthermore, consensual conclusions with respect to the E-S-QUAL scale may also be relevant to the SERVQUAL and any other generic scale.

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How does Human Resource Management influence the implementation of Integrated Management Systems?

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ABSTRACT

Purpose. The importance of human resources has often been emphasized in the area which has become known as Integration of Management Systems. Despite such consideration, little has been espoused regarding the mechanisms by which human resources and Integrated Management Systems (IMS) are related. The aim of this study is to investigate how and why human resource management has affected the implementation of an IMS within an organization.

Design/methodology/approach. Applying a case study approach, we ask for the observations of the employee's experience about human resource practices in the case study organization that have significance for the implementation of the IMS in the firm.

Findings. The results of the study report the respondents' stories about the experiences they have had during the IMS implementation process regarding several human resource practices. We then analyze the employee's responses to understand how the proposed theoretical dimensions related to human resources have impacted the integration of Management Systems (MSs) and find that there are several very related issues regarding the human resources participating in the integration process that will affect the success or failure of the implementation of an Integrated Management System.

Originality/value. This paper provides an original focus on the theoretical and empirical issues regarding the relationship of IMSs and Human Resource Management (HRM), an under researched topic which is vital for the survival of such systems, with the hope of stimulating more systematic research efforts.

Keywords: Integrated Management Systems, Human Resource Practices, Employees, Organizational Culture

Article Classification: Research paper

INTRODUCTION

During the last three decades, quality, environmental and other Management System Standards (MSSs) have proliferated worldwide (see ISO, 2013). For instance, the number of certificates delivered at the end of 2012 for the two most implemented standards worldwide of the International Organization for Standardization (ISO), that is, the ISO 9001 and ISO 14001 standards, reached more than one million and 285,000 certificates respectively (ISO, 2013).

The proliferation of MSSs, such as the ones for occupational health and safety (e.g., OHSAS 18001 and CSA Z1000); for corporate social responsibility and accountability such as SA 8000 or ISO 26000 (Castka and Balzarova, 2008); for security of information systems (ISO 27001); for supply chains (ISO 28000) or for energy management (ISO 50001); gives the option that firms integrate the corresponding MSs into a single system in order to benefit from the existing synergies among them (Labodova, 2004; Zutshi and Sohal, 2005). Therefore, firms are increasingly integrating their MSSs (Karapetrovic and Willborn, 1998; Douglas and Glen, 2000; Karapetrovic et al., 2006; Zeng et al., 2007; Bernardo et al., 2009).

Many benefits and efficiencies are related to the integration of management systems and many of them are related to HRM (Zutshi and Sohal, 2005; Asif et al., 2010; Tarí and Molina-Azorín, 2010; Simon et al., 2011; Zeng et al., 2011). Nevertheless, organizations also come across some challenges in the process of integration which affect how people in the organization react to the integration process (Karapetrovic and Willborn, 1998; Karapetrovic and Jonker, 2003).

Related to this benefits and difficulties of IMSs in relation to HRs, numerous authors have emphasized the importance of top management commitment to the effective implementation of management tools such as TQM or IMS (Deming, 1986; Juran, 1989, Lopez-Fresno, 2010). For their part, authors such as Detert et al. (2000) or Jorgensen (2008) have studied the impact of organizational culture on the successful implementation of new management practices, such as the implementation of an IMS. The role of the quality department and the motivation of its employees has also been considered as a cornerstone that facilitates the implementation of IMSs (Pojasek, 2006; Zeng et al., 2007; Tarí and Molina-Azorín, 2010). Finally, issues like internal communication and collaboration among the different departments involved in the implementation of new processes, have also been studied in the literature (Smidts et al., 2001; Santos et al., 2011).

Thus, in this paper we aim to explore whether, how and why human resource management practices influence the implementation of an integrated management system. The paper follows with a literature review of the topic of HRM and IMS, a methodology section, the results found and the conclusions.

LITERATURE REVIEW

A resource-based view to HR management and IMS. Many studies have focused on the relationship between HRM and firm performance claiming that human resource practices are strategically important to creating and sustaining competitive advantage and promoting firm’s success (Dess and Lumpkin, 2003; Hargis and Bradley, 2011). According to the resource-based view of the firm (RBV) (Wernerfelt 1984; Prahalad and Hamel, 1990; Barney 1991) there are some resources, including human resources, that are valuable, rare, imperfectly imitable, and not substitutable by other resources. These resources can be a source of sustained competitive advantage and improve the long-term competitiveness of the firm (Urbano and Yordanova, 2008).

The reason for the strategic importance of human resources in front of physical resources is that the latter are easier to imitate or substitute than human resources. Therefore, it is especially important that firms develop specific HRM strategies regarding human capital needs, the accurate selection of employees, as well as their training and development as these practices are expected to be positively associated with superior performance (Narasimha, 2000; De Kok et al., 2002; Allen et al., 2013). Also, this strategy should be directed to making sure that HRM practices are consistent and support each other. Obtaining this "internal fit" is often associated with a "best-practice approach to HRM practices" (Huselid, 1995), which suggests that certain HRM practices, either separately or in combination, are associated with improved organizational performance (MacDuffie, 1995).

The RBV can also provide understanding on the strategic relevance of HRM regarding IMS. This theory suggests that because resources are heterogeneous across firms, they will result into different outcomes regarding their competitive advantage and performance. In this respect, the integration of QMS, EMS and other MSs, can be understood as the building of a set of *"unique and hard-to-imitate capabilities"* (Tarí and Molina-Azorín, 2010). Therefore, the benefits of implementing an IMS in order to improve the competitiveness of a firm can be collected when a firm is capable of coordinating a number of heterogeneous resources, including human resources, which are not easy to develop and imitate. In fact, the competitive advantage they can generate does not result from using certain specific technologies and tangible resources, but rather from the existence of certain tacit, intangible characteristics that are requirements for the implementation of an IMS (Tarí and Molina-Azorín, 2010). Amid these strategic resources, the most significant are *"top management commitment, a management style that encourages employee participation and training, team work, the motivation for ongoing improvement, relationships of trust between managers and workers, a culture based on quality and respect for the environment that can pervade and guide the whole organization, and good relationships between the enterprise and its customers and suppliers"* (Tarí and Molina-Azorín, 2010). It is hard to understand how these elements are developed, and how they can have an impact on competitive advantage. Thus, both QM, EM and other management systems, as well as their integrated implementation, can become specific capabilities of the firm that rivals will find it very difficult to copy (Kaynak and Hartley, 2005; Prajogo and Sohal, 2006; Darnall and Edwards, 2006).

The impact of HR practices on the integration of MSs. Related to the integration of MSs and its relationship with human resources, the literature has focused on topics such as the level of integration of human resources, namely whether or not the responsibility for managing one MS falls to the same person that manages other MSs (Bernardo et al., 2009; Simon et al., 2011) finding that, in general, at higher responsibility levels, that is, top management and functional level, the level of integration is higher than at the shop floor level.

Another major topic is the difficulties and benefits of implementing an IMs regarding the HRs involved. In this sense, many authors have studied the main benefits for the people involved in the organization of implementing an IMS:

1. Improved people motivation: a successful implementation of an IMS must guarantee that all the employees have a comprehensive view of the process and a feeling that they all belong to the project and will develop a better employees' response to change (Jorgensen, 2008; Lopez-Fresno, 2010).
2. Enhanced communication: implementing an IMS makes employees become more aware of the existing relationships between the different standards and processes and that allows increasing the exchange of knowledge across the different areas involved in each MSs. In addition, it creates the option of joint training and enhanced communication among all organizational levels by removing the limits existing between the MSs (Griffith and Bhutto,

2008; Jorgensen, 2008; Lopez-Fresno, 2010; Tarí and Molina-Azorín, 2010; Santos et al., 2011).

3. Top management commitment: top management provides the appropriate leadership when it shows its commitment to the implementation of the IMS by providing a clear path to all employees and supporting the IMS with the suitable resources. This also helps to create a team culture, larger acceptance by people, higher staff motivation and reduction of internal inter-functional conflicts (Zutshi and Sohal, 2005; Lopez-Fresno, 2010; Tarí and Molina-Azorín, 2010; Santos et al., 2011).
4. Achievement of cultural change: appropriate leadership and team culture contributes to continuous improvement of the IMS and facilitates cultural change (Zutshi and Sohal, 2005; Jorgensen, 2008; Tarí and Molina-Azorín, 2010).

Regarding the barriers of an IMS with respect to the human resources, a variety of factors, as the ones related to the benefits, can limit or hinder the integration process and its outcome (Karapetrovic et al., 2006; Simon et al., 2011; 2012a; Bernardo et al., 2012). The main difficulties found in the literature are:

1. Inter-cultural conflicts: a consequence of merging the different MSs can be a high complexity associated to training and changes in the organizational methods and culture given that interests and motivations of the employees involved diverge between the different systems (Karapetrovic and Willborn, 1998). Unfavourable attitudes towards the IMS and a hostile company culture can create a climate that makes the success of the IMS implementation difficult (Wilkinson and Dale, 1999; Wilkinson and Dale, 2000; Zeng et al., 2007; Zeng et al., 2011; Lopez-Fresno, 2010; Tarí and Molina-Azorín, 2010; Santos et al., 2011).
2. Employee's hostility: employee's motivation is a key factor for the organization to successfully implement ISO 9001 and ISO 14001 systems in an integrated way. It is frequent that people are reluctant to change the procedures they have been working with for many years. Shop floor employees may show resistance to executing the system because of the extra work it involves regarding the documentation, and redefinition of processes (Matias and Coelho, 2002; Zutshi and Sohal, 2005; Zeng et al., 2007; Asif et al., 2009; Lopez-Fresno, 2010; Zeng et al., 2011).
3. Lack of information flow and coordination among the different areas: this is a vital aspect that can lead to no communication among the organization areas (Zeng et al., 2007; Lopez-Fresno, 2010; Zeng et al., 2011).
4. Lack of top management commitment: the management commitment and support to the IMS are key elements for the integration process to be done and successfully maintained within the organizations. A lack of top management commitment will probably make the project be unsuccessful (Zeng et al., 2007; Lopez-Fresno, 2010; Tarí and Molina-Azorín, 2010; Zeng et al., 2011).

METHODOLOGY

The methodology used in this paper has been qualitative, useful to analyse the processes within organizations from the process participants' point of view (Eisenhardt, 1989). According to Yin (2009), this case study empirically investigates a contemporary phenomenon as a consequence of real-life behaviour in which multiple resources of evidence are used.

This research is a single-case study as it is used as a pilot to analyse, in the near future, the management of the IMS from the employees' point of view with the purpose of contributing to the integration of MSs' literature (following the methodology proposed by Siggelkow, 2007).

A semi-structured questionnaire was designed based on the literature review with open questions. Interviewees were asked about the MSs and the IMS management and cultural change because of their implementation. Specific aspects are detailed in the results section.

Two group-interviews were performed to not use a single source of information that could introduce bias to the results (Gibbert and Ruigrok, 2010). First, the integrated system and the quality managers were interviewed together as they cooperate constantly and then, the same questionnaire was asked to the three employees participating in the study: quality control technician (in the company since 2006), occupation health and safety technician (in the company since 1971), and set up manager (in the company since 2001). The managers interviewed previously took also part in the second interview.

Both interviews were done the same day (April 2014) and lasted for 2 hours and a half. They were recorded but the research group took notes and both sources allow presenting the results. The interviews were transformed into a report and the results were analyzed and discussed with the firms afterwards.

Regarding validity and reliability, the present study meets the requirements of internal validity (Gibbert & Ruigrok, 2010) by using three types of strategy: first, we base the research on existing literature and theories; second, we use pattern matching (Eisenhardt, 1989), and third, we use theory triangulation (Yin, 2009). Construct validity is pursued with different triangulations in the data collection, combining interview transcriptions, direct observation, and the analysis of the secondary data. To pursue external validity, or "analytical generalizability" (Eisenhardt, 1989) we build on a good number of cases and we report the sample characteristics extensively. To ensure reliability, we use some of the widely accepted methods (Gibbert & Ruigrok, 2010), such as digitally recorded interviews and transcription.

The participant organization desires to be anonymous and only some data is provided about it: operates in the flexible packaging industry and has more than 300 employees.

RESULTS

The results are presented in two subsections. First, a general description of the company is presented and second, the participants' point of view about MSs and integration management about the different aspects analysed is commented.

The company. Regarding the MSSs implemented, the company is certified against four MSSs. ISO 9001 for quality management was implemented first, ISO 14001 for environmental management was second, OHSAS 18001 for occupational, health and safety management and UNE 166002 for innovation management were implemented together and EMAS, the European eco-audit, is the last implementation achieved recently. The organization is planning to start, in the near future, the implementation of a total quality management model.

About the integration of MSs, the process involved ISO 9001 and ISO 14001 first and the same year, in 2006, the organization implemented, certified and integrated OHSAS 18001 and UNE 166002. The integration strategy is mixed as at the beginning was sequential and then two MSSs were implemented simultaneously and integrated in the IMS.

The level of integration is partial, as some elements of all MSSs are managed as a single system, but others, such as the representatives, are function-specific. Elements such as audits and documentation are fully integrated. They have a team of 10 employees who are in charge of internal audits. This is coordinated by the IMS department, which is in charge to coordinate annual meetings, training, preventive and corrective actions, etc. The organization has specific software to manage the IMS and information about it is provided in the intranet, available to all the employees.

Employees' point of view. These results are grouped by the main areas of study in order to enhance the analysis of all the participants in the project.

<u>Main changes brought by the MSs</u>

According to the integrated system and quality manager:

> *'The main changes, what has really been useful in an organization like ours, which has a certain size, implementing MS help to organize the firm in general, to organize the processes and to achieve coordination among the different departments.'*

Focusing on specific benefits and difficulties of MSs, the most important benefit of MSs highlighted by the interviewees is putting the processes in order and implementing continuous improvement, and preventive and corrective actions derived from internal audits. Specifically by each MS:

– QMS benefits: training, continuous improvement, products control, etc.:
  'For each specific department there have been improvements. From a quality point of view, the main changes have been in terms of the conformity of pieces, determining critical components along the process to reduce costs, evaluation of suppliers asking them for homologation, etc.' (Integrated system and quality manager)

  'The evolution is positive as more resources have been invested in quality and the culture of quality has been implemented within the organization.' (Quality control technician)

– EMS benefits: hazardous materials management, best practices, waste reduction and recycling (subproducts), change in chemical products, etc.

– Occupational health and safety MS benefits: reducing the number of accidents in 25-30%. The management wants to strictly comply the law in health and safety issues and this already is forcing and helping the firm to make improvements:
  'We don't want the label that says that we are doing these things; we really want to integrate these actions in the normal functioning of the firm and get improvements and added value from them.' (Integrated system and quality manager)

  'The evolution has been positive as the change in this field has been huge both internally and because of legal compliance. Meeting the requirements and training in occupational health and safety measures have been positive and the employees have understood their importance.' (Occupational health and safety technician)

  'This department and its activities are linked closely to occupational health and safety's. My own evolution within the organization has been in line with the awareness of improving the environmental management: changing solvents for non-polluting materials and more sustainable printing, for example.' (Set up manager)

In relation to the main difficulties in implementing and managing these MSs, the interviewees consider:

- The need for continuous training and awareness/extend organizational culture:
  'We need to improve in the training, in a firm like ours, it is difficult to reach all the employees. It is difficult that employees perceive the importance of 'wasting time' doing training on quality or environment. With occupational health and safety, it is easier because they understand its importance. If you go and talk to a line employee, and you ask him to explain you the policy of the IMS, he probably won't know (...) He would know that there is an IMS that we have the ISOs but we need to do continuous training to refresh this knowledge.' (Integrated system and quality manager)
- Top management leadership should be clear
  'The main difficulty is to have a committed top management. The leadership of the management needs to be clear. If leadership is weak, it is difficult to advance'. (Integrated system and quality manager)
- More communication among departments is needed. For the IMS, the activities done are more intangible and its impact is difficult to measure. They would like to be enablers of areas, help in improving the techniques and implement the continuous improvement to the entire organization. For them, each representative should take care of their process, but this feeling of property is difficult to achieve:
  'We tried that each responsible for the processes of their areas took responsibility for them, asked them to draw process diagrams, to improve them and in some areas it works, they are autonomous, but other areas are very dependent on us and on the feedback of internal audits.' (Integrated system and quality manager)

<u>Departments' collaboration</u>

Regarding department collaboration, it is difficult to achieve but they are on the improving path. Some areas collaborate and in some others is more difficult for them to provide feedback or suggestions:

> *'It is our function to enable that all the areas improve and collaborate.'* (Integrated system and quality manager)
>
> *'In the current situation, quality managers have to motivate and make the other departments to be involved. We do continuous improvement but we could do more. The other areas of the IMS, environment and occupational health and safety are more visible, thus the culture is easier to implement. There is a lot of knowledge in the company but it's difficult to share it among departments to improve the processes. Quality circles for continuous improvement should be created but resources and time are a constraint.'* (Quality control technician)

<u>Training</u>

The organization and these managers provide and receive training about internal audits, the course IRCA (to become external auditors) for quality, environment and occupational health and safety, technical trainings like energy efficiency for the environmental area, electric risks for occupational health and safety, EFQM model, etc. For employees there is a lot of training about the product but also general training about the IMS when they are hired:

> *'So we do a lot of training, if it were for us we would do more!'* (Integrated system and quality manager)

'*If we don't do continuous training sessions, employees are not aware of the changes of the company, they are vital.'* (Set up manager)

This general comment is also related to the top management commitment to improve both specific and general training within and outside the organization:

'Top management should visualise how to make useful this more general training.' (Quality control technician)

'Training suppliers on the importance of quality and its positive impact on the organization's activities is difficult. Quality is a field that can always improve.' (Quality control technician)

Top management role

The role of top management has changed in line with the economic situation. At the beginning of the implementation, the owners were the managers and the implication and support was very high. They also decided to create the quality department; they hired employees to support the department and bought a specific machine to control and verify the quality of strategic pieces. In 2008 they also promote the EFQM first report in order to lead the organization to achieve excellence.

In 2009, during the crisis, the management was professionalized and the new managers were more conservative regarding MSs. The budget of the IMS department was reduced in order to cover other needs. However, the organization has sites in different parts of the world and the IMS department is working on implementing quality at the same level in all the sites:

'Top management was the promoter of the changes regarding the implementation of the different MSs. Another thing is the level of accuracy which wants to be achieved when maintaining the systems.' (Set up manager)

Within the main site, the IMS department would like to be more autonomous to make their own decisions and spread the continuous improvement philosophy across the organization:

'They should have a budget assigned by the top management and should make the decisions about the IMS.' (Occupational health and safety technician)

Those activities that do not have a direct measure into money or productivity are difficult to be valued as useful, but everything is important and if more work is done to improve quality, the entire organization will also improve:

'The culture of the organizations is continuously evolving, the top managing evolves accordingly and this has a positive impact on the firm's productivity and profits.' (Occupational health and safety technician)

'Employees should have the need and usefulness of quality and continuous improvement clear. The organization could do more in improving. Quality work is more intangible than the others and it is difficult to measure its usefulness in the short term.' (Quality control technician)

Cultural change

Internal audits importance is accepted by all employees but continuous improvement and awareness are items with a lot of work to be done:

'Continuous improvement made employees being aware and active in compliance as the internal audits are very demanding and they need to have all their work updated. They

(employees) are aware of the existence of potential risks and try to maintain the level.' (Occupational health and safety technician)

The aspect most highlighted is the importance of spreading the MSs philosophy among the employees:

'We have grown in resources, in capacity; another thing is the quality culture, what people feel about it, this culture is lacking. A lot of people in the company does not understand what quality is about, there is a clear objective but a lot of awareness lacks; the people should understand that our objective is not to make them work more or take them time.' (Occupational health and safety technician)

'It is very complicated to implement an environmental or an occupational health and safety culture, but it needs to be done. And top management needs to be involved, otherwise, it won't work. What is most difficult is to raise employee awareness. If I'm working with a 5 people group, we might do it but if it's at firm level, it's very difficult to implement policies. The awareness of the importance of improving the environmental management is the key.' (Set up manager)

Thus, it was shown that it was difficult for the employees to accept the change brought by the merging of the MSs, although they considered that this difficulty could be overcome with more involvement from the top management and more training.

CONCLUSIONS

The objective of this research is to analyse the integration of MSs from the employees' point of view. Based on a single-case study, the following conclusions could be extracted, although they should be taken with caution.

First, the main aspect to take into account is building the appropriate culture and awareness of quality, environment and occupational health and safety (similar to Zutshi and Sohal, 2005; Jorgensen, 2008; Tarí and Molina-Azorín, 2010). No matter the level of implementation or integration of MSs the company has if the employees and top management are not in line or adapted to changes. The evolution of these managerial practices should be simultaneous and with the same objectives for the entire organization. Related to this aspect, as detected in the literature, the integration of MSs level is different, higher in the top management than in the shop floor employees (Bernardo et al., 2009; Simon et al., 2011).

Second, top management commitment and resources allocation is also important (Tarí and Molina-Azorín, 2010). According to the case, when the top management was more committed, more aspects regarding MSs were achieved. In this case, the economic crisis is also playing an important role. However, the integrated system and quality managers as well as the technicians are working to improve the organization's management level.

Related to this, training, communication and collaboration among departments are variables to be considered when continuous improvement is one of the objectives of the company (similar to Griffith and Bhutto, 2008; Santos et al., 2011; Zeng et al., 2011). Understanding the role of the integrated system department considering all the players is a key factor to give value to their work and contribution (Tarí and Molina-Azorín, 2010).

Considering the above variables, two additional aspects could also be analysed both at managerial and academia level: internalization and maturity. First, the internalization level of the practices (Heras-

Saizarbitoria, 2011, Heras-Saizarbitoria and Boiral, 2013). In this specific case, the internalization seems to be done at the managerial level, and their transfer to the shop-floor employees even to suppliers is lower than the desired. Again, training and building the needed culture will help in improving the internalization and thus, the organization's performance.

The second aspect to consider is the level of maturity managing MSs or IMS. This organization implemented the first MSSs in 2002 and keeps implementing new MSs and managerial practices, and these MSSs were integrated in 2006, but they have not reached the culture and the awareness supposed to have when the MSSs are in place for a long time. Thus, it could be said that experience in managing is important but other factors, such as culture, human resources management and awareness could act as barriers for the improvement.

Two main limitations can be highlighted about this study. The first is using a single-case study as it is not allowing extracting robust conclusions about the human resources' perceptions about integration of management systems. The second main limitation is the employees interviewed as all of them were part or have responsibilities regarding the MSs management and their vision could be biased. Employees from all the levels could enrich these findings and this is an aspect to improve in the future research.

Future research is based on increasing the sample with different organizations to analyse the phenomenon widely.

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Improving Supply Chain Information Sharing Using Design for Six Sigma

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ABSTRACT

Purpose. Accurate and reliable information is needed to support decision making processes. Due to the large number of participants typically involved in supply chain operations, organizations often find that it is difficult to effectively share information within a supply chain; hence, this research examined ways to improve information sharing within supply chain operations for one marine transportation services organization.

Design/methodology/approach. An action research, case study approach used the Design for Six Sigma (DFSS) methodology to design an information technology solution that effectively communicates information between the layers within the supply chain regarding the movement of materials via inland tank barges.

Findings. The comparative analysis of verification and baseline measurements conducted suggests this project was successful because the new process fulfilled the needs of the work environment for which it was designed.

Research limitations/implications. Because this case study was conducted in only one organization and utilized a specific DFSS approach, the results obtained from this research may not be generalizable to all organizations/design projects.

Practical implications. For the organization that participated in this research, the successful adoption of the new approach for information sharing improved communication and decision making within their supply chain.

Originality/value. The approach for sharing information developed through this research further supports the value of using DFSS in service environments, and it demonstrates, likely for the first time, how this method was successfully applied in marine transportation services.

Keywords: Design for Six Sigma, supply chain, transportation, information sharing, case study

Article Classification: Case study

INTRODUCTION

Supply chain management adds value to an organization through the effective integration and alignment of various business functions in pursuit of achieving strategic objectives (Sahin & Robinson, 2005). Given the globalization of corporations and the increase in computing power and e-commerce, co-location of supply chain functions is no longer a necessity for many organizations. However, this shift in global logistics presents its own set of challenges, and these issues have effectively elevated the importance of supply chain coordination and information sharing (Fiala, 2005). Supply chain functions generate value through the cohesion of the independent activities within these business operations (Zhu, Gavirneni, & Kapusciniski, 2010). Ensuring that decisions can be made using correct and up-to-date information is imperative for efficient supply chain performance (Manuj & Sahin, 2011).

Like other areas of business, supply chains can utilize technology to enrich their business processes and communicate more effectively (Sahin & Robinson, 2002). The availability of real-time forecast information, demand data, and shipment progress through tailored information technology (IT) applications increases the flexibility and capability of functions along many points of the supply chain (Ye & Wang, 2013). This information provides functions within the supply chain the opportunity to plan, react, and take preventative action to counterbalance fluctuations and delays encountered en route to final delivery of the finished product. However, for this information to be meaningful and help the organization, it must be effectively communicated and shared with all supply chain functions, which can be challenging for some organizations (Liu & Kumar, 2011).

Transportation is the single largest logistical cost for most organizations, and these expenses significantly impact a supply chain's fiscal effectiveness (Goldsby & Martichenko, 2005). As the most widely used method of transportation, marine shipping presents a unique set of challenges for logisticians, schedulers, and other supply chain functions (Mangan, Lalwani, & Fynes, 2008). The efficiency of the shipping process affects more than the separate organizations that operate individual vessels. Shipping also impacts cargo owners, third-party logistics services, other intermodal connections (i.e., rail, truck, etc.), and ultimately the customers of the finished products. Therefore, improvements made to logistics within the marine transportation field often have a large effect on many other existing supply chains. Domestic inland barging focuses specifically on the movement of cargoes along the inland river systems of the U.S., and a large portion of this work involves the transportation of petroleum products (Mudrageda & Murphy, 2008). Specialized inland barges are utilized to move bulk cargoes between terminals, refineries, and end customers/consumers. The movement of a single cargo requires many decisions, the coordination of several supply chain functions, and commonly involves many different organizations.

It is interesting to note that little research has been conducted that examines the use of structured improvement methods to redesign supply chain operations. This research attempts to fill this gap in the literature, and it specifically focuses on designing a system to improve the communication of information through a multi-tier supply chain system within a marine transportation services organization. Using an action research approach (Reason & Bradbury, 2008), researchers worked closely with the Transportation Coordinators within this organization to determine the best way to utilize an IT communication solution (i.e., a SharePoint site) to support their operations. To develop this new approach for sharing information, the team of researchers and employees from the organization used the Design for Six Sigma (DFSS) methodology, a structured method for building quality into products/services in order to achieve Six Sigma (i.e., virtually defect/error free) performance (Hasenkamp, 2010; Schroeder, Linderman, Liedtke, & Choo, 2008). While the literature contains several examples about how DFSS has been used in services, this case study uniquely demonstrates how this approach can be applied to value-enabling elements within service-based operations such as a communication/information sharing process.

The following section provides some background information concerning topics related to this research. Then, the case study is presented. This discussion includes further information about the organization in which this research was conducted, as well as details regarding how the DFSS methodology was implemented, including the tools and techniques used. Finally, some concluding remarks are offered that summarize the benefits of this research to the organization involved in this case study and beyond.

BACKGROUND

Information sharing. It is well documented that the need for accurate information in a supply chain context is essential. Madlberger (2009) states that the vital issue for supply chains is the unevenness of information between supply chain functions. Hung, Ho, Jou, and Tai (2011) describes the necessity to obtain important information in a timely and accurate fashion. That is, the sharing of data levels the playing field between functions and aids management in gathering situational-information. However, because many supply chains contain third parties or several groups within the same organization, the information that they communicate to the other parties is only as effective as the commonality that binds them (Posey & Bari, 2009). For example, specific and complicated data may only be useful to share if it can be deciphered by the other functions within the supply chain.

Several previous researchers have indicated that decision making and overall supply chain performance improves when information is shared between functions (Li, Lin, Wang, & Yan, 2006; Simatupang & Sridharan, 2008). The sharing of information is said to improve supply chain agility and visibility, and therefore positively impacts supply chain stability. While previous research suggests that there are few downsides to information sharing between supply chain functions, Hall and Saygin (2012) argue that simply the act of transferring data between activities will not improve supply chain performance unless the information is accompanied by more robust requirements for collaboration/cooperation. Existing purely in a vacuum, without high levels of trust and communication between parties, information sharing would be moot. To be meaningful, information needs to be presented clearly and in a fashion that can be easily understood by the audience (Cantor & Macdonald, 2009). Otherwise, large amounts of information may tax other functions and waste time and resources in attempting to decipher it.

Communication and collaboration. Communication is a critical task for each function within a supply chain. Increased perceptions of trust between supply chain entities helps to build stable relationships and contacts that are more likely to communicate effectively. As Wagner and Buko (2005) describe, the more intensely and often that people communicate across the supply chain, the more clear organizational goals and objectives become, which may increase the overall level of coordination across supply chain functions.

To reach the optimal levels of coordination within a supply chain, the objectives of the organization as a whole must be understood and shared by all functions. These mutual values guide business practices and drive efficiency. A lack of coordination may occur when necessary information is not available to make decisions and when functions operate without the guide of system-wide objectives (Sahin & Robinson, 2005). However, supply chain management is facilitated by clearly defined reporting structures and easily-accessible information networks; hence, individual supply chain functions should be focused on high-level organizational interests to ensure alignment of the supply chain as a whole.

Supply chain improvement methods. Existing research addresses both theory and application (via case studies) of Six Sigma principles to solve problems in transportation and supply chain fields. For example, Nooramin, Ahouei, and Sayareh (2011) applied this approach to improve marine container terminal operations. Also, Antony, Kumar, and Banuelas (2006) documented research done using Six Sigma to reduce the number of injuries for work done with marine containers. Similarly, Chang and Wang (2008) used a case study to show the benefits of a Six Sigma improvement model on replenishment forecasting.

While the Six Sigma methodology has proven to be a successful process improvement approach, unfortunately it does not target fundamental changes to the structure of the underlying production/service process. To address this issue, Six Sigma applications have grown to include the design and redesign of both products and services, which is known as Design for Six Sigma (DFSS) (El-Haik & Roy, 2005). DFSS focuses building quality into products/services by identifying what customers want/need, translating these into critical-to-quality characteristics, deploying these through specific aspects of the product/service design, and verifying that the final design appropriately addresses the original intent (i.e., to fulfill customers' needs) (de Mast, Diepstraten, & Does, 2011; El-Haik & Al-Aomar, 2006; Yang & El-Haik, 2003). Previous discussions in the literature have pointed out that as there is no standard framework to guide the use of the DFSS methodology (Watson & DeYong, 2010); yet, Yang (2005) suggests that the DMADV (Define, Measure, Analyze, Design, and Verify) methodology is appropriate to use when designing service processes, as it specifically addresses redesigning processes, which is a common occurrence in service-based organizations.

CASE STUDY

Organizational context. This research was conducted at a marine transportation services organization that is a subsidiary of a major U.S. oil corporation. The organization studied provides marine transportation solutions, marine services, and other nautical expertise to transport corporation-owned petroleum and oil cargoes via marine vessels. The researchers involved in this project worked closely with the Inland Team, a division of the Commercial Department of this organization. This team manages the transportation of petroleum and oil cargoes via U.S. domestic inland waterways using inland tank barges by assigning barges to customer-requested oil movements. As part of the Inland Team, Transportation Coordinators allocate and monitor the movement of the barges carrying the oil cargoes. To track the movement of barges, Transportation Coordinators produce a traffic report, or slate, on a daily basis that is sent to customers and related third parties (grouped by similar cargo type). Slates are used by the Transportation Coordinators, Product Schedulers (i.e., customers), and third party vendors (i.e., barge operators, inspection companies, etc.) to communicate the current position and status of barges, as well as pertinent details regarding each barge. As slates are updated, they are distributed by Transportation Coordinators to the interested parties via email as a Microsoft Excel attachment.

Unfortunately, delivering slates via email has become a cumbersome process due to the frequency of updates and the size of attachments. In an effort to streamline the slate distribution process, the Inland Team within this organization wanted to develop an alternative method for distributing slate updates. Just prior to beginning this research, the organization's management mandated that data be shared via SharePoint sites, as much as possible, in order to increase the visibility of the data and provide a platform for collaboration; yet, few hard-line requirements were provided as to how to set-up these sites. As SharePoint was new to most parties involved in the slate distribution process, they selected to use the DFSS approach to develop and implement a new method for sharing information (i.e., distributing slates) using SharePoint that effectively addresses the needs of those involved in the process. Hence, the overarching questions guiding this research were "what does the slate sharing process need to do to support the work done by the Inland Team?" and "how should those needs be fulfilled?"

The Inland Team conducted this DFSS project through a participatory action research method of inquiry that involved employees and researchers working together to design the new slate sharing process (Reason & Bradbury, 2008). Within the DMADV framework, the action research process of planning, taking action, and evaluating the action, which leads to planning for further action was used to ensure that what was learned from one phase of the project was then used as the input to the subsequent phase (Coughlan & Coghlan, 2002). The specific details regarding each phase of the DMADV process used in this project are described in the following sections.

Define phase. The design team began this project by creating a project charter. The specific project goals were identified through the following problem and mission statements:

Problem statement: The Inland Team currently distributes slates via email attachments, which often leads to confusion within supply chain operations, and they do not yet have a method for sharing this information via SharePoint.

Mission statement: Establish a method for distributing slates using SharePoint, thus improving communication within supply chain operations.

A project management plan was created to further capture the DFSS process for this project, which contained the following steps:

(1) Define the current slate distribution process
(2) Interview users (i.e., those who create and receive slates) to identify their needs
(3) Create an affinity diagram to organize users' needs
(4) Develop and administer a survey to prioritize users' needs
(5) Identify the top-rated users' needs
(6) Develop metrics to address the top-rated needs
(7) Establish baseline measurements for each metric
(8) Conduct brainstorming and benchmarking sessions with subject matter experts
(9) Create options profiles to describe potential design ideas
(10) Determine the final design for the new slate distribution process
(11) Implement the new process
(12) Obtain verification measurements for each metric to ensure the new process effectively addresses users' needs

In order to begin identifying users' needs and determining the requirements for how to redesign the slate distribution process, the design team first needed to understand the Transportation Coordinator's current equipment nomination and slate distribution process. To define the process from a high-level perspective, a SIPOC (Suppliers, Inputs, Process, Outputs, and Customers) diagram was created, as depicted in Figure 1. As shown in the centre of this diagram, the process begins as transportation requests are received and appropriate barges are nominated (i.e., assigned) for each request. The inputs to this process include transportation requests, equipment nominations, etc., and these are supplied by Schedulers and Towers. The outputs of this process include voyage orders, slates, and dock schedules, which are used by Transportation Coordinators, customers, and refinery personnel.

Suppliers	Inputs	Process	Outputs	Customers
Schedulers Towers (i.e., third party barge service providers)	Transportation requests Equipment nominations Transportation Coordinators Order Fulfil to Revenue (OFR) program Slate users Traffic updates	1. Receive transportation request 2. Nominate equipment in OFR 3. Send voyage orders via email 4. Update daily traffic updates (i.e., position reports, estimated time of arrival, etc.) 5. Export OFR slate (traffic report) to Microsoft Excel spreadsheet 6. Send slate to users (i.e., customers) via email	Slates Voyage orders Invoices (based on voyage orders)	Schedulers Towers Transportation Coordinators Billing Clerks

Figure 1 – High-level view of the slate distribution process

To develop a more detailed understanding of the slate distribution process, a flowchart (provided in Figure 2) was created by the design team. Schedulers initiate the slate distribution process by sending transportation requests to the Transportation Coordinator. The Transportation Coordinator then creates a new job (i.e., movement) in the Order Fulfil to Revenue (OFR) program, which is the computer system used to track all barges, job details, and traffic updates. From there, the Transportation Coordinator faces several decision points. Once the barge number/name has been identified, the vetting process begins where again there are several decisions that must be made. Once a barge is cleared by the vetting process, the job details (i.e., barge name, cargo quantity, load and discharge port, etc.) can be entered into OFR. The Transportation Coordinator gathers these details and works with the Schedulers and Towers to complete the process. Once the barge has been loaded, the Transportation Coordinator updates OFR each day with the current position of each barge, and its estimated time of arrival to its discharge location. Once all of the barges have been updated, the Transportation Coordinator saves this information in OFR and creates the final slate that is sent to all users via email. This phase of the design project helped the team better understand how information is shared between the parties involved in the slate distribution process, and this deeper level of understanding helped to guide the rest of the design project.

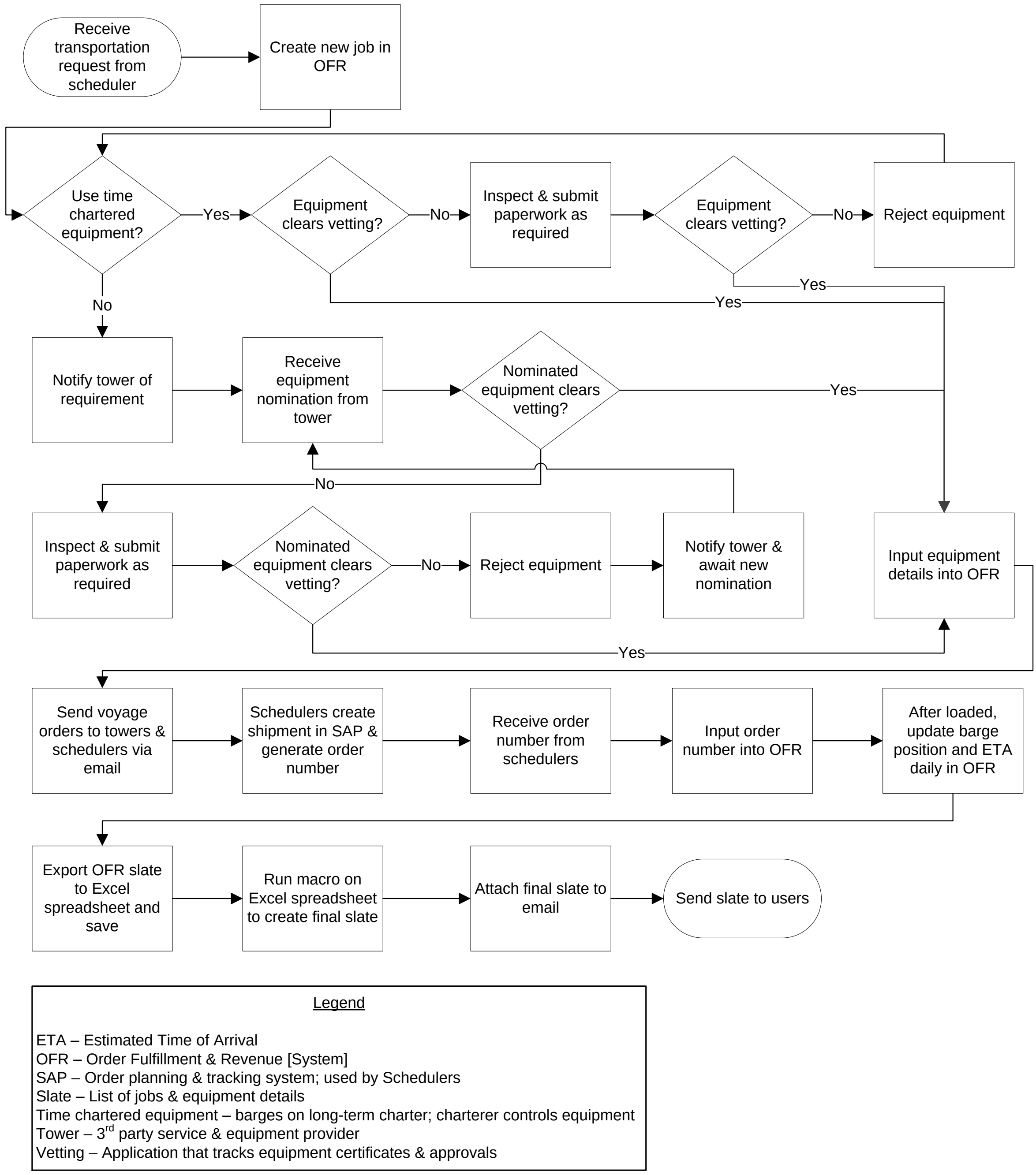

Figure 2 – The Transportation Coordinator's equipment nomination and slate distribution process

Measure phase. In this phase of the project, the design team identified the needs of those involved in the slate distribution process (i.e., the users) through a user need analysis (Ulrich, Eppinger, & Goyal, 2011). To do this, a series of open-ended interview questions were created to examine how slate users actually utilize slate information, what they liked and disliked about the current slate distribution process (i.e., sharing slates via email attachments), and what they would change about the process given the opportunity. Interviews were requested with 27 slate users. Potential interviewees were identified in order to gain an adequate and diverse representation from the main user groups, such as customers, Transportation Coordinators, and third-party service providers.

Those who participated in these interviews had varying levels of professional experience and most were not familiar with the DFSS process or SharePoint.

The design team successfully conducted 22 interviews (i.e., an 81% response rate). Table 1 provides a sample of the survey questions and responses collected during interviews. The responses to each question asked during the interviews were then translated into an interpreted need statement (i.e., a description of what the new process needs to do, but not how to do it). For example, in the second question shown in Table 1 the interviewee responded that they liked when Microsoft Outlook notifies them that an email contains an attachment. Therefore, the design team's interpreted need for this response was that the new slate distribution process should provide the user with a notification of new or updated information.

Table 1 – Example of a user needs interview

Question	**Response**	**Interpreted Need**
1. Typical uses, i.e., why do we need to share (send or receive) slates?	Must share information in a widely acceptable format (using computer applications); handwritten messages are not acceptable.	Supports compatibility with currently used computer applications
		Offers improved efficiency over handwritten slate updates
2. What do you like about the current process of sharing slates via email?	The notification that is given in Outlook that an email contains an attachment.	Provides user with a notification of new or updated information
3. What do you dislike about the current process of sharing slates via email?	Slates could get lost in collaboration (not continued to be attached to email) between work groups.	Helps to ensure that changes to documents are visible to all collaborating on document
4. Do you have any suggested improvements for the process of sharing slates?	Need a solution for third parties; conduct almost all of business with third parties.	Provides options for third party access to slates

Then, the Inland Team (which has five members, all of whom are knowledgeable about the slate distribution process) organized the interpreted needs by category in an affinity diagram. The results of this work are shown in Figure 3, which consists of needs organized into seven different categories; hence, having those who are most familiar with the process create the affinity diagram helped the design team to further understand the broad themes associated with the users' needs as well as the details regarding each individual need statement.

Next, the design team used their experience with the slate distribution process to select the needs that they felt have the most significant impact on the design of the new process. This smaller sub-set of 13 needs was included in a prioritization survey in order to identify the top-rated users' needs. This survey, which is shown in Figure 4, listed the needs as design "features," and those who completed the survey were asked to rate how important each need was to them on a five-point scale, where a "1" indicated the feature is undesirable and "5" indicated the feature is critical.

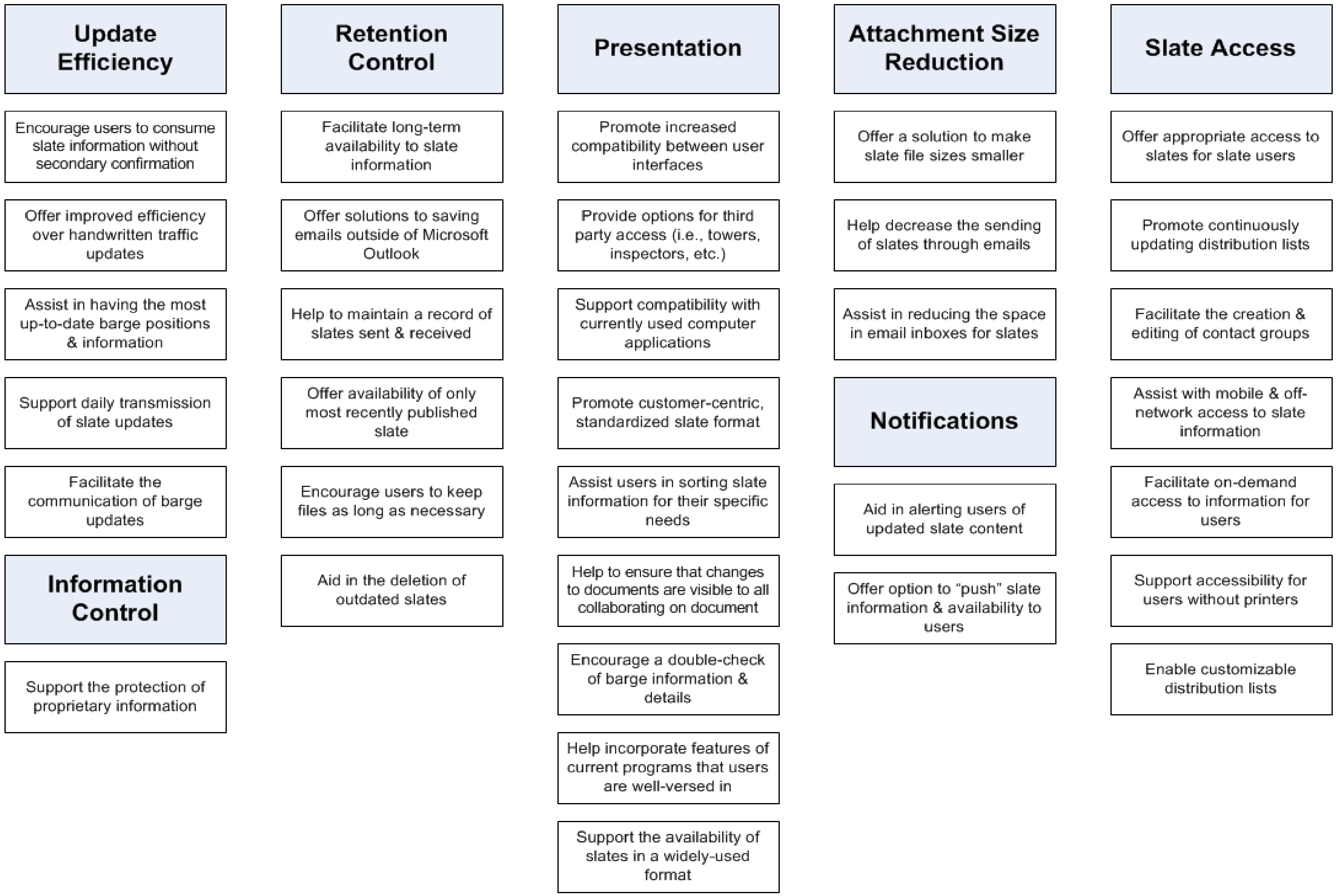

Figure 3 – Overview of the interpreted needs identified through interviews

Instructions: Please indicate how important the features of the slate distribution process listed below are to you, using the following scale:

1. Feature is undesirable. I would not consider a CLPPM with this feature.
2. Feature is not important, but I would not mind having it.
3. Feature would be nice to have, but is not necessary.
4. Feature is highly desirable, but I would consider a CLPPM without it.
5. Feature is critical. I would not consider a CLPPM without this feature.

Rating	Feature
	The slate distribution process:
________	1. Facilitates long-term access to slate information.
________	2. Aids in reducing the number of emails required to be sent or received in order to distribute slates.
________	3. Promotes efficiency in communication of slate updates.
________	4. Provides options for third party access (i.e., Towers, Inspectors, etc.).
________	5. Aids in alerting users of updated slate content.
________	6. Support daily publishing of slate updates.
________	7. Helps incorporate features of currently used computer programs and operating systems.
________	8. Assists in making only the most recent slate version available.
________	9. Provides appropriate access to slates for users.
________	10. Assist users in sorting slate information for their specific needs.
________	11. Assist with mobile and off-network asscess to slate information.
________	12. support compatibility with currently used computer programs.
________	13. Help maintain a record of slates that are sent and received.

Figure 4 – The user needs prioritization survey

The same group (27 members of the organization) that had been invited to participate in the interviews associated with this design project were also asked to complete the needs prioritization survey. The design team successfully collected 24 completed surveys (i.e., an 89% response rate). The analysis of survey responses indicated that five needs were rated as either “4” (i.e., highly desirable) or “5” (i.e., critical) by 90% or more of respondents. These top-rated users’ needs are listed in Table 2, and the importance of each was determined based on the median value of all survey responses. The design team used this information to ensure that the most important users’ needs were the focal point of the remainder of their project work.

Table 2 – Top-rated users’ needs

No.	Survey Item No.	User Needs	Importance (median survey response)
1	3	Promotes efficiency in communicating slate updates	4
2	6	Supports daily publishing of slate updates	5
3	9	Provides appropriate access to slate users	5
4	11	Assists with mobile and off-network access to slate information	4
5	12	Supports compatibility with currently used computer programs	5

Analyse phase. Next, a series of metrics were developed based on the top-rated users' needs. The nine metrics established by the design team are given in the needs-metrics matrix shown in Figure 5. These metrics address the users' needs from various perspectives. The dots shown in the matrix indicate which metrics address each need. For comparison purposes later in the project, the design team collected baseline measurements regarding the current slate distribution process (i.e., sharing slates via email attachments) for each metric. These measurements capture the performance of the current process before the new process design was conceived or implemented. The baseline measurement for metric 1, slate update interval (count/week), was determined based on four Transportation Coordinators who were asked to recording the number of slate updates they made over a three week period. The responses (four total; 100% response rate) were averaged and recorded by the design team for the baseline measurement.

		Metrics	1	2	3	4	5	6	7	8	9
			Update interval (count/week)	Ease-of-use (five-point scale)	Number of slates printed daily (count/day)	Everyone who needs access has access (Yes/No)	Information can be accessed through the web (Yes/No)	Compatible with Microsoft Excel (Yes/No)	Compatible with Microsoft Outlook (Yes/No)	Compatible with OFR (Yes/No)	Compatible with SharePoint (Yes/No)
Top-rated Users' Needs											
1	The slate distribution process promotes efficiency in communication of slates.		●	●		●					
2	The slate distribution process supports daily publishing of slate updates.		●	●							
3	The slate distribution process provides appropriate access to slates for users.			●		●	●				
4	The slate distribution process assists with mobile and off-network access to slate information.			●	●		●				
5	The slate distribution process support compatibility with currently used computer programs.			●			●	●	●	●	●

Figure 5 – Metrics that address the top-rated users' needs

Metric 2 (ease-of-use) and metric 3 (number of slates printed daily, count/day) were measured through an informal survey of 16 users who were intimately familiar with the current slate distribution process. Respondents were asked to rate the ease-of-use of the current slate distribution process and record how many slates they printed per day for a three week period. A total of 11 respondents participated in the survey (i.e., a 69% response rate). The design team collected this information and calculated the average number of slate updates per week, ease-of-use score, and number of slates printed daily to establish the baseline measurements.

For the remaining metrics (numbers 4-9), the Inland Team members (five total, which had a 100% response rate) were asked the yes or no questions associated with the compatibility of the current slate distribution process with other programs. There was no variation in the responses obtained, so the responses were used as the baseline measurements. Collecting baseline measurements for the current slate distribution process allowed the design team to see where improvements were necessary in order to fulfil the previously identified top-rated users' needs. This understanding proved to be a critical factor towards determining the design of the new slate distribution process and implementing those changes within the organization.

Design phase. The design phase consisted of working to develop design ideas to fulfil the top-rated users' needs, while also practically addressing the natural constraints of the slate distribution process. Brainstorming and benchmarking sessions were conducted with SharePoint experts and other professionals both within and outside the organization. During these sessions, the design team asked participants how they could best go about fulfilling the top-rated users' needs that were previously identified and create a successful information sharing process. The questions asked included:

How do you/could we effectively:

- Promote efficiency in communicating slate updates?
- Support daily publishing of slate updates?
- Provide appropriate access to users for slates?
- Assist with mobile and off-network access to slate information?
- Support compatibility with currently used computer programs?

The design ideas collected were organized into an affinity diagram by the Inland Team, as shown in Figure 6. The diagram included themes such as site construction (i.e., site structure, access to information, and application compatibility) and process methodology, such as distribution of information, and update schedule and frequency. Note that some of the design ideas were utilized in multiple categories, as depicted by the dashed lines shown in Figure 6.

To identify further design ideas, the team utilized the options field/options profile method that was originally developed to provide a systematic way for a collaborative group to portray a finished design using pre-established options (Pugh & Clausing, 1996). In order to create various profiles for how the new slate distribution process could be designed, the design team narrowed down the design ideas from Figure 6 to a sub-set of ideas that represented specific options. In using the options profiling approach, the design team selected one or more options within each dimension of the design to create a viable profile for the design. In total, the design team created 25 possible profiles (labeled A through Y) covering many possible option and dimension combinations.

Site structure

- Create library for each slate
- Create one library for slates and give access to each document
- Ability to keep several days of slates
- Create own sub-site for slates; access control for third parties
- Create library for each Transportation Coordinator
- Create library for each customer; simplify third party access
- No proprietary information on slates/on slate site

Access to information

- Perform audits on current distribution lists
- Grant access by position (not name of individual); less administrative burden
- Individual login for third parties
- Create a list in SharePoint for distribution; update here and not Outlook
- Utilize existing distribution lists as templates for granting access
- Access to all within corporation; no proprietary information
- Access to all within organization
- Give access to slates only by request
- Create library for each Transportation Coordinator
- Access to all within SRM + EMCC and R&S schedulers
- Create library for each customer; simplify third party access
- Use Outlook contact groups

Distribution of information

- Send alerts to customers for newly updated content (via lists?)
- Create a list in SharePoint for distribution; update here and not Outlook
- Only update customers as needed/as new information is available
- Update slate information daily and upload to site
- Use keywords in Outlook and create rules to auto-forward messages
- Use current Outlook contact groups
- No updates to users
- Send text alerts upon updating information
- Provide direct links to customers/users

Application compatibility

- Continue to utilize Microsoft programs for data interfacing
- Use of web-based system
- Any new applications (OFR) must be compatible with Microsoft
- Ensure compatible versions of software
- Ensure support for older operating systems
- Differences in versions (xls vs. XLXS); may lose functionality and formatting

Update schedule and frequency

- Make updates multiple times daily
- Upload new slates by certain time each day; eliminates need for alert
- Only update customers as needed or as new information is available
- Update slates upon completion (ideally each day or every other day)

Figure 6 – Ideas obtained from brainstorming and benchmarking sessions

The best 11 profiles were further assessed based on the metrics established previously (see Figure 5) using a concept selection matrix, as shown in Table 3. Members of the Inland Team worked together to rate each profile on a three-point scale, where “3” represents exceeding expectations for the criteria, “2” represents fulfilling the criteria, and “1” represents not meeting the criteria. The profile with the highest score was profile “B,” meaning that this is the design that most effectively addresses the users' needs. Profile “B” is shown in Figure 7. Please note that the options are given in the white boxes, the dimensions are depicted by the shaded boxes, and the options included in profile “B” are outlined in a thick black line.

The design team then moved forward with implementing the new slate distribution process as outlined in profile “B.” This work included building the new SharePoint platform, which involved creating space on the existing Inland Team's SharePoint site, creating user groups, obtaining the contact information for each individual originally receiving the slate, checking the permissions of the user groups to ensure that proper access was granted, and formatting the SharePoint space to make it user friendly. Because of the number of users impacted by the proposed process change, management mandated that a sample be used to test the new slate distribution process. This sample group, which consisted of the 11 users who had previously completed the survey for the baseline measurements for metrics 2 and 3, was used as the implementation audience in the Verify phase.

Verify phase. Once the new slate distribution process had been used by the implementation group for eight weeks, verification measurements were collected to determine if the new design effectively fulfilled users' needs. The same approach for collecting the baseline measurements used in the Analyse phase was also used to collect the verification measurements. For metric 1, the Transportation Coordinators (four total; 100% response rate) were asked to record the number of slates updated each week, which were then averaged by the design team. The survey for metrics 2 and 3 was sent to the 11 users who had previously completed the survey for the baseline measurements, and all (100% response rate) completed the survey for the verification measurements. As before, responses were averaged and recorded by the design team. The Inland Team (five total; 100% response rate) was asked the yes and no questions associated with metrics 4-9. As was found previously, there were no discrepancies in the answers, so the responses were recorded as shown in Table 4.

Table 3 – Concept selection matrix for determining the final design of the new slate distribution process

Selection Criteria	**Design Concept/Profile** (Scale: 1 = Will not meet criteria; 2 = Will fulfil criteria; 3 = Will exceed expectations for criteria)										
	A	**B**	**C**	**F**	**G**	**I**	**N**	**O**	**P**	**V**	**X**
1. Update interval	2	3	2	2	2	2	2	2	2	2	2
2. Ease-of-use	4	5	4	3	3	3	3	3	4	3	2
3. Number of slates printed daily	2	2	2	2	2	2	2	2	2	2	2
4. Everyone who needs access has access	3	3	3	2	2	1	2	2	3	3	3
5. Information can be accessed through the web	2	2	2	2	2	2	2	2	2	2	2
6. Compatible with Microsoft Excel	3	3	3	3	3	3	3	3	3	3	3
7. Compatible with Microsoft Outlook	2	2	2	2	2	2	2	2	2	2	2
8. Compatible with ORF	3	3	3	3	3	3	3	3	3	3	3
9. Compatible with SharePoint	2	2	2	2	2	1	2	2	2	2	2
Total	**23**	**25**	**23**	**21**	**21**	**19**	**21**	**21**	**23**	**22**	**21**

Site structure	Access to information	Update schedule and frequency	Distribution of information	Format of information	Application compatibility
Create library for each slate	Access to all within corporation; no proprietary information	Daily	Direct links via email	Microsoft Excel spreadsheet	Microsoft platform
Create one library for all slates	Access to all within SRM + Chemicals and Refining organization schedulers	Multiple times daily	Text/SMS alerts	Plain text	Web-based
Create own sub-site for slate within Inland Site	Utilize current Outlook contact groups	Only as required/as new information is available	Auto-forward through Outlook	Web text	OFR
Create library for each Transportation Coordinator	Grant access by position (not name of individual)	Update by a specific time each day	None		Microsoft Outlook
Create library for each customer	Give access to slates only by request				
	Individual login for third parties				

Figure 7 – The final design of the new slate distribution process in the form of an options profile (denoted by bold boxes)

Table 4 – Comparison of baseline and verification measurements for the slate distribution process

Metric No.	Need Nos.	Metric	Units	Baseline Measure -ment	Verification Measure- ment	Change
1	1, 2	Update interval	Count/week	5	5	No change
2	1-5	Ease-of-use	5 point scale	3	5	Increased by 2 points
3	4	Number of slates printed daily	Count/day	19	8	Decreased by half
4	1, 3	Everyone who needs access has access	Yes/No	Yes	Yes	No change
5	3-5	Information can be accessed through the web	Yes/No	No	Yes	Improved
6	5	Compatible with Microsoft Excel	Yes/No	Yes	Yes	No change
7	5	Compatible with Microsoft Outlook	Yes/No	Yes	Yes	No change
8	5	Compatible with OFR	Yes/No	Yes	Yes	No change
9	5	Compatible with SharePoint	Yes/No	No	Yes	Improved

The comparison between the baseline and verification measurements provided in Table 4 suggests there was no negative impact on the process as a result of redesigning it. While the number of slate updates per week (metric 1) remained constant, both "ease-of-use" and "number of slates printed daily" measures improved. Specifically, "ease-of-use" increased and "number of slates printed daily" decreased. Also, the metrics regarding slate information being available on the web (metric 5) and process compatibility with SharePoint (metric 9) were both upgraded from "No" to "Yes." Based on the positive achievements of this small-scale implementation of the new slate distribution process, management approved a larger-scale rollout. Data was collected during these additional implementation efforts to ensure the effectiveness of the new slate distribution process in terms of its ability to fulfil users' needs.

CONCLUSIONS AND IMPLICATIONS FOR SUPPLY CHAIN MANAGERS

This research effectively demonstrated the use of DFSS through an action research, case study conducted within a marine transportation supply chain. Prior to undertaking this design project, the organization shared critical supply chain information through periodic emails with sizable attachments. Utilizing the DMADV methodology, the design team identified the requirements for a new slate distribution process based on users' needs, involved those who knew the process well in generating specific design ideas for effectively addressing users' needs, and implemented the new process within the organization. The success of these efforts is evident through the comparison of baseline and verification measurements, which indicates that the new slate distribution process effectively fulfills the needs for which it was designed.

The organization studied in this research greatly benefited from this design project in terms of the gains made regarding communicating/sharing important supply chain information through an efficient and effective new process. However, this was not an easy process. The project manager largely lead the efforts to complete all the tasks in this project. For example, if people were not available to meet as a group to complete an activity, the project manager would talk with them inidiviually and then combine their input/responses so the project could move to the next phase. In the end, persistence won out and now gone are the days of various supply chain functions using outdated information to make decisions. Now, all current information regarding the movement of barges carrying oil cargos is available via a SharePoint site for all those involved in the process to easily access at a moment's notice. Additionally, notifications are sent to those involved when updates are made, and this information is accessible via the web.

While this research clearly provided useful benefits for one marine transportation services company, the results obtained from this study may not be generalizable to all organizations/DFSS projects due to the limitations of this research. For example, this case study was conducted in only one organization and utilized a specific DFSS approach. To draw more concrete conclusions from this type of research, more cases will need to be considered. In addition, while the approach used in this case study targeted addressing the specific nature of the design problem faced in this one organization, other organizations may need to use a somewhat different type of DFSS approach depending on the problem they are trying to solve. Given these limitations, further research is needed to identify other design approaches that can be used to address designing/redesigning service processes. As Sahin and Robinson (2005) point out, this might be of particular interest to help grow the value of supply chain management within organizations. This work could address a myriad of issues including, but not limited to, developing additional ways to share information (Li et al., 2006; Simatupang & Sridharan, 2008), communicating more effectively (Sahin & Robinson, 2002), and/or reducing the unevenness of information across supply chain functions (Madlberger, 2009).

As this case study serves as an example of how to use DFSS to develop value-enabling elements within service processes based on relatively straightforward design methods, it is hoped that others may draw upon this work to redesign existing processes and/or design new processes for the benefit of their organization. Engineers that design new products, for example, are not the only ones that need to use design methods. Often we find that processes in a wide range of environments can be improved by redesigning them, particularly once a point of diminishing returns using process improvement methods alone is encountered (Yang, 2005); hence, more work is needed to expand the use of design methods, and further research is needed to develop a better understanding of the factors that have a significant impact on the success of design efforts, especially in service environments.

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Do ISO 9001-certified hotels get a higher customer rating than non-certified ones?

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ABSTRACT

Purpose. This paper in progress tries to shed light on the customers' perception of ISO 9001. More specifically, the work analyzes whether customers of ISO 9001 certified hotels are more satisfied than the customers of non-certified hotels of similar category and location.

Design/methodology/approach. The paper contains the preliminary results of a study carried out in 2013 with a total sample of 186,769 guest ratings of 828 Spanish and Italian hotels (with 207 ISO 9001 certified hotels and 621 non-certified ones). The statistical analysis was carried out based on a comparison of means, a correlation analysis, and a Logit analysis

Findings. In general terms the ISO 9001 certified hotels don't receive a statistically significant better evaluation or rating by their customers. Indeed, the statistical analysis carried out based on a comparison of means, a correlation analysis, and a Logit analysis confirms that certified hotels have a statistically significant lower rating in terms of value for money than non-certified ones.

Research limitations/implications. The study underlines the possible limitations and pitfalls of this kind of research. The research also discusses the potential dangers in inferring directly that ISO 9001 certification leads to superior business performance and superior customer satisfaction as it's frequently underlined in both practitioner and scholarly literature of the field.

Originality/value. This study makes an original contribution to the literature, as there is a clear lack of researches aimed at analyzing the comparative impact of ISO 9001 in improving customers' satisfaction of certified and non-certified companies.

Keywords: ISO 9001, business performance, customer satisfaction, empirical research, hotel industry.

Article Classification: Research paper.

INTRODUCTION

Despite the fact that the ISO 9001 reference standard to implement and certificate Quality Management Systems (QMSs) has been adopted by more than one million organizations across the world, the way it is perceived by final consumers or customers of services remains largely underexplored. On the contrary, in the scholarly literature there is a plethora of research articles that analyze comparatively the impact of ISO 9001 standard on the improvement of the business and operational performance of certified and non-certified companies (see, for a recent review, Heras-Saizarbitoria and Boiral, 2013). Surprisingly, there is a clear lack of researches aimed at analyzing the comparative impact of this standard in improving final customers' satisfaction of certified companies, notably for the specific case of the empirical studies based on the proper evaluations or ratings of the final customers of certified and non-certified companies.

Taking into account this gap evidenced in the literature, this paper —a work in progress— aims to make a contribution to the specific case of the organizations belonging to the hotel industry. More specifically, this study tries to analyze whether customers of ISO 9001 certified Spanish and Italian hotels are more satisfied than the customers of non-certified Spanish and Italian hotels of similar category and location. We focus on the Spanish and Italian hotel industry due to three reasons. Firstly, the hotel industry is one of the service sectors of activity that have attracted more interest on ISO 9001 certification (Tarí *et al.,* 2010; Alonso-Almeida *et al.,* 2012; Tarí *et al.,* 2012; Psomas, 2013). Secondly, ISO 9001 certified hotels try to reinsure final consumer about the quality of the services offered to them (Perrigot, 2006). Thirdly, Spain and Italy are two of the most important countries of the world both in terms of their relative importance of their hotel industry (Cortes-Jimenez and Pulina, 2010; Seetaram *et al.,* 2013) and their certification intensity of ISO 9001 (Marimon *et al.,* 2010).

The remainder of this paper is arranged as follows. Following this introduction, the paper goes on to present the theoretical framework and research hypotheses. The next describes the methodology adopted. The results of the quantitative field work carried out are then summarized. The paper concludes with a summary of the preliminary contributions and implications for further research.

LITERATURE REVIEW AND HYPOTHESES

A great deal of research has focused on the measurement of the impact and benefits of ISO 9001 (for a review of this type of study Benner and Veloso, 2008; Martínez-Costa *et al.,* 2009; Molina-Azorín *et al.,* 2009 and Sampaio *et al.,* 2009 and Heras-Saizarbitoria and Boiral, 2013 are interesting).

This measurement generally uses quantitative surveys, which have played a dominant role in the literature on ISO 9001. For example, the benefits of ISO 9001 implementation have been widely surveyed. Thus, the ISO 9001 adoption has been associated with superior productivity and effectiveness (Douglas and Glen, 2000; Jang and Lin, 2008), customer satisfaction (Moatazed-Keivan, 1999; González-Torre *et al.* 2001), employee motivation (Kunnanatt, 2007; Santos and Escanciano, 2001), etc. Generally speaking, empirical studies have corroborated the positive qualities inherent in applying ISO 9001 for business competitiveness and efficiency, although critical studies also exist that stress negative aspects and weaknesses deriving from its implementation of these international standards. Anyway, all these results and other similar ones must be analyzed with great care as the methodological limitations of this type of studies are rather obvious despite this fact is seldom underlined. First, the surveys are used to be based on the perceptions of managers who are supposed to have taken part in the implementation process of ISO 9001. Despite perceptual measures are often used in the empirical management literature and are considered to satisfy reliability and validity requirements (Ketokivi and Schroeder, 2004), it's feasible to pint out that the results of these surveys may be influenced by the self-reporting bias related to the personal interests of the respondents (Heras *et al.,* 2002; Heras-Saizarbitoria and Boiral, 2013), such as the social desirability bias of the respondents (Arnold and Feldman, 1981). Secondly, reverse causality bias could be a problem, since the outcomes of the adoption of ISO 9001 may influence the perception of its drivers (Heras-Saizarbitoria *et al.,* 2011).

In order to overcome this type of bias other studies have tried to shed light on the impact of ISO 9001 on performance based on "more objective data" on firms from existing records such as commercial databases containing economic and financial information (e.g. Häversjö, 2000; Heras *et al.* 2002; Dick *et al.* 2008; Wayhan and Balderson, 2007; Corbett *et al.* 2005; Benner and Veloso 2008; Martínez-Costa *et al.* 2008). Overall the results are mixed, but in a majority of studies a significant positive relationship is found between the adoption of ISO 9001 and a company's performance. Nevertheless, although these variables have the advantage of avoiding respondent bias, it's also obvious that many other concerns have to be taken into account, such as the need to control for unobserved heterogeneity and the influence of treatment-effects vs. selection-effects (see, for instance, Heras-Saizarbitoria *et al.,* 2011).

Table 1: Impact of ISO 9001 in the hotel industry: a literature review of empirical works

Authors	*Country*	*Sample*	*Main findings*
Alonso-Almeida & Rodríguez-Antón (2011)	Spain	403 hotels	The customer satisfaction is not increased with the implementation of management standards
Claver *et al.* (2006)	Spain	2 hotels	The adoption of quality systems as ISO 9001 increase the customer satisfaction
Nava-Carballido & Rivas-Tovar (2008)	Mexico	96 hotels	The performance of an organization improves when it implements a program of ISO 9001:2000
Minazzi (2006)	Italy	1 hotel	ISO 9001 increase the customer satisfaction of the hotel
Tarí *et al.* (2010)	Spain	301 hotels	QMS may improve the hotel's image and have an impact on customer satisfaction and service quality

Source: own elaboration.

Then, as underlined by Heras-Saizarbitoria and Boiral (2013) further critical and rigorous empirical studies are necessary in order to analyze the real perceptions of the various stakeholders (consumers, managers, suppliers, intermediary clients, workers, public administration, etc) regarding the adoption of ISO 9001 and its real effects. Thus, as previously stated, there is a clear gap of works that shed light on the comparative impact of ISO 9001 in improving final customers' satisfaction of certified companies, notably for the specific case of the empirical studies based on the proper evaluations or ratings of the final customers of certified and non-certified companies. And this is specially necessary in the service sectors as the way ISO 9001 is perceived by final consumers or customers of services remains largely underexplored.

Within the hotel industry the adoption of Quality Management practices have been extensively studied (see, for recent reviews, Tarí *et al.,* 2010; Wang *et al.,* 2012). Nevertheless, as shown in Table 1 the empirical works aimed at analyzing the impact of ISO 9001 in the hotel industry has been not so prolific. As shown in Table 1 overall the results are mixed, but in a majority of studies a significant positive relationship is found between the adoption of ISO 9001 and the company's performance (e.g. hotel's image, customer satisfaction). In these cases the surveys were also carried out based on the perceptions of managers who are supposed to have taken part in the implementation process of ISO 9001. Then, the aforementioned biases may be underlined. An alternative to avoid these biases could be to use customer ratings aimed at analyzing the quality of service received by final costumers at hotels. In deed, the impact of online user reviews and ratings on the hotel industry is being more and more underlined in the scholarly literature (e.g. Chaves *et al.,* 2012; Browning *et al.,* 2013). Needless to say that this issue has a relevant link to the rich literature on customer satisfaction of hotel and hospitality services (see, for a review Li *et al.,* 2013).

Nevertheless, as far as we know this source of information has not been used yet to analyze whether customers of ISO 9001 certified hotels are more satisfied than the customers of non-certified hotels. In the hotel industry the rating by customers is frequently captured in terms of a set of different factors. As far as we have evidenced the most popular ones are general customer satisfaction with the service, cleanliness of hotel, comfort of the hotel, value for money and the quality of the service provided by the personnel or the staff of the hotel. These aspects are used to be evaluated with a Likert type scale for each factor. Then, taking into account the previously reviewed general scholarly literature on the impact of ISO 9001 on customer satisfaction the following hypotheses may be posited regarding these factors that are rated by the final customers of the hotels:

Hypothesis 1: ISO 9001 certified hotels receive higher customer ratings than non-ISO 9001 certified ones regarding the factor of general customer satisfaction.

Hypothesis 2: ISO 9001 certified hotels receive higher customer ratings than non-ISO 9001 certified ones regarding the factor of the level of cleanliness of the facilities than customers of non-ISO 9001 certified hotels.

Hypothesis 3: ISO 9001 certified hotels receive higher customer ratings than non-ISO 9001 certified ones regarding the factor of the degree of satisfaction with the staff of the hotel than customers of non-ISO 9001 certified hotels.

Hypothesis 4: ISO 9001 certified hotels receive higher customer ratings than non-ISO 9001 certified ones regarding the factor of the degree of satisfaction with the comfort of the hotel than customers of non-ISO 9001 certified hotels.

Hypothesis 5: ISO 9001 certified hotels receive higher customer ratings than non-ISO 9001 certified ones regarding the factor of the degree of satisfaction with the facilities of the hotel than customers of non-ISO 9001 certified hotels.

Hypothesis 6: ISO 9001 certified hotels receive higher customer ratings than non-ISO 9001 certified ones regarding the factor of the value for money than customers of non-ISO 9001 certified hotels.

METHODS AND DATA

The field work was carried out in 2013 with a total sample of 186,769 guest ratings of 828 hotels (676 Spanish and 152 Italian), with 207 ISO 9001 certified hotels and 621 non-certified ones. This later non-certified hotels where selected with a specific research protocol that combined aspects of random and purposive sampling to ensure that the results provided are robust and avoid potential bias. To construct this matched sample for each ISO 9001 certified hotel we select three non- ISO 9001 certified hotels of the same hotel category (same number of starts) and with almost the same geographic location, as this is analyzed in the specialist literature as an important source of customer satisfaction/differentiation for hotels (e.g. Shankar *et al.,* 2003; Juaneda *et al.,* 2011).

Data was obtained from Booking.com website, one of the Europe's leading online hotel reservations brokers. This data-source that is gaining more and more attraction for scholarly surveys (e.g. Chaves *et al., 2012;* Bezzubtseva and Ignatov, 2013; Herrmann and Herrmann, 2014) has a very important advantage compared to other similar ones: customer ratings are only carried out but real customers that have received a specific service by the hotel under review. In order to try to get the collaboration of Booking.com a specific formal contact was realized with the company in 2012. Unfortunately, due to issues of data protection this collaboration wasn't obtained so a desktop research was planned in order to obtain all the data. From each hotel, information about the address, number of rooms, stars and customer's ratings, was obtained from Booking.com website. More specifically, the average rating per hotel by customers was obtained for the following specific dimensions of service quality: cleanliness, comfort, location, facilities, staff, value for money and overall satisfaction rating. The ratings were given using a Likert scale from 0 to 10. When the information related to address, number of rooms and/or stars of the hotel where missed or was incomplete that information was obtained directly from the corporative webpage of each hotel.

Data of ISO 9001 certified hotels in Spain and Italy was obtained from Sincert — the institution that accredits the Italian certification bodies— in the case of the Italian hotels and from the Spanish Ministry of Tourism and different certification bodies in the case of the Spanish hotels.

RESULTS

In Table 2 the correlation analysis of the data is shown. There are statistically significant correlations showing that ISO 9001 certified hotels have more rooms, more stars and worst value for money. However, both the significance and the correlation coefficients are low. In the case of the first two variables it's plausible, in our perspective, to interpret that bigger hotels and hotels with more stars are more prone to adopt ISO 9001. In other words, a selection effect is evidenced in this case, what could be linked to a signaling or reputation motivation for the pursuit of ISO 9001 certification (Heras-Saizarbitoria et al., 2011).

The corresponding analysis of differences of means confirms the results of the correlation analysis. The ISO 9001 certified hotels are significantly bigger, have significantly more stars and its value for money is significantly lower. If we analyze these differences we evidence that they are not very large but with samples that are so big, the differences are statistically significant.

Table 2: Correlation analysis of the sample

	Rooms	*Stars*	*Clean*	*Comfort*	*Location*	*Facilities*	*Staff*	*Value for money*	*Satisfaction*
Rooms	1								
Stars	0.269**	1							
Cleanliness	-0.184**	0.264**	1						
Comfort	-0.067	0.402**	0.858**	1					
Location	-0.097**	0.051	0.287**	0.194**	1				
Facilities	-0.030	0.290**	0.803**	0.865**	0.194**	1			
Staff	-0.049	-0.018	0.171**	0.102**	0.046	0.145**	1		
Value for money	-0.040	-0.009	0.573**	0.628**	0.015	0.632**	0.142**	1	
Satisfaction	-0.133**	0.229**	0.897**	0.883**	0.479**	0.885**	0.167**	0.707**	1
ISO 9001	**0.081***	**0.080***	**-0.005**	**0.015**	**-0.045**	**0.024**	**-0.030**	**0.076***	**-0.028**
Mean with ISO	**105.37***	**3.6522***	8.4353	8.0343	8.4246	7.8908	8.2778	7.7894 *	8.1419
Mean without ISO	**88.71***	**3.5169***	8.4422	8.0071	8.5196	7.8481	8.3415	7.9068 *****	8.1774

Source: Prepared by the authors. Notes: *p , 0.05 and * *p , 0.01 in two-tailed tests; cell entries are standardized coefficients.

Table 3: Logit analysis

Variables	Beta	Sig.	Stand. Error	Wald	Exp (Beta)	95.0% EXP(B) Lower	95.0% EXP(B) Upper
First Step							
Satisfaction	-0.884	0.001	0.258	11.778	0.413	0.249	0.684
Facilities	0.776	0.004	0.266	8.517	2.173	1.290	3.660
Second Step							
Satisfaction	-0.524	0.079	0.298	3.094	0.592	0.330	1.062
Facilities	0.802	0.003	0.267	9.012	2.230	1.321	3.764
Value for money	-0.400	0.017	0.167	5.676	0.670	0.482	0.932

	First Step	Second Step
Observed (n)	828	827
ISO (n)	621	620
No ISO (n)	207	207
-2 Log likelihood	921.768	916.083
Cox & Snell R^2	0.239	0.244
Nagelkerke R^2	0.319	0.326
Omnibus Tests of Model Coefficients (Chi-square)	226.084	231.768
Sig.(Chi-square)	0.000	0.000

First step	*Score*	*Sig.*
Clean	0.884	0.347
Comfort	0.352	0.553
Location	0.991	0.320
Staff	0.272	0.602
Value for money	5.737	0.017
Global statistics	6.752	0.240
Second step		
Clean	0.234	0.628
Comfort	0.210	0.646
Location	0.286	0.593
Staff	0.256	0.613
Global statistics	1.065	0.900

Source: Prepared by the authors.

Once the correlation analysis have been carried out we applied a forward step-wise logistic regression analysis. This selection method contrasts the entry of each variable based on the significance of the statistic score, and the removal based on the likelihood ratio of the probability of its correspondent conditional parameter. Considering these aspects the variables selected in the second step are three, namely satisfaction, facilities and value for money. All the other variables are excluded from the function as they are not considered to be statistically significant.

As it can be observed the only variable showing significance is value for money in the first step so it enters into the second step in the following equation:

$$ISO= \beta(Satisfaction) + \beta(Facilities) + \beta(Value\ for\ money) + \varepsilon$$

$$ISO= -0.524*(Satisfaction) + 0.802*(Facilities) - 0.524*(Value\ for\ money) + \varepsilon$$

The model is significant with a Chi-square of 231.768, in other words, is statistically significant for 0.000. The value of the Nagelkerke R square is 0.326 is acceptable, suggesting that the model explained 32.6% of the variation in the dependent variable (Nagelkerke, 1991). When the “value for money” is included in the model in the second step, the variable of satisfaction loses significance and its value is reduced. The reason of this decrease is related with the correlation between these two elements that is very large 0.707. However, the model calls for introducing this variable.

Then, considering the model results and previous analyzes we will be contrasting hypotheses. First, Hypothesis 1 is rejected. There is a negative correlation but low and not significant between satisfaction and ISO 9001 certification. Similarly, this is also evidenced through the difference of means test that doesn`t show significant differences, since ISO 9001 certified hotels show a slightly lower satisfaction index. Finally, the logit model introduces the variable of satisfaction with negative sign from the first step. Besides this variable in the final model takes a significance level of 0.079 and a negative value of β -0524.

Neither the Hypothesis 2 can be accepted. Both the regression analysis and the referenced test of differences in means evidenced that there nearly are no differences. Furthermore, the conditional binary logistic model discards this variable, i.e., ISO 9001 certification appears to have no impact on satisfaction with the cleanliness. Similarly, Hypothesis 3 cannot be accepted. Both the regression analysis and the difference of means test evidenced that there is little difference and these are no significant negative sign. Furthermore, the conditional logistic binary model discarded this variable. Thus, ISO 9001 certification appears to have no impact on a higher rating by the customer with regards to the service provided by the staff of the hotels.

In the same way, Hypothesis 4 cannot be accepted. The ISO 9001 certified hotels have obtained slightly higher rates but there have not be found any significant differences in any of the three tests. For this reasons, ISO 9001 certification appears to have no impact on a higher rating by the customer with regards to the comfort of the hotels.

Instead, Hypothesis 5 can be partially accepted. If both the correlation analysis and the test of mean differences, it is found that although users of the hotels with higher ISO give value to the facilities offered by hotels, there were no significant differences in the contrasts. However, in the binary logistic regression model this variable appears with a positive sign β = 0.802 and it is significant (0.003). Finally, Hypothesis 6 is not only discarded but the reverse hypothesis could be also accepted. Both the regression analysis and the test of differences of means show that customers of ISO 9001 certified hotels rate significantly lower the value for money, although both the values obtained for the mean difference as the correlation indicator are not high. Similarly, the logit analysis confirms that ISO 9001 certified hotels have a significantly lower value for money as the value in the model is -0.400 and the significance level is 0.017.

PRELIMINARY DISCUSSION AND CONCLUSIONS

In general terms the findings of the empirical work carried out indicate that the ISO 9001 certified hotels do not receive a statistically significant better evaluation or rating by their customers. Indeed, the statistical analysis carried out based on a comparison of means, a correlation analysis, and a Logit analysis confirms that ISO 9001 certified hotels have a statistically significant lower rating in terms of value for money than non-certified hotels. The guest rating is only significantly better for the case of ISO 9001 certified hotels in the specific case of the evaluation given by customers to the facilities of the hotels —an issue that might be related to a higher propensity for certification in the case of the hotels with higher ratings.

Thus, our pioneering findings for the specific case of the Spanish and Italian hotel industry are not consistent with the general assumptions of the practitioner literature that take for granted the relation between the implementation and certification of ISO 9001 and a superior satisfaction from the customers. Similarly, the supposed signaling value of ISO 9001 of a superior level of service quality of the certified organizations still extensively underlined in both the scholarly (e.g. Rusjan and Alic, 2010; Cao and Prakash, 2011; Han *et al.,* 2012) and practitioner (e.g. Calvert, 2012; Tricker, 2013) literature might be also called into question. Then, for practitioners our findings should give pause for thought, as rather inflated signaling expectations of ISO 9001 certification are likely to be unfounded.

The limitations of our research have to be underlined. Although we have used indirect and thus "more objective" variables in our research which have the advantage of avoiding respondent bias such as the social desirability bias, we accept that many other distortions and biases could be underlined, especially due to the limited characteristics of the sample (e.g. focused in two regions of Europe, a non-longitudinal sample). Similarly, the comparison of results across different hotel categories (i.e. number of rooms, stars, etc.) therefore needs to be re-examined. Despite the method used to carry out the statistical analysis is a conventional one, more sophisticated methods aimed at controlling unobserved heterogeneity could improve the reliability of the work. In the same line, we've to underline that our study does not try to analyze the causality of these findings but it rather tries to underline the possible limitations and pitfalls of this kind of research. The existence of associations/correlations between ISO 9001 certification and customer ratings and other indicators needs to be interpreted with care, as they not necessary reflect direct causality. As underlined by Heras *et al.* (2002) time ago, here we again refer to the potential dangers in inferring directly that ISO 9001 certification leads to superior business performance and superior customer satisfaction as it's still frequently underlined in both practitioner and scholarly literature of the field.

As stated this is a work in progress that should be developed. For instance, implications for managers should be discussed in the light of the achieved results. Future research should extend our work on the study of the evolution of the satisfaction of the customers of organizations that have implemented and certified ISO 9001 in the hotel industry and in many other relevant industries for the most disseminated international standard.

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Gastronomy Management: a comparative analysis of the existing quality standards

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ABSTRACT

Purpose. The aim of this paper is to analyze and compare the existing quality standards in the gastronomy sector.

Design/methodology/approach. Based on secondary data, the most implemented quality standards within this sector are analyzed, namely the ISO 9001 focusing on the sector of 'hotels and restaurants', the ISO 22000, the 'Q' Spanish standard for the tourism sector, and the Michelin stars.

Findings. The results, although descriptive, show differences among them. Regarding the structure, the main difference between the management system standards and the Michelin stars is in the evaluation and certification process, as it is known and planned in the former group but not in the latter. The diffusion results confirm the increase on sectoral-focused quality standards.

Originality/value. Although studies analyzing the importance of sectoral standards have been published, this study is one of the first focusing on four different quality standards in the gastronomy sector. Implications for both practitioners and academia are also discussed.

Keywords: standards, Michelin star system, ISO 9001, 'Q' Spanish standard, gastronomy sector

Article Classification: Research paper

INTRODUCTION

The standardization of management systems (MSs) phenomenon has grown in recent years (see ISO, 2013). According to the available data, the most widespread MS standards are those published by the International Organization for Standardization (ISO): more than a million certificates for ISO 9001 (ISO, 2013), the quality management system (QMS) and more than 250,000 organizations certified against ISO 14001 (ISO, 2013), the environmental management system (EMS). Other management system standards (MSSs) have also been implemented and certified within organizations, such as those for occupational health and safety (e.g., OHSAS 18001), social responsibility (e.g., SA 8000), food safety (e.g., ISO 22000), energy (ISO 50000), among others.

One of the hot topics about the future of these MSSs is analyzing its diffusion. It could be analyze from three main points of view (Llach et al., 2011; Marimon et al., 2011, Alonso-Almeida et al., 2013): factors (i.e., why these MSSs widespread within and outside organizations and countries), model (i.e., the different stages of diffusion and evolution forecasting), and scope (i.e., to what extend is the analysis done: word level, country level, sectoral level).

This last aspect of diffusion is increasing its interest in the academia and management field as it can condition the strategy of both normalization bodies and organizations. According to the existing literature, it is forecasted that sectoral MSSs will take the place of the generic MSSs such as ISO 9001 and ISO 14001. In this line, one of the most analyzed sector, because of its normalization level at all degrees, has been the hospitality sector in general and some focusing on hotels (see e.g., Casadesús et al., 2010; Alonso-Almeida et al., 2013).

Taking this into consideration, the aim of this paper is to analyze and compare the existing quality standards regarding structure and diffusion in another area of the hospitality sector that has increased in importance in recent years: the gastronomy sector. An additional quality standard not analyzed in-depth yet is the Michelin stars system.

The remaining of the paper is structured as follows. Next to this section, the literature review is posed considering both the structure and diffusion of quality standards within the gastronomy sector. Then, the methodology and results are presented and finally the main conclusions are discussed.

LITERATURE REVIEW

The literature review is divided into two subsections. The first is presenting the analysis of the quality standards, based on their structure. The second presents the diffusion of MSSs.

Quality standards: structure and main characteristics. The quality standards analyzed in this paper are focused on the gastronomy sector, i.e.: quality management system (QMS) based on the generic ISO 9001 and the sectoral ISO 22000 for food safety, the Spanish 'Q' and the Michelin stars system.

The main aspect among them is that the ISO standards as well as the Spanish 'Q' are management systems, affecting the process, and the Michelin stars are awards focused more on the result than in the process, thus, the scope is different. Table 1 shows the common dimensions of these four quality standards in the sector as proposed by Heras (2006).

Table 1. Quality standards common elements

	ISO 9001	ISO 22000	Spanish 'Q'	Michelin stars
Geographical dimension	International	International	National	International
Promulgating body	ISO	ISO	ICTE	Michelin
Sector	General	Food chain sector	Tourism sector	Gastronomy sector
Organizational extend	Entire organization	Entire organization	Entire organization	Entire organization
Certifiability	Certifiable	Certifiable	Certifiable	Certifiable
Content	Implementation and documentation	Implementation and documentation	Implementation and documentation	Performance (results)

Source: Based on Heras (2006), ISO (2005a, 2008), ICTE (2014), Michelin (2013)

In relation to the six dimensions of the table, main differences are found regarding the sector, the geographical scope and the content. Only ISO 9001 is a generic standard than can be implemented in any organization regardless sector and size (ISO, 2008), while the rest are related to the food sector and at the same time, only the Spanish 'Q' is national (ICTE, 2014). On the other hand, the content is different among the management systems and the Michelin stars. The management systems' aim is to specify the requirements to implement, document, maintain and improve a quality management system (ISO, 2005a, 2008, ICTE, 2014), while the Michelin stars system aims to recognize the fine dining restaurants (Michelin, 2013).

The most important differences are in the implementation and certification processes. For the first aspect, the management systems follow a similar implementation process that can be summarized into (ISO, 2005a, 2008; Biasini, 2012; ICTE, 2014): analysis of the initial situation, development (identification of processes and their interrelation, documentation creation and resources allocation), implementation (training, internal auditing and improvement). A consultant can help in the implementation. In the case of the Michelin stars system, the restaurant has not a specific guideline to implement a specific process in order to achieve the award so the restaurants have to do their best because the inspectors will evaluate only the final result (Michelin, 2013).

Regarding the certification process, although voluntary in all cases, it is active in the case of management systems but passive in the Michelin stars system. For QMS standards (Casadesús et al., 2005; Claver et al., 2011) those organizations willing to obtain the certificate need to be evaluated by a certification body. The organizations apply for the certification and after choosing the certification body both organizations schedule and plan the audit. During the audit both parties collaborate and communicate, the organization audited knows the content of the audit and the criteria applied. After the audit, the third-party auditors deliver the final report to the organization and discuss the results. In the case of a positive evaluation, the organization achieves the certificate and is registered. A follow-up audit is done the year after and the certificate should be renewed in 3-years' time. In the case of a negative evaluation, the organization needs to implement corrective and preventive actions and be evaluated again.

The Michelin stars system could be labeled as a single-side process, as the restaurants do not know the day of the audit neither the final report. The restaurants evaluated are those registered in the guide and some of them are evaluated to be considered for the award. The evaluation criteria are objective and the most important aspects are the quality of products, creativity and presentation, the cook and the taste (Apicius, 2013). But it is also important the regularity of the team and the relationship quality/price (Ottenbacher and Harrington, 2007). The evaluation is anonymous as the inspector acts as a client and pays the bill. The restaurant is then evaluated and in some occasions, the inspector presents itself to the restaurant and comments on some aspects of the service (Apicius, 2013). No final report or any other feedback is provided to restaurants and they only know the result when the guide announces the restaurants awarded. Differently from the management systems, there are three levels of award: one star is for good restaurants in its own category, two stars for “excellent cooking which worth a detour” and three stars for an “exceptional cuisine, worth a special trip” (Michelin, 2013). In the case of the Michelin system, each year the restaurants are evaluated and can renew the award, achieving a higher recognition or not renewing it.

Thus, although these differences should be taken into consideration when comparing these quality standards, all of them are devoted to improve the organization’s processes and results to satisfy and delight their customers.

DIFFUSION OF MANAGEMENT SYSTEM STANDARDS

The diffusion of MSSs has been widely analyzed as it allows forecasting their future and planning the best strategy for normalization bodies, organizations and academia.

Three are the main points of view to study this phenomenon: diffusion factors, model of diffusion and scope of analysis. Regarding the first aspect, it refers to those characteristics that explain and help in the diffusion of MSSs, e.g., because of commercial exchange activities (Corbett and Kirsch, 2004), direct foreign investment, institutional support (Delmas, 2002), cultural affinity, experience with previous standards (Delmas and Montiel, 2008), supply chain (Corbett, 2006), stakeholders’ pressure (Xia et al., 2008), organizational characteristics (Hashem and Tann, 2007), among others, have been discussed as enablers of diffusion of contagion effect to expand these MSSs across organization, sector and country barriers.

The second refers to the model this diffusion follows. There is consensus that the S-curve is the model that fit better regardless the scope of diffusion (see e.g., Marimon et al., 2006; Casadesús et al., 2008). This model also allows determining different stages across the pattern: starting, taking-off, saturation and retrocessive (Marimon et al., 2009; Franchescini et al., 2010). The first stage refers to the starting point of the process, when only a few organizations are certifying these MSSs (beginners) and ends when a critical mass of certificates is achieved. The second stage starts when the number of certificates increases fast and exponentially, their growth takes-off, and ends when the great majority of organizations has implemented and certified the MSSs. The next phase is the last of positive growth, as it considers those organizations that does not have the certification, a littler amount, and those certifying in the last place (laggards). Once this situation is achieved, the last stage, retrocessive, contains those organizations that are not renewing for whatever the reason; the certificate of the MSS, in other words, the decertification process begins (see ISO, 2013).

The last aspect of diffusion is the scope. It refers to the level of analysis, i.e., considering the diffusion process at an international level, country level or sectoral level, for example. Studies analyzing the diffusion of MSSs, specifically ISO 9001 and ISO 14001, at international level are the most common and allow introducing the model and its stages and analyzing and comparing the diffusion among countries, such as in Franceschini et al. (2004, 2006, 2010), Marimon et al. (2006, 2009), Casadesús et al. (2008) and Heras-Saizarbitoria et al. (2013). At national level, Franceschini et al. (2008) analyzed the diffusion in Italy, and Casadesús et al. (2010) and Alonso-Almeida et al. (2013) analyzed it in Spain. The latter studies are also focusing in a specific sector, the hospitality sector. In Llach et al. (2011) and Marimon et al. (2011), the international diffusion model of ISO 9001 and ISO 14001 is analyzed considering sectors of activities.

As it is understood from the previous words, all diffusion aspects are correlated and evidence of that are the possible scenarios once the saturation point has been achieved (see also Bernardo et al., 2013). The new S-curve could be based on:

a) the internalization of the known standards to take profit of the experience in its management (see e.g., Heras-Saizarbitoria, 2011)

b) The certification of an existing sector-specific standard that fits better to the organizations' activities, for example ISO 22000 or BRC for food safety (Gotzamani and Kafetzopoulos, 2012), 'Q' Spanish trade in Spain for tourism (Casadesús et al., 2008; Alonso-Almeida et al., 2013), among others

c) The implementation of a new standard for the organization that makes it more efficient, e.g., a social responsibility MSs (Castka and Balzarova, 2008), an innovation management MS (Coelho and Matias, 2010), an energy MS (Coelho et al., 2003), among other possibilities.

According to the existing studies, the tendency seems to be the decertification (not renewing the certificate) of the generic MSSs such as ISO 9001 and ISO 14001 (see e.g, Marimon et al., 2009, 2011; Franchescini et al., 2010), to invest the effort and money to implement and certify sectoral MSSs, more in line and adapted to each sector demands (see e.g., Llach et al., 2011, Alonso-Almeida et al., 2013).

METHODOLOGY

The methodology of this paper could be labeled as hybrid as both qualitative and quantitative data have been used. Secondary data was used in both methodologies.

In order to analyze and compare the structure of the selected quality standards, a content analysis of the norms and complementary information has been done (see also Alonso-Almeida et al., 2013). The comparison is based on the different phases of implementation and evaluation of compliance.

To analyze and compare the diffusion of these quality standards, quantitative data from the available resources has been used, i.e., ISO survey data (as in previous studies on diffusion such as Marimon et al., 2009, 2011; Alonso-Almeida et al., 2013) and Michelin stars awarded. Although the data for the Spanish Q was demanded, no answer was received. The use of these data is limited as not all the years are provided (ISO 9001 certificates for 2003 and 2005 are missing data) and the period of time is not the same for the three standards (from 2007 on, when ISO 22000 was published, all data is available). Thus, the conclusions extracted from this comparison should be taken with caution.

The study is focusing on Spain and the gastronomy sector. The former because it has a long experience in quality MSSs implementation (see ISO, 2013) and the latter, because it has grown in importance both in recognition and as economic contributors (INE, 2014). Specifically for Spain, the number of certificates and recognitions of quality standards has increase and it is considered the leading country in terms of gastronomy and awards.

RESULTS

The results are presented separately for the structure analysis and diffusion.

Quality standards structure. The results, although descriptive, show differences in the implementation of these standards. The implementation of ISO 9001, ISO 22000 and 'Q' standard are similar, as they are published guidelines that organizations can implement and certify. The Michelin stars system is different as the requirements to be met to obtain the star are not specifically published. However, all of them are compatible and a restaurant can have the three management systems implemented and certified and be awarded with one-two-three Michelin star.

The most important difference is in the evaluation stage. While the quality management system standards certification audits are planned and both the auditee and auditor know all the aspects to be analyze, in the Michelin stars system only the inspector knows this information, as the evaluation in each restaurant is anonymous, so, the restaurants do not know in advance that they will be evaluated.

This last aspect is important as the internalization and compliance with requirements are different. Internalization phenomenon has been analyzed in the literature (see e.g., Heras-Saizarbitoria, 2011) as the implementation and management of these quality practices can become a routine or be superficial. Although it is obvious that a good implementation and internalization is better to get benefits this could be independent of passing the certification audit (Dogui et al., 2014). Thus in the case of management system standards the certificate can be obtained if the documentation is prepared before the audit that is known but it is not the case of the Michelin system, as the restaurant does not know when the audit will be done and the quality performance and compliance should be of high level always.

Another aspect to consider is that in the management system standards case, those organizations with a negative evaluation have the chance to recover and implement corrective and preventive actions and be evaluated again. The Michelin stars system does not give this opportunity to those restaurants not awarded.

To sum up, the Michelin stars system is a recognition based on the result and the management systems are improving the process that if it is well implemented, will lead to more satisfied customers. In addition, an important difference is that Michelin does not publish the evaluation criteria or guideline understood as a standard as ISO is defining it: "document established by consensus and approved by a recognized institution that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose specific criteria to follow" (ISO, 2014), but these criteria are objective enough to be used as indicators to measure the result. Nevertheless, all of them, management systems or recognitions, share some commonalities and one is giving evidences of the quality level of the organization, in this case, of the restaurant.

Quality standards diffusion. The three quality standards with available data are analyzed and compared in this section. First, all data is referring to Spanish certificates and Michelin stars. For ISO 9001 and ISO 22000 all certificates where considered, although it could mean that the same organization has more than one certificate. The same was considered regarding the Michelin stars, as the data used refers to the total amount of stars awarded, and not the restaurants awarded. These results are the first step of the analysis as more data are needed to conclude the study.

Figure 1 shows the evolution of the three standards. Considerations about the figure should be posed. The scales are different to make the comparison possible. Thus, ISO certificates are scaled in the main axis, while Michelin stars are scaled in a secondary axis.

Regarding the ISO certificates by sectors, the first aspect to be considered is that none of them is referring specifically to restaurants and thus makes this analysis to be taken with caution. Knowing this limitation, the growth rate of ISO 9001 certificates was high until 2008 when the growth seems to stabilize. It seems that this standard could be reaching the saturation point (in line with previous studies on diffusion of management systems, such as in Llach et al., 2011, Marimon et al., 2011).

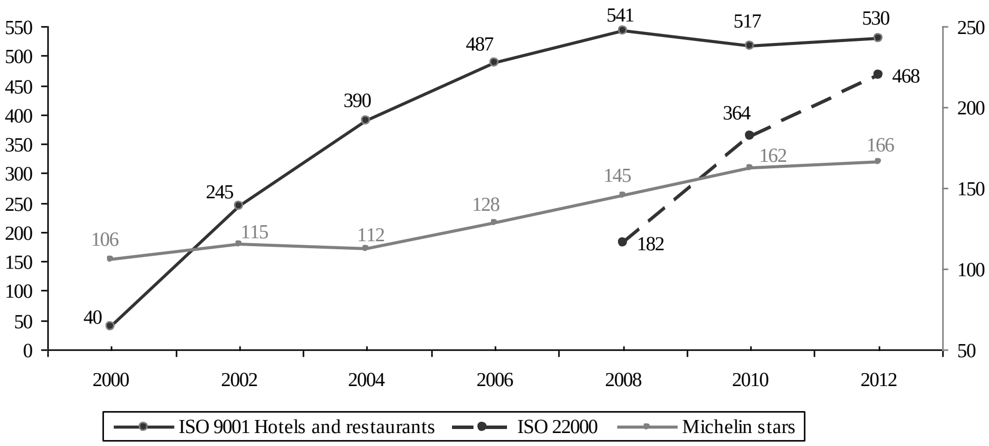

Figure 1. Evolution of quality standards

Source: ISO (2001, 2003, 2005b, 2007, 2009, 2011, 2013), Michelin (2013).

The evolution of ISO 22000 certificates is shorter (it was first published in 2005) but it seems clear that the growth rate is higher than for the ISO 9001. This is in accordance with the tendency in those sectors with a specific quality standard in which organizations prefer to implement and certify sectoral standards because they fit better with their activities and those more generic as is ISO 9001 (see e.g., Casadesús et al., 2010; Alonso-Almeida et al., 2013). Also, the experience of having ISO 9001 or another management system implemented before the implementation of ISO 22000, published later, can explain the fast growth of the certifications (Corbett and Kirsch, 2001, 2004; Vastag, 2003). It can be extracted from the figure that in a short period of time, it looks like the ISO 22000 certificates will overpass the ISO 9001 certificates in this sector.

The evolution of the Michelin stars in Spain has been smoother. From the beginning of the period analyzed until 2004, the growth rate was almost constant, but from 2005 on the number of stars was grown significantly although not at the same level as for ISO certificates. The growth rate for the last years analyzed seem to be stable but the available data for 2013 and 2014 show an increase in the stars awarded (178 for 2013 and 192 for 2014). Considering not the total of stars but the restaurants, in 1998 90 restaurants were awarded (79 restaurants with one star, 9 restaurants with two stars and 2 restaurants with three stars) and the number increases until 139 in 2012 (117 restaurants with one star, 17 restaurants with two stars and 5 restaurants with three stars). This evolution shows a tendency of the gastronomic restaurants to be awarded but also exemplifies the methodology of the institution as restaurants are passive in the process.

To sum up and comparing the evolution of the three quality standards, it seems that both sectoral standards, although different in objectives and methodology, are growing and the more generic standard, i.e., ISO 9001, is achieving the saturation point. These results contribute to the existing literature defending that a sector-specific standard is preferred by the organizations as they allow a better fit with the organization's activities as well as giving them the opportunity to differentiate from competitors and gaining competitive advantage (see e.g., Llach et al., 2011; Marimon et al., 2011; Alonso-Almeida et al., 2013).

CONCLUSIONS

The aim of this paper is to analyze and compare the existing quality standards in the gastronomy sector. Based on a hybrid methodology combining qualitative and quantitative data, the following conclusions could be extracted.

First, there are multiple quality standards on the gastronomy sector that are compatible.

Second, in terms of structure and characteristics, points in common are the assurance of quality in both processes and results and recognition. Main differences are in terms of implementation and certification.

The quality management system standards specify the implementation, documentation, maintenance and improvement of a quality management system, its implementation and certification are voluntary, and all parties are involved in the certification process. The certificate, renewed every three years, assures compliance with the standard requirements. Third-party audits are planned and all participants know the evaluation criteria. Michelin stars' system refers to the certification process as there are no guidelines for the implementation of the criteria analyzed. The external evaluation by the Michelin inspector is anonymous and the only information the restaurants know is if they are awarded or not. The award it renewed annually. Both methodologies, although the aims of the standards are different, have positive and negative aspects. For organizations is better to know the criteria and have feedback to improve but knowing when they are going to be evaluated could develop a negative behavior and only maintain the system to pass the audit. The need to keep up-to-date the quality requirements could be the best assurance for improving clients' satisfaction.

In terms of diffusion, although the results obtained should be taking with caution, the evolution of the quality standards evidences the tendency of an increasing implementation of sectoral quality standards rather than generic like ISO 9001. In relation to the previous comment, the need to be certifiable standards should be analyzed in future research.

Implications for the standardization institutions are based on the evaluation process. The gastronomy sector could be a pilot test to implement a hybrid methodology to assure the compliance of quality standards requirements and improve clients' satisfaction. Another aspect that has been discussed in the literature is the auditors' independence and competence that could be improved by a better evaluation process. Managers should consider the possibility of decertify generic standards, which is achieving the saturation point, and invest in those sector-specific standards that fit better with their activity and allow them to delight customers' requirements. In addition the sectoral standards give the opportunity to differentiate from competitors leading to the gain of competitive advantage. The main problem for them is also the proliferation of many quality standards with different criteria that are considered more as image than excellence.

One of the limitations of this study is the available data, as the evolution of all the quality standards could not be analyzed. In addition there are not enough Michelin information about criteria, process and evaluation, so it is difficult to compare the Michelin star system with the MSs. Also, Spain is the only country analyzed.

Finally, future research is based on analyzing in-depth the Michelin stars system in order to be able to compare the criteria and propose hybrid evaluation criteria.

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Trade-offs between teaching and research activities as antecedents of student satisfaction

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ABSTRACT

Purpose. Universities must ensure that academic staff is qualified and competent for their job. Indeed, different attempts can be found in the literature measuring their performance and capturing students' satisfaction. Metrics assessing academic quality are, however, not free of controversy. First, it is difficult to find consensus on the best proxies for academic quality. Second, different patterns are observed when examining teaching and research activities performed by lecturers. While some authors suggest that these two activities are complementing each other and are positively influencing students' satisfaction, some others argue that rivalry effects are shown. This paper aims at shedding new light on this debate by means of an empirical approach where we examine the relationship between research and teaching quality and its impact on students' satisfaction.

Design/methodology/approach. For the purpose of this study, 80 different subjects offered at the Universitat Internacional de Catalunya (UIC) have been considered. Different statistical methodologies have been used to test our hypothesis: test of Mann-Whitney, contingency analysis and Structural Equation Modelling (SEM).

Findings. Our results support those studies signalling that current incentive systems at universities might be research-biased, negatively impacting on teaching quality, and consequently on students' satisfaction. Findings also suggest that there is no relationship between research and teaching quality.

Originality/value. Trade-offs between teaching and research quality in the Spanish university setting are tested. Both teaching and research quality are desirable outcomes. Therefore, studies investigating their collateral effects are necessary. While universities would like their lecturers to excel in both dimensions, very little is known about how to effectively accomplish with this ideal standard.

Keywords: higher education, teaching quality, research quality, students' satisfaction

INTRODUCTION

With the rise of the evaluative state (Neave, 1998), the assessment of university quality has become a meaningful topic amongst academics and policy makers. Indeed, both public and private bodies, as well as universities, are designing and implementing strategies that ensure a proper performance of higher education institutions in their daily activities.

Universities are acknowledged to play a key role in human capital development, but also in the provision of new knowledge (D'Este and Patel, 2007). This means that, in addition to providing highly qualified graduates and researchers, universities are also expected to provide innovative solutions that address the challenges faced by organisations today. Teaching and research are, therefore, core activities that universities should looked at when carrying out quality assessment processes. In addition, there is growing awareness on how universities can contribute to regional development through collaboration with businesses, local and regional governments and other local actors which are closely linked to the concept of the universities' third mission or knowledge transfer activities (Laredo, 2007).

Different types of evaluations are envisioned; however, those adopting a lecturer-centred approach are gaining popularity. Lecturers are in charge of teaching students but also of actively participating in research activities. This suggests that both teaching and research quality are in their hands. Given this high responsibility that lecturers have acquired, university managers are in charge and must have the means to ensure that lecturers are qualified and competent for their job. Teaching, research, knowledge transfer, and to a lesser extent, administrative tasks are the four categories of academic work for which faculty members are usually evaluated. Different measuring systems can be found in the literature. However, these assessment models are not free of controversy as it is difficult to find consensus on which are the best proxies for each type of activity. This debate is accelerated when lecturers are required to excel at all activities simultaneously, but especially on teaching and research ones (at least, for the Spanish case).

Based on the a foregoing, for the purpose of this paper, we only concentrate on teaching and research activities, which, for the Spanish higher education context, are those activities with the highest weight in the lecturers' evaluation processes for promotion purposes.

The relationship between research and teaching activities is a controversial issue in the field of higher education management (Halse et al., 2007;, the primary role of the medieval university was the Robertson & Bond, 2005). In its origins diffusion of knowledge rather than the advancement of science *per se*. Said differently, teaching was central to academic identity. Universities as teaching institutions existed until the mid-19th century when the specific teaching mission was linked to knowledge creation processes, following the Humboldtian model (Mora, 2001). The underlying reason behind this new model was that research and teaching, if combined, were believed to produce synergies. This paradigmatic shift entailed the introduction of research activities as a core function alongside with the dissemination of knowledge through teaching tasks.

Social and economic changes then occurred, followed by a massive incorporation of students into the higher education system. Universities evolved from a vertical conception to an open matrix one (Solé-Parellada et al., 2001) and in the 1970s a growing sense started to emerge placing research as the primary objective in university campuses (Elen et al., 2007). Over the years, teaching and research functions were increasingly acquiring separate identities, and nowadays there is as growing awareness that they have become separate activities of faculty work (Barnett, 2005; Jenkins & Zetter, 2003). However, when both activities are viewed from the standpoint of a learning process, it is easier to conceive that, at least conceptually and ideally, they should be mutually reinforcing (Becker & Kennedy, 2005; Brew, 2003; Burke & Rau, 2010).

Students' choice is found to be influenced by teaching quality and university's prestige (which is related to research quality) (Gautier & Wauthy, 2007). Although the existing literature provides well justified arguments for a positive, negative and even null effect between teaching and research activities, to the best of our knowledge, there is little evidence on how students' satisfaction is determined by lecturers' performance in these two activities. Based on this argument, in this paper we examine teaching and research acknowledgments (internal and external) obtained by faculty members as antecedents of students' satisfaction.

To do this so, in this paper we propose an exploratory analysis in order to answer the following research question: What is the relationship between research and teaching quality and their impact on students' satisfaction? Focusing on the specific case of the Universitat Internacional de Catalunya, we use different methodological approaches, including structural equation modelling, to validate a set of hypotheses.

Following the introduction, the paper is organized as follows. Section 2 reviews the literature on the potential trade-offs between teaching and research activities from where hypotheses emerge. Section 3 provides an overview of the Catalan accreditation framework for the assessment of faculty members. Section 4 describes the methodological approach, and Section 5 lays out the results. The discussion of the findings and policy implications are put forward in Section 6.

LITERATURE REVIEW

Teaching quality versus research quality. Literature examining the tensions between research and teaching components of lecturers' daily activities have reported different conclusions. Different approaches can be found: some based mainly in theoretical ground, other from a qualitative methodology based on full interviews, other based on empirical work or on data collected through surveys. Regardless the approach, we classify these studies in three distinct groups, according to the observed sign in this relationship: positive, negative or null (see Figure 1).

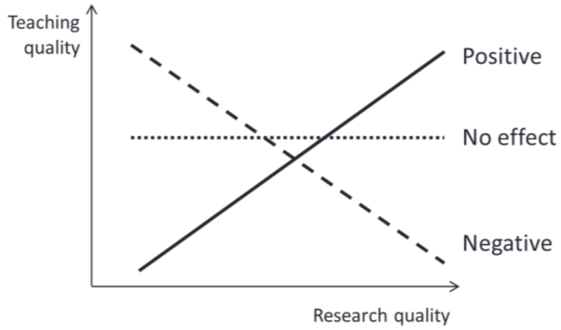


Figure 1. Potential scenarios resulting from the teaching-research nexus paradigm.

Positive effect

Several studies have reported a positive relationship in the teaching-research nexus (Durning & Jenkins, 2005; Elton, 2001; Griffiths, 2004; Healey, 2005; Robertson, 2007). The main premise from which positive effects are expected is based on the fact that the qualities underlying a good teaching and successful research outcomes are pretty similar. In both cases the lecturer should be creative (imagination, originality, inventiveness), highly committed with his/her tasks (perseverance, dedication, hard work), possess critical analysis, and be good in disseminating and communicating knowledge (Hattie & Marsh, 1996). That is, attitudes, values and competencies that lead to teaching excellence are also likely to lead to research quality (uz Zaman, 2004).

Another explanation is that teaching and research are found to reinforce each other because lecturers base their teaching on their research, and generate their research ideas from their course teaching (Shin, 2011). Reinforcing effects are therefore accepted in both directions. On the one hand, research contributes to teaching because research-active lecturers are at the cutting-edge of their fields, which translates in more accurate and updated material which captures more easily students' attention (Marsh & Hattie, 2002). Likewise, presenting the researcher's own material adds a sense of authenticity that differs from presentations where teachers discuss the work of others with neither passion nor an active involvement (uz Zaman, 2004). On the other hand, there are also claims that research benefits from teaching. Preparation of teaching materials as well as students' ideas at class may help identify gaps in the literature and detect new research directions (Coate et al., 2001). Also, sharing the results of one's research efforts with an appreciative audience provides priceless feedback that could be used to improve research outcomes. In this regard, it is found that undergraduate and postgraduate students show different attitudes towards research activities (Lindsay et al., 2002). While both groups acknowledge the benefits of lecturers being highly involved in research activities, the latters (postgraduates) emphasised the importance of the relevance and utility of lecturer research to the content of their learning.

<u>Negative effect</u>

A second bunch of studies argued that teaching and research are conflicting activities, leading to a negative relationship between them (Parker, 2008; Serow, 2000). A divergent reward system model is one of the main arguments supporting this thesis (Hattie & Marsh, 1996).

Both teaching and research are time-consuming activities. As time and other resources are scarce, faculty members tend to prioritize those activities that are going to report them a greater benefit. Usually, this benefit is measured in terms of stability within the academia. Given the weight given to research in evaluation processes for tenure and promotion, young academics that need to carve out an academic career are more likely to reduce the time and effort spent on teaching in favour of that spent on research as this long-distance race is conditioned, to a great extent, to their research capacity (Marsh & Hattie, 2002).

Also, research activities may entail contracts with third parties, and this implies additional revenues. On the contrary, teaching does not usually significantly contribute towards overall salary. This situation might revert in those cases where lecturers are well-paid (such as in executive courses in a business school). Consequently, teaching might detract from conducting research activities (uz Zaman, 2004).

<u>No effect</u>

Finally, teaching and research have also been considered as separate activities with little impact on each other (Noser et al., 1996; Ramsden & Moses, 1992).

Authors supporting this position claim that in some research centres where there is no teaching, high quality research is performed (Ramsden & Moses, 1992). This means that teaching and research could be considered independently. Another argument is that these activities are different enterprises because they involve different tasks, which in turn, require different preparation and personality traits (Shin, 2011).

Mediating variables. As previously shown, there are a number of factors driving lecturers' decisions and shaping the relationships between teaching and research activities (Coate et al. 2001; Shin, 2011). These factors (also referred as mediating variables) can be classified according to whether they refer to background variables (personal goals, abilities, rewarding systems, etc.) or resources.

As for the background variables, previous studies suggest that research does not have a direct influence on teaching to the same extent in all subjects areas and at all levels (Coate et al., 2001; Noser et al., 1996). While a positive but small relation is usually found for undergraduate level, a more diffuse link appears at the graduate level. Similarly, the direction and intensity of this relationship might differ across academic disciplines (Becher & Trowler, 2001; Kreber & Castleden, 2009; Lindblom-Ylänne et al., 2006; Trigwell, 2005). For instance, in humanities this relationship is found to be more direct at the undergraduate level, whereas at a postgraduate level is strengthened in sciences.

Likewise, academics' ability may also condition research and teaching activities. In this sense previous studies indicate that those academics whose research efforts are in areas strongly related to teaching may be favoured in comparison to their counterparts who can more difficultly incorporate knowledge into their classroom practice (Shin, 2011). Further indicators of motivation are personal goals (Marsh & Hattie, 2002) which are modulated by the lecturer's beliefs about the teaching-research nexus.

Promotion incentives are also central to the debate on rivalry effects between teaching and research. It is well documented that research has outranked teaching in the university's faculty reward system (Parker, 2008). Indeed, reward structures (including tenure, promotion and faculty salaries) are clearly favouring research activities over teaching ones (Fairweather, 2005). Many academics attributed this to the impact of university rankings which had prompted universities to accentuate the importance of research (Taylor, 2006). Additionally, research outcomes are much easier to be quantified and compared than teaching ones.

Incentives are clearly affected by the career stage of the lecturer (Baldwin et al., 2005). For instance, academics in a weaker contractual position would have stronger incentives to conduct research in order to create reputational signals that are expected to increase their probability to be appointed by universities. To the contrary, full professors have few exogenous incentives to make visible their research (i.e. articles published in academic journals), being their only motivation endogenously determined by their own interest in conducting research in their knowledge fields, the enhancement or consolidation of research projects, or reputational factors. On the other hand, when looking at the specific weight that promotion assessments give to the teaching dimension of academic quality, we can observe that it tends to be underscored. Indeed, maintaining a minimum standard in the student satisfaction surveys is enough. Consequently, instructors that are in their initial stages would not have such a strong incentive to deliver good lectures as they do have for conducting quality research. On the contrary, incentives to publish diminish as academics consolidate their careers as they have less extrinsic pressures to produce research outcomes. This means, that they can spend more time in preparing lectures than that spent when starting.

Lastly, resources should also be considered when analysing the tensions between teaching and research activities. Because time is a scarce resource, lecturers should manage it effectively according to their interests and needs (Gautier & Wauthy, 2007). Based on what precedes, it is reasonable to argue that time allocated to teaching and research tasks experiment significant fluctuations throughout the academic life of an instructor. Probably during the first stages research will be occupying most of the time. However, as the lecturer advances in the academic career, teaching but also administrative tasks will gradually gain importance.

Measures. There are important concerns on whether the measures employed to assess teaching and research performance are adequate proxies of quality in their respective dimensions. For instance, Shin (2011) finds that different signs were observed depending on the indicator used for research quality. Similar results are found when evaluating teaching quality.

Concerning research metrics, common indicators tend to use bibliometric data (Sarrico et al., 2010). Information of this type is widely available, including measures such as the number of papers published in scientific journals indexed in specific databases, papers published in high top journals (i.e. first quartile in their areas), or citations counts. All these metrics are accepted to reflect both the quantity and quality of the research activity (Abramo et al., 2008). However, these variables are usually criticised because they can be influenced by self-citation and friend-citation practices (Toutkoushian et al., 2003) and might represent and incomplete picture of the research dimension of university quality incomplete (Van Raan, 2005). On top of that, these citation practices pattern differs from one knowledge area to another. Therefore, results should be taken with a grain of salt.

Perhaps a more convenient measure of research quality would be that one including weighted composites of different research outcomes (both quantitative and qualitative) (Daghbashyan, 2009; Turner, 2005; Tyagi et al., 2009). While some academics suggest that aggregate dimensions can be obviated for introducing biases (weights are not objective) and not being a substantive basis in the literature for making such judgments (Salerno, 2004), other authors argue that only composite indices can really reflect multiple dimensions of research quality (Tyagi et al., 2009).

As for assessment of teaching quality, student voice is now being heard more than ever. Students are the direct recipients of university teaching, becoming the primary consumers of the higher education system. Therefore, asking them directly about their perceptions is crucial, as there is a widespread agreement that they have the most first-hand information concerning their instructors' teaching behaviour (uz Zaman, 2004)

A common practice to obtain students' perceptions of lecturers consists in the use of surveys, where students are asked to fill in an evaluation sheet. Questions included in course evaluations typically refer to those characteristics that have been found to describe what constitutes an effective teacher. The literature is inconclusive in this sense, so items inquiring whether the lecturer is knowledgeable about, demonstrates a strong interest in the subject, is organized and prepared for class, is able to assist with and encourage student learning, is dynamic in the classroom with effective presentation skills, or is fair and equitable in the evaluation of students can be easily found. The reliability and internal validity of these questionnaires have been tested and there is a consensus among academics that data obtained through these instruments is consistent (Gravestock et al., 2008; Kulik, 2001) and indispensable (Seldin, 2004; 2006).

Despite the proliferation of these instruments as tools for evaluating teaching quality, as Berk (2005) articulates, multiple sources can provide a more accurate, reliable and comprehensive picture of teaching than just one sole source. In this sense, evidences from the candidate for tenure or from peers constitute other ways of gathering information (Knapper, 2001; Knapper & Wright, 2001; Seldin, 2006).

First, self-assessments reports such as teaching dossiers provide reflective appraisal of how the instructor has designed and delivered the course. These reports are intended to clarify an instructor's approach to teaching. Certainly, one of the central evidences included in a teaching dossier is the philosophy statement. Other common elements comprised provide information on pedagogical strategies used, representative course materials, sample student work, a list of teaching responsibilities, and research in teaching, if any (Seldin, 2004).

Second, and similar to the peer-reviewing processes of publishing, the literature also stresses the importance of engaging peers in the process of evaluating teaching (Arreola, 2000; Berk, 2005; Johnson & Ryan, 2000; Paulsen, 2002; Seldin, 2004). Although these evaluations are less trustworthy than those made by students due to a potential "halo" effect, peer reviews can help identifying areas of teaching which students are not yet able to perceive (uz Zaman, 2004).

Undoubtedly, an interesting snapshot can be obtained by triangulating information from all these different sources.

Hypotheses and research model. Lecturers have a dual academic life. They are expected to perform both teaching and research activities, without one damaging the other. Although this is a very challenging task, lecturers that possess good research skills but also have a teaching vocation succeed, regardless they have passed an evaluation process (either of their research or teaching activity). A teaching vocation implies lecturers to be very careful and meticulous with their work, that is, to be actively involved in the learning process of the students, to be near them and offer help when needed, to have good subject knowledge and prepare lessons in detail so that most pupils enjoy the lessons and are keen to participate, etc.

Both youth (i.e. a young faculty member) and maturity (i.e. a senior lecturer) can generate an interest for teaching. Reasons for engaging in teaching activities may be different throughout an academic career. While for the young lecturer motivations for performing a "good teaching" may include to emulate those professors they respected as students, not to disappoint the person that hired them, etc., over the years these motivations are transformed in something much more substantial, where teaching quality takes a greater dimension (Bailey, 1999; Norton et al., 2005).

Responses coming from students' surveys capture whether faculty members are interested and committed with their teaching activities, regardless the accreditation held by the instructor. This is so because students are rarely aware of how the accreditation system works, thus, they are concentrated on evaluating the performance of the instructor. Accordingly, we hypothesise that:

Hypothesis 1: *Students' satisfaction is the same whether faculty members are accredited or not.*

According to several authors (Noser et al., 1996; Ramsden & Moses, 1992), teaching and research should be considered as independent activities, because while teaching concentrates in the transmission of knowledge, research stresses the discovery of knowledge. Moreover, these two activities demand different abilities and preparation; consequently, they involve different personality traits. An effective teacher may not be an effective researcher, and vice versa. As a result, one might expect a zero effect between these two activities.

Information regarding research activities is only available for those lecturers holding a research accreditation, thus, hypothesis 2 is formulated as follows:

Hypothesis 2: *For faculty members holding a research accreditation, research quality and teaching quality are not related.*

Instructors willing an academic career must pass an accreditation process (see Section 3). However, due to the current incentive system, their curriculums should be driven by research interests, therefore, time and efforts tend to be oriented towards research activities at the expense of their teaching. Consequently, little attention is given to education. This may lead to instructors less available for students, and less concerned about the opinions of their students. Also the design of the course and the activities (preparing the course, up-dating the material, designing new and stimulating class activities, etc.) may be negatively affected by this "research" focus. Undoubtedly, this situation is perceived by students, increasing a sense of carelessness towards teaching that can generate dissatisfaction. Based on this rationale, we hypothesize that:

Hypothesis 3: *For faculty members holding an accreditation, the level of the accreditation is negatively related to students' satisfaction.*

Those lecturers that are good communicators are motivated and feel what they teach, are therefore concerned with an effective student learning and are also interested in improving their teaching skills. All these efforts are positively valued by students, leading to high records in students' evaluations.

As teaching assessment procedures implemented in Catalan universities (either by the candidate or by their peers) are precisely based on the collection of evidences that cover the aforementioned aspects of the teaching performance, we conclude that the level of teaching quality positively influences student satisfaction.

For the purpose of this paper, two hypotheses are tested, making a distinction between whether the lecturer holds a research accredited or not:

Hypothesis 4a: *When considering accredited lecturers, the level teaching quality positively influences student satisfaction.*

Hypothesis 4b: *When considering non-accredited lecturers, the level teaching quality positively influences student satisfaction.*

The resulting model is depicted in Figures 1 and 2. As shown, student satisfaction is expected to be explained by research and teaching assessments, performed at the individual level of the lecturer. Two models are envisioned: Model 1 (Figure 1) for those lecturers holding a research accreditation (and also, having been subjected to a teaching evaluation process), and Model 2 (Figure 2) for those being only evaluated in terms of teaching.

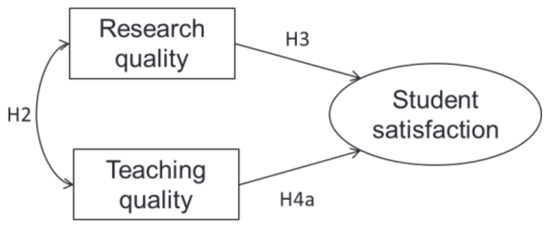


Figure 1. Model 1 (faculty members holding a research accreditation)

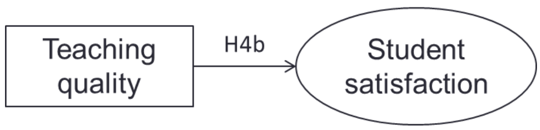


Figure 2. Model 2 (faculty members that do not hold any research accreditation).

Institutional programmes evaluating academic staff in Catalan universities. Quality assurance criteria and guidelines in the European Higher Education Area sponsored by the European Association for Quality Assurance in Higher Education (ENQA) include the assessment of academic staff in terms of the quality of their performance. Institutions must therefore have the means to ensure that academic staff is qualified and competent for the job. This implies that the assessment of the activities performed by faculty members (both internal and newly external candidates applying for a position) is a key issue.

In Catalonia, there are two external agencies in charge of performing these assessment processes: the Catalan University Quality Assurance Agency (AQU), which is specific for the Catalan region, and the National Agency for Quality Assessment and Accreditation of Spain (ANECA), with has a larger scope, and is in charge of evaluating the performance of universities and research from all Spanish regions.

AQU is a public entity with an internationally recognized status. Its mission is to assure the quality of the Catalan higher education system through compliance with the European standards of quality and to safeguard the interests of society in the quality of higher education. AQU represents the main instrument for the promotion and assurance of quality in the Catalan higher education system. Since 2003 AQU has been carrying out the pre-selection assessment of academic staff.

Lecturers in Catalonia can also be evaluated by the National Agency for Quality Assessment and Accreditation of Spain (ANECA). This agency has a broader scope. Its aim is to provide external quality assurance for the whole Spanish Higher Education System (including regional systems such as Catalonia, Galicia or the Bask Country, which have their own quality agencies) and to contribute to its constant improvement through evaluation, certification and accreditation.

When a Catalan university needs to replenish a vacant position, to be eligible, candidates must hold an issued accreditation by AQU or ANECA. Although these two agencies (AQU and ANECA) are operating under the same European principles, they assess lecturers using own standards. Yet, the names of the resulting categories (according to the level of achievement) are also different, because different criteria are used.

Table 1 summarises the academic categories (based on the accreditation awarded by AQU or ANECA) that exist in Catalan universities. These categories are ordered according to their level of exigency, being 0 the simplest one, and 7 the most demanding one.

Table 1. Types of accreditation awarded by the Spanish and the Catalan accreditation agencies, ordered according to their level of requirement.

Coding	Accreditation	Original name	Accreditation agency
0	Teaching staff at private university	Professor de universitat privada	AQU
1	Temporary lecturer	Profesor colaborador	ANECA
	Temporary lecturer	Professor col·laborador	AQU
2	PhD assistant lecturer	Profesor ayudante doctor	ANECA
	Tenure-track lecturer	Lector	AQU
3	PhD lecturer	Profesor contratado doctor	ANECA
	Teaching staff at private university	Profesor de universidad privada	ANECA
4	Senior lecturer	Profesor titular	ANECA
5	Tenured assistant professor	Professor agregat	AQU
6	Professor	Profesor catedrático	ANECA
7	Full professor	Catedràtic d’universitat	AQU

At this point it is worth mentioning that the aforementioned categories are substantially research-biased. This means that the assessment they provide is much more able to reflect the quality of research activities than that of teaching ones.

Both AQU and ANECA have established procedures exclusively devoted to evaluate candidates in terms of teaching quality. However, not all instructors are required to take this evaluation (as opposed to the accreditation process described before), having this assessment an optional character. Thus, aiming at guaranteeing a minimum level of quality in terms of teaching, universities have developed their own mechanisms in order to assess the teaching quality of their academic staff.

METHODOLOGY

For the purposes of this study 80 different subjects offered at the Universitat Internacional de Catalunya (UIC) have been considered: 44 taught by lecturers holding an accreditation of their research activity, and 36 without any. The data set includes information for the academic year 2013/14. Different information sources are used: (1) results from students' satisfaction surveys; (2) research accreditations issued either by AQU or ANECA; and (3) teaching quality assessments performed by the Department of Innovation and Educational Quality (DIEQ) at UIC.

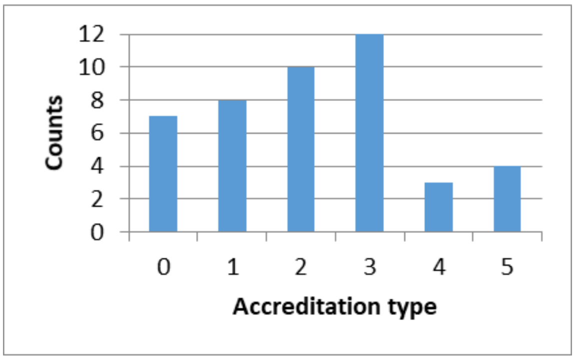
Questionnaires for students' evaluation of teaching activities have been considered to proxy student satisfaction. Based on Pratt (1997), student satisfaction has to consider three aspects of teaching: organization and planning (reading list, timing or workload), implementation and interaction (technical skills or class management, among others) and results (learning outcomes or effectiveness). In this respect, UIC created and assessed a scale taking in count these three topics (see Table 2). This scale was validated in 2007 using data gathered from two subjects taught at two different campuses. It includes 10 items and uses a five-point Likert scale. Items grouped in three dimensions: organization and planning (items 1 to 3); implementation and group interaction (items 4 to 9); and results (item 10).

Table 2. Items included in the students' satisfaction survey.

Organisation & Planning
1. The reading list and additional materials for the course contributed to improving my appreciation and understanding of the subject.
2. The course organisation and activities were well prepared and thoroughly explained by the lecturer.
3. The workload of this course was appropriate to set time for learning.
Implementation & Interaction
4. The lecturer clearly presents and highlights the most important points of the course.
5. The students were encouraged by the lecturer to take part in the class discussions.
6. The lecturer properly answers students' questions and guides students in the development of the different tasks to be completed.
7. The lecturer uses didactic resources that facilitate the learning process.
8. The content of the exams and other assessed assignments matched the course content and the emphasis placed on each topic by the lecturer.
9. The lecturer showed a genuine interest in all of the students and was readily available to students outside of class time.
Results
10. The task performed by this lecturer has helped me to improve my knowledge, skills or attitudes.

As for the research accreditation type, following the classification in Table 2, research quality has been operationalized through a seven-point Likert scale, from 0 (meaning having no accreditation of any type) to 7 (accreditation as a full professor). Figure 3 graphically illustrates the descriptives for the sample considered. From the graph, it can be interfered that none of the professors evaluated held an accreditation neither as a professor nor as a full professor.

Figure 3. Classification of lecturers according to accreditation type.



Data reporting information on teaching quality was gathered from the DIEQ. This department is in charge of assessing lecturers in their teaching activities. In order to decide whether the lecturer is capable of performing high quality teaching three different types of evidences are collected. First, the viewpoint of students is considered through the students' satisfaction survey. Reports form peers are also taken into account. In this case, a report from the supervisor of the candidate is required. Finally, the candidate has to prepare a self-assessment report, emphasizing his/her strengths and points of improvement and provide an example of a course syllabus he/she has designed.

Once these evidences are collected, a committee is designated who will be in charge of assessing the quality and suitability of the candidate in terms of teaching. A final decision is then made, which can range from unfavourable to highly favourable, as shown in Table 3.

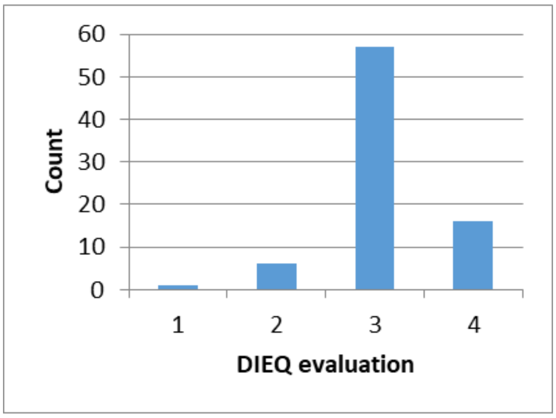
To operationalise the teaching quality dimension a scale including 4 different categories has been used. Thus, for each lecturer, a level is assigned according to the last assessment he/she has received from the DIEQ. The resulting scores are summarised in Table 3.

Table 3. Items included in the teaching quality scale.

1 Unfavourable
2 Favourable with conditions
3 Favourable
4 Highly favourable

Figure 4 shows the results for the sample considered. As it can be observed, most of the lecturers evaluated by the DIEQ achieved a "favourable" assessment.

Figure 4. Classification of lecturers according to the results obtained in the DIEQ evaluation.



To verify the hypothesis proposed we used different statistical methodologies. For the first hypothesis, an analysis of contingency is used in order to identify a potential interaction between student satisfaction and research quality. For the second hypothesis, we apply a Mann-Whitney test, comparing the 10-items included in the student satisfaction survey. Two groups are considered: one including those lecturers holding any type of accreditation and a second group for those that do not possess any. Finally, in order to test hypotheses 3 and 4, structural equation modelling (SEM) is used. SPSS v20 and EQS statistical programmes were used for data analysis.

RESULTS

Testing H1. We analysed if student satisfaction is the same whether faculty members are research accredited or not. Two subsamples or groups are analysed: a first group of 44 accredited academics and a second group of 36 non-accredited academics.

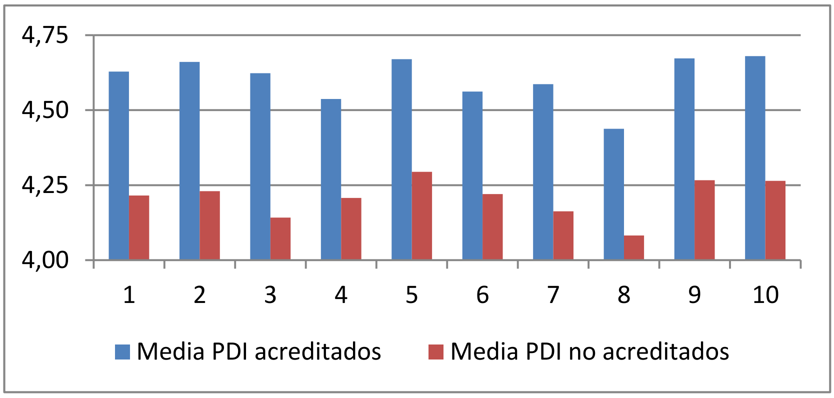
The U-test of Mann-Whitney reveals that the distribution of all 10-items is the same in the two categories (see Table 4). This result prevents us to confirm our hypothesis suggesting that student satisfaction is condition by a research accreditation.

Table 4. Items included in the teaching quality.

Item	1	2	3	4	5	6	7	8	9	10
Significance level	.896	.981	.545	.688	.612	.720	.938	.931	.911	.692

In order to examine this result in more detail, we decided to plot the results for the two groups and compare them qualitatively. Although hypothesis 1 has been rejected, Figure 5 seems to indicate that accredited lecturers are achieving higher scores compared to non-accredited counterparts.

Figure 5. Mean of accredited and non-accredited academics.



Testing H2. Hypothesis 2 aims at assessing the relationship between teaching and research quality. A contingency analysis was performed. Here, the sample included the subsample of lecturers holding a research accreditation, that is, 44. Given its small size results must be analysed with caution. Results are presented in Table 5.

Table 5. Contingency table of research quality and teaching quality.

		Teaching quality			
		"2"	"3"	"4"	
Research quality	"0"	1	6	0	7
	"1"	2	3	3	8
	"2"	1	8	1	10
	"3"	0	10	2	12
	"4"	0	2	1	3
	"5"	0	3	1	4
		4	32	8	44

Statistics show a low association level. Particularly, the Spearman correlation is of .213 at .165 level of significance. R of Pearson is of .219 at .153 significance level, and the Gamma index is .303 at a significance level of .132. All these figures allow us validating hypothesis 2.

Testing H3 and H4

Validation of "organisation" and "interaction with the group" factors of satisfaction

Two exploratory factor analysis were performed in order to confirm the unidimensionality of the factors "organisation" and "interaction with the group" (Table 6). Consequently, other two confirmatory factorial analysis were afterwards conducted. The reliability of these factors was then assessed in accordance with Hair et al. (1998). Cronbach's alpha coefficient and composite reliability exceeded the threshold value of 0.7 for internal consistency in all cases. In addition, the variance extracted for each scale was greater than 0.5. Similarly, the convergent validity was confirmed for both scales as all variables were high and significant at 0.05 level.

Table 6. Confirmatory Factor Analyses of the two satisfaction constructs.

F1 Organisation & planning				F2 Implementation & interaction			
	Standardized loads	t-statistic	R2		Standardized loads	t-statistic	R2
Item 1	.902		.813	Item 4	.862		.742
Item 2	.899	12.122	.808	Item 5	.813	6.396	.661
Item 3	.958	17.088	.918	Item 6	.917	11.570	.842
				Item 7	.920	14.264	.847
				Item 8	.869	11.405	.754
				Item 9	.781	6.604	.609
Fit indices							
Just identified model: fitness cannot be assessed.				Satorra-Bentler scaled χ: 3.301			
				Degrees of freedom: 9			
				CFI: 1.000			
Reliability and Convergent validity							
Cronbach's alpha: .941				Cronbach's alpha: .944			
Average Variance Extracted (AVE): .847				Average Variance Extracted (AVE): .743			
Composite Reliability (CR): .943				Composite Reliability (CR): .945			

Structural equation models (Models 1 and 2)

Model 1 and 2 (as defined in Section 2.4) were estimated with the robust maximum likelihood method from the asymptotic variance-covariance matrix. EQS 6.1 software was used for this purpose. The fit indices obtained in the two models corroborate their goodness of fit (Table 7).

Table 7. Results of the two models tested using SEM.

	Model 1 Sample: 44 accredited (a)	**Model 2** Sample: 36 non accredited (a)	**Hypothesis**
Correlation research level – teaching quality	.169 (1.558)	—	H2: Rejected
Path: Research accreditation → Satisfaction	-.352 (-2.298) (b)	—	H3: Accepted
Path: Teaching quality → Satisfaction	.379 (6.755) (b)	.480 (4.724) (b)	H4: Accepted
Path: F3-organisation&planification	1.000 (2.437) (b)	.996 (12.852) (b)	
Path: F3-implementation&interaction	1.000 (2.664) (b)	1.000 (6.347) (b)	
Path: F3-results	.878 (2.893) (b)	.849 (1.0E+38) (b)	
Fit indices			
Satorra-Bentler scaled χ	69.230	71.562	
Degrees of freedom	50	41	
p-value for the χ	0.037	0.002	
CFI	.773	.905	
RMSA	.095	.146	

(a) Each cell contains: standardized solution and t-statistic in brackets
(b) Significant at the 5% level.

Results for the first model (see Figure 6 and Table 7) indicate a negative relationship (-.352) between the level of the research accreditation and student satisfaction. That is to say, a lecturer with a higher professional category, would have a worse evaluation by students. In the light of this finding, hypothesis 3 is accepted.

Figure 6. Results of SEM.

To validate the relationship between teaching quality and student satisfaction, both models have been taken into account. In the case of non-accredited lecturers, the relationship between teaching quality and student satisfaction is found to be positive (.480) and significant. For accredited lecturers (model 1), it is clear that teaching quality is also positively related to student satisfaction (. 379). Consequently, hypothesis 4a and 4b can be accepted.

As expected, results show that the research level achieved by the lecturer has a negative impact on student satisfaction. Moreover, when comparing the two models it is possible to interfere that although passing the evaluation process of the DIEQ, teaching quality exerts a highest (and positive) influence on students' satisfaction when the lecturer does not hold a research accreditation.

Our results are in accordance with those of Serow (2000), signalling that research outputs are the most relevant merits of any lecturer for internal professional career. We insist on the fact that our sample is from only one university, and the size is not really big enough to vouch for reliable analysis. The conclusions drawn from it have to be taken with caution. Thus, based on our particular results, findings suggest that current incentive systems at universities negatively impacts on student satisfaction.

DISCUSSION

Universities are expected to be centres for high quality education and hubs of research and innovation. Therefore, examining how students' satisfaction is affected by the profile of the lecturer in terms of teaching and research is of great interest.

This paper contributes to the literature that examines the trade-offs between teaching and research quality. One of the main findings of the research is that the level of teaching quality does not depend on the level of research, as no correlation has been found between these two variables. Moreover, students' satisfaction is the same for both groups of accredited and non-accredited lecturers.

Within the group of accredited lecturers, our findings indicate that the highest the engagement in research activities, the worst the evaluations of the teaching performance coming from students' surveys. This situation can be explained by several reasons. First, there is a limited time and energy for lecturers to do both teaching and research tasks in a high level of quality. Second, teaching and research require diverse abilities or skills, and therefore, it is difficult to find both in the same person.

Third, current incentive systems are research-biased. In this sense, accredited lecturers have more stable labour contracts compared to non-accredited ones. Promotion of lecturers on the basis of research sends a signal to young academic staff to reduce their motivation to teach and increase students' learning. This situation provides a clear incentive for lecturers to render careless attention to teaching activities in favour of research ones. Future research efforts are needed in this direction in order to confirm our intuitions. Direct interviews with lecturers may report interesting findings that could help us to obtain a more comprehensive picture of the motivations of lecturers throughout their academic career.

Our results also indicate that teaching quality exerts a positive impact on student satisfaction. In this respect, differences arising from holding a research accreditation or not, seem not to be determinant. Particularly, when analysing the group of faculty members holding a research accreditation, research quality and teaching quality are not related. Yet, when considering the group of non-accredited faculty members, our findings indicate that the level of teaching quality has a stronger effect on student satisfaction in comparison with the one of those lecturers holding a research accreditation.

Our findings also signal to research-biased incentive systems, which are negatively impacting on teaching quality, and consequently on learning outcomes. Indeed, given the weight that research productivity has in evaluation systems, it becomes clear that for those faculty members who want to carve out an academic career, their incentives will be conditioned, to a great extent, by their capacity to perform research activities rather than by their ability in teaching. This leads us to conclude that current accreditation systems are not obtaining the expected results in terms of teaching. While these two activities should be complementing and enriching each other, empirical evidence suggests that students perceive disadvantages from staff involvement in research activities.

High quality teaching and high quality research are both desirable outcomes. Undoubtedly, universities expect their lecturers to excel in both dimensions; nevertheless, there is very little evidence on how this ideal could be effectively accomplished.

Probably the main limitation of this study relates to the specific analysis of a Catalan private university and the reduced sample considered. Future studies should be conducted with bigger samples and in other universities with similar regulatory frameworks. Another limitation deals with the measures selected to capture teaching and research quality. Although it was possible to create valid and reliable measures that consider viewpoints from different stakeholders, university quality is a broad term that, while in theoretical models seems to be relatively easy to be measured, its practical operationalization is constrained by the availability and feasibility of obtaining the appropriate data.

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Assessing service quality in public transport: the causal role of demographic characteristics and any perception difference among the subcategories

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ABSTRACT

Purpose. This paper first seeks to evaluate customers' service quality in public transport, and then identifies potential demographic characteristic factors that may influence customer perceived service quality as well as any behaviour differences among the subcategories.

Design/methodology/approach. Manager interview and random sampling method was used to survey 288 consumers of public buses. Exploratory and confirmatory factor analyses were used to confirm the scale validity. Thereafter, Structural Equation Modeling, U de Mann-Whitney and Kruskal-Wallis tests were used to assess the causal paths and the behavior differences among the subgroups.

Findings. The three dimensions of functional, convenience and physical environment quality were confirmed as underlying factors to assess customer perceived quality in public transport setting. Age and owning a driving license are factors that directly and positively affect service quality whereas education was negatively related to perceived quality. In contrast, the relationships between being a car user, gender and perceived quality were not supported. The results also showed that service quality have less importance for younger commuter as compared to adults. However, the current study does suggest that people with university education and above may be a better audience for advertising appeals focusing on one of these three significant dimensions of service quality.

Originality/value. This study is the first to propose service quality scale based on real user of public service transport as well as to provide definitive insight on the direct role of demographic characteristics on perceived quality.

Keywords: Service quality, Age, Education, Driving license, Public transport service

Article Classification: Research paper

INTRODUCTION

In the last thirty years, the economic globalization has fostered the ongoing process of residential suburbanization, employment decentralization and the increase in household revenue. All these factors in turn have spawned a pattern of travel that is more suited to the private car than to public transport. Undeniably, the changes observed in urban travel nowadays can be summarized by a growing number of motorized trips as well as an increase in the use of the private car (Hensher, 2003; Litman 2008; Schoettle and Sivak, 2014). In order to reverse this trend, some government and local authorities are now trying to implement actions that could contribute to the generation of positive user's attitudes to public transport (Martin et al., 2012).

According to Matas, (2004), the declining trend in public transport ridership can be reversed through an active public transport policy based on low cost travel passes and most importantly improvements in the quality of service offer. In this respect, some researchers have examined whether quality improvements have effects on satisfaction with public transport services and frequency of perceived negative critical incidents (Friman, 2004; Eboli and Mazzulla, 2010). Surprisingly, one of the most important finding of these studies is that the satisfaction people experience when using public transport services is influenced by quality improvements only to a very limited extent. Thus, prompting call to understand "where" a public transport service must efficiently allocate resources to improve the service of quality offer and thus increase customer satisfaction and differentiate itself from its competitors.

Moreover, it was evidenced and generally accepted that the delivery of superior service quality in retail sector is a vital tactic for success and business survival. With the economic globalization, even the public sector organizations have come under a growing pressure to deliver superior service quality. Yet, customer needs and expectations are different when it comes to governmental services and their quality requirements. Given that service quality practices in public sector organizations is slow and the outcomes are harder to measure (Ramseok-Munhurrun et al., 2010). Besides, there is a lack of freedom to act in an arbitrary way; more scrutiny from the public and press in addition to the pervasive influence of politics and a requirement for decisions to be based in law (Teicher et al., 2002). These distinction roles suggest vastly different kinds of expectations and accountability that may call for different decision making practices (Nutt, 2006).

Despite the debate, some authors have frequently emphasized the need to examine ways to increase customers' acquisition decision related to perceived service quality (Yaya et al., 2014). Obviously, understanding these antecedents can help service provider to gain competitive advantages by implementing specific strategies to increase their service quality offer. Particularly in public transport where service quality is a matter of the greatest importance because an improvement of quality levels can attract further users (Eboli & Mazzulla, 2008). Moreover, previous researches have demonstrated that delivery of higher levels of service quality reduces customers' perceptions of the potential benefits of alternative competitors, enhances repurchase intentions, contribute to the market share and return on investment (Parasuraman et al., 1988; Brady and Cronin, 2001; Karatepe et al., 2005). In addition, higher service quality results in customer satisfaction and loyalty, greater willingness to recommend to someone else, reduction in customer complaints, and improvement of customer retention (Hensheret al., 2003; Ladhari et al., 2009; Marimon et al., 2012; Yaya et al., 2013). Furthermore, even though a substantial amount of research on service quality can be found in the marketing literature, little attention has been paid to the influence of some demographic characteristics such as gender, education, age etc. on the construct of perceived service quality.

Against this background, the objectives of this study are threefold: first, to provide based on management interview and on up-to-date literature review the most comprehensive customer service quality assessment on public transport. Second, to identify demographic characteristics (gender, age, education, driving license and car user) that may influence customer perception service quality on public transport and finally, to categorize if there is any differences in term of service quality perception among the demographic characteristic groups.

This paper is structured as follows: After this introduction, the second section presents a review of literature, the conceptual framework and research hypotheses. Thereafter, the methodology used is described in the third section. Subsequently, the results are presented in the fourth section. Finally, the paper ends with the conclusion and management implications.

LITERATURE REVIEW

Service quality assessment in public transport. Service quality has been conceptualized and defined as the outcome measure of the gap between customers' expected performance of service offered and its perceptions of the level of service received (Parasuraman et al., 1998). In general, the concepts of service quality are fundamental to successful business because they are crucial to costumers' decisions making (Yaya et al, 2011). Despite the phenomenal growth of the service sector, only a handful of researchers have focused on developing service quality (Parasuraman et al., 1998; Ladhari et al., 2009). This is probably due because of the difficulties involved in delimiting and measuring the construct. Given that unlike goods quality, which can be measured with some objectivity, service quality is abstract and elusive. The unique features of services such as inseparability of production and consumption, intangibility, and heterogeneity make measurement of quality a very complex issue (Karatepe et al., 2005).

Nonetheless, early research groundwork on service quality was based the disconfirmation paradigm and two schools of thought dominate the extant literature. In adapting the disconfirmation paradigm the Nordic school proposed two service quality dimensions: the functional quality which identified how the service is delivered and the technical quality that represents the outcome of the service (Grönroos, 1984). On the other hand the American school also divided the quality construct into different dimensions and comprehend customers' experiences such with the Tangibles, Reliability, Responsiveness, Assurance and Empathy that in turn served a common them represented by SERVQUAL. By using SERVQUAL as a modifier, Brady and Cronin, (2001) argued that service quality constructs conforms to the structure of a third order factor model including, interaction quality, physical environment quality, and outcome quality. Overall, it is generally accepted that all these models have contributed to better understand the service quality concept. However, there are still two important issues that are matters of debate. The first relates to the debate of whether service quality must be defined following the Scandinavian or the American conceptualization. The existing literature point toward that the SERVQUAL (American school) is the mostly used in the literature.

The second issue is that although there has been considerable progress as to how service quality should be assess, the applicability of a generic scale for measuring service quality in all settings has been questioned (Yaya et al., 2012). Given that many of the generic SERVQUAL items just do not apply in any specific context, some managers and researchers are often forced to radically modify the scale items (Ladhari et al., 2009). Drawing on that Karatepe et al., (2005) argued that instead of taking an existing instrument and trying to fit it to the context, a better approach is to develop an instrument specifically for the focal service. Given that, the more specific the scale items are in a service quality instrument and the more applicable they are to managers own contextual circumstance, the better the information collected are useful. For these reasons, many techniques for measuring service quality and defining the importance of service quality attributes and global satisfaction on public transport have been proposed in the literature.

For example, Ramseook-Munhurrun et al., (2010) have used and adapted the generic model of SERVQUAL to evaluate how closely customer expectations of service and front line employees perceptions of customer expectations match. The key finding of the study is that front line employees' perceptions should focus on those dimensions which receive lowest ratings and attributes with high gap scores. Moreover, Eboli & Mazzulla, (2008) used a stated preference experiment to provide a way to measure service quality in public transport based on convenient students' sample. The authors concluded that the dimensions of quality viewed from a customer's perspective are complex and perceptions about qualitative characteristics of service are very different among users of public transport. Build on earlier research by the authors, Hensheret al., (2003) proposed service attributes to calculate an overall service quality index. They argued that their propose service quality index can be used to investigate ways of quantifying service quality, calculate the satisfaction associated with existing service levels and compare the levels within and between bus operators.

In addition, Beirao and Sarsfield-Cabral (2007) proposed a qualitative study of public transport users and car drivers in order to obtain a deeper understanding of travellers' attitudes towards transport and to explore perceptions of public transport users. This qualitative study highlighted some key factors influencing mode choice. In fact, the key findings indicate that the choice of transport is influenced by several factors, such as individual characteristics and lifestyle, the type of journey, the perceived service performance of each transport mode and situational variables.

Although there is general agreement that public transportation service quality is multidimensional, certain general observation can be made. For example, some have adapted and used generic models scale such as the SERVQUAL. However, significant confusion in the literature seems to exist in regards to the content, the number and the nature of the dimensions influencing consumer perceptions of public transport service (Hensheret al., 2003; Eboli & Mazzulla, 2008; Ramseook-Munhurrun et al., 2010). Moreover, there were problems associated with some components of exploratory or confirmatory factor analysis, the hierarchical nature of the service quality constructs and the use of many techniques not based on customer evaluation (Yaya et al., 2012). In addition, some have used convenient sample rather than genuine user (Karatepe et al., 2005; Ladhari et al., 2009). Therefore, the scales developed in those previous studies raised some important questions that call for additional research on the topic (Parasuraman et al., 1998).

Relationships between demographic characteristics and perceived service quality. According to Ganesan-Lim et al., (2008) it is important to understand the relationship between the customer's perception of service quality and demographic information such as age, gender, education and income level. This information is useful for ensuring there are suitable products available for the target market (Yaya et al., 2014). For example, men and women have been shown to differ in their attitudes toward both the Internet and the traditional services. According to Stafford (1996), service quality seems more important to women than to men in the traditional bank service, although men also find certain aspects of quality to be highly important. Moreover, Mokhlis (2012) showed that male customers attached greater importance on empathy, tangibles and reliability than did female customers. The authors further argued that online environment has an effect on buying attitudes, but more strongly so for women than for men. Whereas men's functional concerns are amplified rather than changed in the shift from conventional to online buying, women's motivational priorities show a reversal, and less involvement in shopping. In contrast to men, women's online buying is associated with social experiential factors barriers and facilitators such as efficiency, identity related concerns grounded in their attitudes toward conventional buying. Consequently, we anticipated that

H1: gender will directly and positively affects customer perceived service quality

Indeed, age allows a marketer to determine how wants and needs change as an individual matures (Stafford, 1996). According to Eagle, (2009) people in the same age group display similar shopping behaviour and this information is important to retailers to understand more about their market. Besides, Ganesan-Lim et al., (2008) found that age has a big influence on the perception of service quality. This however is different based on the study by Yaya et al., (2014) who found no relationships and no differences in the various subgroups categories of age, education, and income in terms of service quality, value, and satisfaction online banking. Consequently, the authors concluded that customers' demographic characteristics limitation on the adoption of online banking is now a past history.

H2: Age will directly and positively affects customer perceived service quality

Likewise, Kotler & Armstrong (2010) intimated that demographic characteristics are an accepted basis of segmenting markets and customers. The authors further argued that in the last sixth decade or so, there has been an increase in educated people in the United States and this leads to an increase in the demand for quality products. According to Litman (2008), one of the most important public transport benefits is that it increases education and employment participation by non-drivers. According to Samat et al., (2006) training and education has no significant impact on the perception of service quality. However, the authors argued that it may have happened because the measurement used to assess the level of training and education practiced in the service organizations were more focused on the skills not on the delivery of service itself. Thus, there is an imperative need to understand just how education affects perceptions of service quality deliver by public transport. Since, the outcome is of paramount importance to determine which elements of service quality are important to different education groups.

H3: Education will directly and positively affects customer perceived service quality

In general, a full driving license is obtained after completing a driver's education course and passing written and practical tests. In the driving license course, students are not only thought on how to handle a car in the proper and safe manner, they are also thought the rules of the road and the laws involved as well as the basic car maintenance. According to Martin et al., (2012), actions that generate positive attitudes towards the use of public transport may increase customer perception of public transport. Such action may include introducing the concepts of sustainable mobility in the curricula of formal education and the driving license lessons. More recently, Schoettle and Sivak (2014) examined the attitudes of young adults and the potential influence of recent societal changes, including graduated licensing; changes in transportation and communication technologies; changes in the social status attached to driving and car ownership. One the study main conclusion was that young adults without a driver's license in comparison with the general population of the same age tend to have less education and higher unemployment. Drawing on that, it was anticipated that

H4: Having a driving license will directly and positively affects customer perceived service quality

According to Martin et al., (2012) study, the psychological and social factors that influence an individual's choice of transport mode often results in a preferred use of the private vehicle over public transport. Even so, public transport systems need to become more market oriented and competitive. This requires an improvement in service quality, which can only be achieved by a clear understanding of travel behaviour and consumer needs and expectations. Therefore, it becomes essential to measure the level of service in order to identify the potential strengths and weaknesses of public transport service (Beirao and Sarsfield-Cabral, 2007). Consequently this study anticipated that

H5: Being a Car User will directly and negatively influence customer perception of service quality

Moreover, Kotler & Armstrong (2010) intimated that demographic characteristics were an acceptable basis of segmenting customers and markets. Linked with this, Stafford (1996) it is critical to determine which elements of service quality are more important to different customers because different demographic segments might perceive different elements of service quality to be more important than others. Thus, this demonstrates the importance of determining whether or not it exist a significant difference in term of perceived service quality between each segment of the demographic characteristics. Therefore, it was hypothesis that

> *H6: there is significant difference in term of perceived service quality between the subcategories of gender, age, education, having driving license and car user.*

METHODOLOGY

Questionnaire and measures. One of the explicit objectives of this study was to determine customer perception of public transport service quality and then the importance that the users place on certain improvable variables. To accomplish these objectives, we followed a multistep process. First we searched for articles published in leading academic and practitioner oriented related to public transport service. Some important factors such as tangibles, service environment and responsiveness, in addition to empathy, cleanliness etc. were identified. Nonetheless, some of those factors contained variables that were specific to retail industry or contain potential confounding feature. Consequently, an in-depth interview was organized with the Girona city council management of the public bus transport.

After the interview, it was evidence that the quality of the public transport service is covered by many other specific factors such as the service "reliability" which reflects how good the bus transport service follows published schedules, the "aesthetics" which represents how the employees and bus are appealing. Also, the output of the management interview brought to light some other important facts such as "tangibles" which reflects how the buses are preserved and the ability to accommodate various users, including people with disabilities, prams and baggage. In addition, factor such as "information", "user comfort and security" were suggested. Finally, "convenience" that represents the extra features such as the appropriateness and other services that enhance user comfort and enjoyment were also proposed.

To ascertain a good content validity, we search through the literature for any items related to those relevant factors and used them as modifier (Brady and Croning, 2001). The survey questionnaire was organized as follows: the first section started with the 22 items to assess the service quality and closed with a single question to assess overall service quality. The service quality modifier items were adapted from (Parasuraman et al., 1998; Hensheret al., 2003; Friman, 2004; Beirao and Sarsfield-Cabral, 2007; Eboli and Mazzulla., 2008; Litman, 2008). All the statements were assessed based on the 11 point Likert-type scale ranging from "Strongly Disagree" (0) to "Strongly Agree" (10). The second section sought demographic data on respondents (gender, age, education). Respondents were also asked to respond by "Yes" or "No" if they possess a driving license. In addition, respondents were asked if they were "regular", "sporadic" or "not all" car user.

Sampling and data collection. In order to validate the correct formulation and maximize the content validity, the questionnaire was pilot tested on a small group of 15 students and professors. A few of them suggested alternatives for some confoundable wording question. In particular, they identified a total of three questions that were correctly reworded. Finally, the survey method was selfadministering questionnaires distributed at various locations of the medium size city of Girona. Public transport users were selected by choosing a random starting point and choosing every fourth individual customer in succession thereafter. Respondents were primarily screened to safeguard that they had used the service within the last three months.

Data collection was completed in April 2012. After rejecting some incomplete or invalid questionnaires, the resulting sample consisted of 288 valid completed questionnaires. Obviously, it was necessary to check that the final data collected was undeniably a representation of the bus user population. The comparison showed that the sample accurately reflects the population in general, except for the age group (17 – 24) which was overrepresented.

RESULTS

Demographic characteristics profile. A summary of the demographic characteristics profile of the respondents in the study shows the sample was biased towards female (63%). The sample profile also indicated that 29% attended college and primary school, 39.90% had a Bachelor's Degree and 13.70% had a Master Degree and above. On the other hand, 11.70% of respondents were attending professional training and 5.50% did other type of education. Moreover, 51.20% of respondents were aged from 17 to 24 whereas 23.70% were aged between 25- 44 and 25.10% were 45 years old and above. The sample was slightly skewed towards respondents (56.40%) who have a driving license. Furthermore, 78.70% said they are car user and 14.10% indicate that they use a car sporadically and only 7.20% said they have never use a car.

Assessment of the perceived service quality scale. Arrays of Exploratory Factor Analysis (EFA) were conducted to exclude items not deemed important by respondents using normalized varimax as the rotation method. The Kaiser criteria of eigenvalues greater than 1 was utilised to determine the initial number of factors to retain (Hair et al., 1998). Careful scrutiny on the items loading were used to identify and discard items that loaded poorly (load value < 0.5), cross-loaded or loaded equally in more than two factors. Close inspection on the items loadings on their respective constructs revealed that Q1 "Bus service always complies with the time scheduled", Q7 "Information at the bus stops is appropriate" and Q18 "The current price of the ticket seem right to me" loaded poorly, thus were discarded. Furthermore, a new principal components analysis was carried out using the remaining items. A check on the items loadings on their respective constructs revealed Q2 "Connections with other buses lines are adequate", Q13 "I feel safe with driving provided by the driver" and Q19 "The information on incidents such as route changes, summer time schedules etc. is appropriate" loaded in more than two factors, hence, were deleted.

After several iterations, a final group of 16 items measuring three dimensions with a total variance of 61.44% remained. The Kaiser-Meyer-Olkin (KMO) measure was 0.92, the Bartlett's sphericity test was 2240.11 with df = 120 and a significance of $P < 0.001$. According to the load of the items on their respective factors, the scale to measure public service transport service quality was composed of three dimensions namely "Functional Quality"; "Physical Environment quality" and "Convenience quality". The dimensions were rationally given a name that makes a good representation of all the items under the factor.

Structural Equation Modelling (SEM) was used to further examine the service quality dimension measures and their reliability and validity. The good fit of the psychometric properties of the items was assessed through a comprehensive Confirmatory Factor Analysis (CFA) using Partial Least Squares (PLS). All the items retained were assessed in the same model and were restrained to load on their respective factors. Individual item was deemed valid if its load value was greater than 0.7

(Carmines and Zeller, 1979). The overall results of the CFA loadings showed that the majority of the items exceeded the acceptable threshold. Moreover, CFA was also performed using EQS 6.1 software package to confirm the robustness of the scale. The scale fit was evaluated and the results of the robust maximum-likelihood showed the CFI was 0.90, the IFI was 0.91, the BBNFI was 0.89 and RMSEA was 0.06. Besides, the Satorra-Bentler scaled chi-square χ^2 was 236.56 with 101 degrees of freedom. The ratio χ^2/df was 2.3 and all standardised factor loadings were statistically significant (at $p<0.000$). These results indicate that global fit was acceptable. The loads were all high (at a significance level of 0.05) and the scale was therefore shown to be an acceptable fit for the data.

Furthermore, the validity of the individual item on their corresponding factors was confirmed by their load values that met and exceeded the acceptable threshold and by the t-values of the factor loadings that were all found to be statistically significant at $P< 0.001$. Moreover, the internal reliability of the scales was assessed based on three indicators. Specifically the Cronbach's Alpha (α), the Composite Reliability (CR) and the Average Variance Extracted (AVE). The results indicated that the scale possessed a high internal consistency and reliability, since each individual α and the CR was greater than the minimum accepted value of 0.7 (Peterson et al., 2013) and the AVE value was greater than the accepted threshold of 0.5 (Fornell and Larcker, 1981). Additionally, the convergent validity was established because all t-values were significant and the AVE values greater than 0.5. In addition, all the construct pairs in the model were tested for discriminant validity following Fornell and Larcker, (1981). Discriminant validity was confirmed, since all construct pairs assessed through linear correlations were less than the square root of their corresponding AVE. Besides, discriminant validity was also confirmed by authenticating that each element included in the model represents a separate entity. The overall results further confirmed discriminant validity. Since, the correlation coefficients were less than 1 by an amount greater than twice their respective standard errors (Hair et al., 2011).

Causal path model assessment of factors that influence service quality. Instead of regression analysis, the causal relationship paths between the different constructs were assessed by means of the Partial Least Square Structural Equation Modelling (PLS-SEM). PLS-SEM was deemed more reliable with this study objective. For the reason that PLS-SEM has an important capability of estimating latent variable scores as exact linear combinations of their associated manifest variables and treats them as perfect substitutes for the manifest variables (Hair et al., 2011). Moreover, PLS-SEM can achieve high levels of statistical power because it provides a flexible framework for testing a range of possible relationships between categorical independents and continuous dependents (Kline, 2011). Moreover, SEM can model all regression equations simultaneously and quantify the contribution of each predictor to the covariance structure, whereas neither the interaction of continuous variables nor the interaction terms for categorical independent variables in a regression model can do so (Kupek, 2006). The structural path representing the model's relationships was estimated by means of Partial Least Squares (PLS) with the Smart PLS 2.0 software package.

To assurance that the statistically significance paths of the inner model parameter estimates were stable, the causal relationship paths were assessed based on 5 000 re-samples Bootstrapping method in accordance with Hair et al., (2012). The overall results showed that no all the hypotheses were supported ($p < .05$). As predicted, Age was directly and positively related to customer perceived service quality as a whole (H2). Details analysis indicated that Age has the strongest influence on the perception of Physical Environment Quality, follows by Convenience and then Functional Quality.

In the same vein, the study results also indicated that owning a Driving License is a factor that influences customer perceived service quality (H4). Possessing a Driving License influences equally customer perception of Functional (H4a), Physical Environment Quality (H4b). Nonetheless, owning a Driving License has no influences on perception of Convenience (H4c). Contrary to our prediction, being a Car User has no effects neither on overall service quality nor on any of the factors associated (H5). Moreover, the results show Education was strongly and negatively related to customer perceived overall quality (H3) with Convenience (H3c) as the strongest factor follows by Environmental (H3b) and Functional (H3a). In contrast, the proposed relationships between Gender and all the dependent variables of service quality were not supported (H1).

In addition, independently of the SEM results, the sample was also subjected to the U de Mann-Whitney and Kruskall-Wallis tests to detect if there were any mean differences among the subcategories. The overall results indicate significant mean difference between the subcategories of education. The results reveal an interesting finding. Customers with high school follow by college education appeared to have the highest perception of the overall service quality and its three components. In contrast, those with Professional Training follow by University Degree and above education rated lowest their perception of physical environment follow by convenience and then functional Quality.

The overall results also indicated that age was proved to be a discriminating variable on all the three factors of perceived service quality. An inspection of the factor score means reveals there is a consistent linear trend across the dimensions. The mean importance rating for those aged 17-24 is lowest than any other subcategory group. Besides, convenience was the factor those aged 17-24 rated lowest mean score, follows by physical environment and then functional quality. Nevertheless, the importance rating for those aged 45 and above was the highest across all the dimensions. Contrary to our predictions, the overall results indicates there were no significant difference of perceived service quality between the subcategories of Male and Female and between owing or not a driving license. In the same vein, the overall results also indicate no significant difference of perception of service quality between those using a car regularly, sporadically and not all.

CONCLUSION AND MANAGEMENT IMPLICATIONS

Nowadays, there are several different forms of public transportation services available including buses, various forms of train systems that provide short or long distance travel, ferries, subways etc. The benefits and importance of public transportation impacts each and every one. Not just in terms of environment benefice as it cuts down on the amount of the cars on the road and hence reduces the emission of carbon dioxide, it also contributes in the reduction of air pollution, noise and traffic congestion (Teicher et al., 2002; Friman, 2004; Eboli and Mazzulla., 2010). In social term, public transportation ensures that all members of the society including people with disabilities, children etc. are able to freely move around without any restriction. In addition, it provides basic mobility, such as access to medical services, essential shopping, education or employment opportunities (Litman, 2008). Thus, providing a superior service quality in public transport service is one of the crucial aspects to take into account while talking about citizen welfare.

Drawn on the management interview and the review of literature, this study first seeks to develop a multi items scale that could be used to assess the service quality of public transport service. The overall, results indicated that Functional, Physical Environmental and Convenience represent the underlying dimensions of customer perceived service quality in public transport setting. Obviously, Functional Quality is composed of items related to aesthetic, assurance, empathy and responsiveness; while Physical Environmental quality is composed of items related to atmosphere, comfort, ease of access, safety and security. Finally, the Convenience Quality was composed of items related to reliability, efficiency and suitability.

Thereafter, this study seeks to comprehend the fundamental demographic characteristics that may influence the perception of service quality dimensions. The overall results showed that age and owning a driving license are factors that directly and positively affect all the dimensions of customer perceived service quality. This is consistent with Schoettle and Sivak (2014) who argued that young driver licensing in the USA preferred to use public transportation because maintaining a vehicle is too expensive. The output result is consistent with (Stafford, 1996; Ganesan-Lim et al., 2008) who also found age has a big influence on the perception of service quality.

On the other hand, Education directly and negatively influences the construct of overall service quality and all its components. This was consistent with the study of Schoettle and Sivak (2014) who found that 37% of students said they were too busy or do not have enough time to get a driver's license. In contrast, the proposed relationships of both Gender and being a car user on service quality were not supported. This was in accordance with Yaya et al., (2014) who also found gender not to be related to service quality in the banking sector.

Moreover, across the three dimensions of customers perceived service quality the means decrease considerably as age decreases. The immediate consequence was that the attributes of service quality have less importance to younger commuter as compared to adults. Moreover, the behaviour difference between the subgroup categories showed customers with high school follow by college education alleged the most important factors to be taken into account while developing public transport service must be the functional quality, follows by physical environmental and the convenience quality. In contrast, the means score of those with Professional Training education follows by University Degree and above were very low across all the dimensions of service quality. The current study does suggest that people with university education and above may be a better audience for advertising appeals focusing on one of these three significant dimensions of service quality.

Indeed, the proposed customer perceived service quality can help public transport service management to identify which service quality factors are considered the most important by their customers. It can also be used to help prioritize future quality of service improvement initiatives, measure the degree of success of past initiatives and track changes in service quality over time. Factors, such as age, education and owning a driving license can be used for monitoring, evaluating, and implementing improvements in service quality offer.

In addition, service provider can offer a targeted service based on the importance each subcategory group according to the degree of importance given to each dimension of service quality. For example, a development of sustainable mobility workshops with information related to low service charge may improve customer consumption of public transport. Besides, it is important to start promoting the importance of public transport in schools and college with the end means that ensure the acquisition and knowledge on how to properly use all possibilities offered by the public transport. Moreover, promotional efforts related to the convenience quality items might be highly effective for those aged 17-24. Targeted services, such as express commuter buses, and services to students' special events may have a significant difference on the students' perception of service quality. Introduction of sustainable bus with no/limited CO_2 emission in the curriculum, bus comfort improvements such as more and better seats may improve perception of service quality for people with higher education. All in all, it is imperative for public transport service managers to be sensitive to the different demographic characteristic segments when developing corresponding marketing and promotion strategies.

Even though findings of this study provide initial direction in assessing service quality, some limitations must be acknowledged. The sample split into the subgroups of demographic categories shows only about 20% were "No" and "occasional" car user. Moreover, there was a slight gender bias. Therefore, future research may use a larger and balance sample size. Another limitation was that the study was confined to the bus service industry and in one country which makes the generalizing the results risky. A replication of this study in different country and other transportation public service such as subway and long distance train service would therefore be desirable.

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Six Sigma DMAIC project to improve the performance of an aluminium die casting operation

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ABSTRACT

Purpose. The purpose of this paper is to illustrate an application of the Six Sigma DMAIC problem-solving methodology in a Portuguese industrial enterprise, aimed at reducing the rejection rate of a specific manufactured product due to defects generated in the aluminium die casting operation.

Design/methodology/approach. Along the five-stage roadmap, a set of analytical tools was structurally employed to better characterize the problem, define the product's critical to quality characteristics, estimate the process baseline, determine the relevant cause-and-effect relationships, identify the significant root causes for the high rejection rate, and implement an improvement plan.

Findings. To the successful execution of the Six Sigma project greatly contributed the belief and support of top-management and the active involvement of team members. Another key finding is that not all die casting defects were caused by factors inherent to the die casting operation itself, but also by incorrect procedures adopted in other areas of the process.

Research limitations/implications. The project is not fully completed, since some of the improvement actions are being implemented.

Practical implications. The findings demonstrate the importance of adopting the systems approach principle in a Six Sigma project.

Originality/value. Few Six Sigma case studies are described in such detail in the literature, mainly practical applications in Portugal. The paper proves the advantages of combining advanced quality engineering techniques with Lean tools, and demonstrates the importance of conducting a Six Sigma project using the systems approach principle.

Keywords: Design of Experiments, Die casting, DMAIC, Lean, Six Sigma

Article Classification: Case study

INTRODUCTION

Six Sigma is a project-by-project, customer-focused and data-driven approach that makes use of a structured and systematic methodology, which relies on the DMAIC (Define, Measure, Analyze, Improve, Control) roadmap, to enhance the capability of business processes. To be effectively implemented, this problem-solving methodology requires full management belief and commitment, a well-trained and experienced technical project leadership to act as a change-agent, and a dedicated and competent multifunctional project team.

Despite its growing popularity, few practical applications of Six Sigma in Portugal have been reported. This paper describes a concrete application of a Six Sigma project in a Portuguese industrial enterprise, by outlining the activities that were carried out during each phase of DMAIC and by illustrating how, when and why a set tools and techniques were employed. The project was identified and selected to improve the current manufacturing process, in order to minimize the rejection rate of a specific produced item, an aluminium window handle model.

The paper is organized around five main sections. In section 2, a brief overview of Six Sigma is performed. The current state of the implementation of Six Sigma in Portugal is analyzed in section 3. The case study is presented and described throughout section 4, as well as the discussion of its results and its practical implications. Finally, the conclusions of this paper are summarized in section 5.

SIX SIGMA

Six Sigma has been labeled and defined in a variety of ways, but it is often described from the following three viewpoints:

- Metric.
- Methodology.
- Management system.

The name Six Sigma derives from statistics, as the sigma level metric is a measure of conformance quality (De Mast, 2007). Achieving a six-sigma level quality means that processes are producing nearly perfectly, with a probability of not producing more than 3,4 defects per million of opportunities (DPMO) (Pande *et al.*, 2000). Not all processes need to perform at such level of quality. The metric perspective of Six Sigma is well explained in Breyfogle III (1999) and in Barone and Lo Franco *et al.* (2012).

From a methodological viewpoint, Six Sigma is a project-by-project approach that is carried out through a succession of predefined phases, inspired on the PDCA cycle (Harry and Schroeder, 2000). DMAIC (Define, Measure, Analyze, Improve, Control) is a five-phase roadmap used in Six Sigma projects targeting the performance improvement of an existing process, product or service. Figure 1 depicts the general activities that usually takes place in each of its phases. To support factual data analysis and decision-making during the project activities, appropriate tools and techniques are employed. Between each transition of phase, a formal project review, called “tollgate”, takes place.

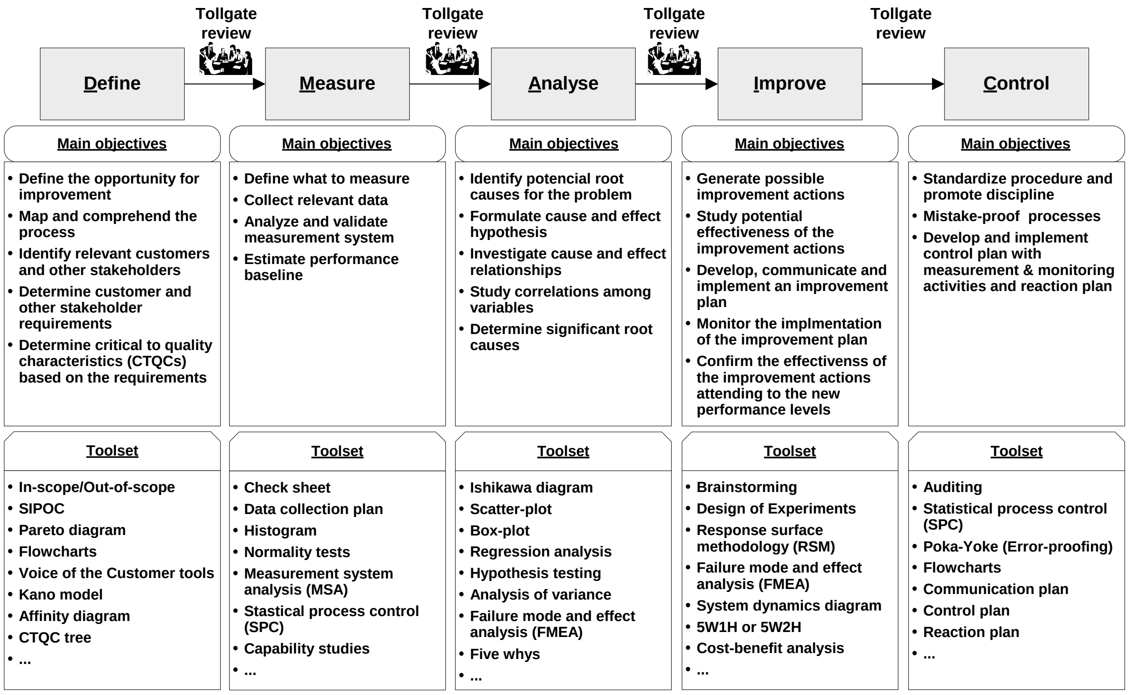


Figure 1 – The DMAIC roadmap of Six Sigma [From Marques, 2013)]

When combined with Lean Management, the resulting approach is known as Lean Six Sigma (George *et al.*, 2005). Lean, a concept that derives from the Toyota Production System (TPS), uses a set of principles and tools to detect and eliminate all forms of waste throughout the value stream, which represents the entire collection of activities necessary to produce and deliver a product or service (Pepper and Spedding, 2010). Waste is any event within the value stream that does not contribute to add value to the product or service from the customer viewpoint. Six Sigma focuses on reducing process variation and enhancing process control, while Lean drives out waste and promotes work standardization and flow (Su *et al.*, 2006). They are different but complementary. Lean principles and tools can be utilized in all phases comprising the DMAIC roadmap.

Design for Six Sigma (DFSS) is methodological branch of Six Sigma that should be applied when innovation efforts are involved in a project (Hoerl and Gardner, 2010). Thus, DFSS is carried out to redesign an existing product, service or process, or to create a new one. Several DFSS roadmaps have been proposed in the literature, but the IDOV (Identify, Design, Optimize, Validate) and the DMADV (Define, Measure, Analyze, Design, Verify) are the most often employed (Shahin, 2008).

Regardless of the adopted methodological approach, all Six Sigma projects go through the following five stages (Marques *et al.*, 2014):

1. Identification of Six Sigma projects.
2. Selection of Six Sigma projects.
3. Six Sigma project planning
4. Six Sigma project execution and completion.
5. Post Six Sigma project.

The first three stages mentioned are sometimes performed in a pre-project stage called "Recognize". As a management system, Six Sigma is an enterprise wide initiative, aligned with its strategy and business processes' goals, which deployment relies on a well-trained role structure, with specific levels of responsibilities (Zu *et al.* 2008). The human infra-structure of a Six Sigma program as well as the typical roles of a Six Sigma project, are well described in Kubiak and Benbow (2009). A relatively new issue on Six Sigma concerns the integration of a Six Sigma program with management system standards, in particular ISO 9001 for quality management systems. Karthi *et al.* (2011) and Marques *et al.* (2013) provide a good insight on this subject.

SIX SIGMA IN PORTUGAL

The amount of information about the current state of the applicability of Six Sigma in Portugal is scarce. This section aims to contribute for a better characterization of the initiative in the country. To that purpose, a specific literature review was conducted and relevant data and information were identified and analyzed.

Conceição and Major (2011) carried out a survey study to determine the extent to which Six Sigma is adopted by the largest 500 non-financial companies operating in Portugal. Their main conclusions were the following:

- The implementation of Six Sigma still has little expression in those companies.
- Despite this, companies demonstrate a good interest in Six Sigma, just surpassed by ISO 9001 and Balanced Scorecard.

Pacheco (2012) also showed that the majority of Portuguese companies (about 82%) consider Six Sigma an important methodological approach, but reveals that other less complex quality methods, such as benchmarking and many of the quality basic tools, are considered to be more important than Six Sigma.

Carvalho (2008) also attempted to assess the extent to which Portuguese companies adopt a set of total quality management approaches, including Six Sigma. To that purpose, the largest 1000 non-financial companies operating in the country were surveyed. From the 124 questionnaires received and validated, only 13 of the companies indicated to have adopted Six Sigma.

For Lopes *et al.* (2011) one of the reasons that can explain why just a few number of Portuguese industrial companies adopt Six Sigma is the fact that its implementation is more demanding when compared to other quality improvement approaches, which requires more investment in resources and training. Based on the results of a survey targeting Portuguese industrial companies, Silva *et al.* (2010) concluded that the inability to quantify benefits could be other of the obstacles to the widespread of more advanced approaches, such as Lean and Six Sigma; according to the study, managers are reluctant to adopt new continual improvement paradigms if the expected benefits are unclear.

Peer-reviewed literature containing case studies or practical applications of Six Sigma in Portugal was identified. The results are shown in table 1. According to our literature review, the first case study was published in a Portuguese journal in 2009 by Matthé (2009). In the following year, Delgado *et al.* (2010) published the first Six Sigma case study that took place in Portugal in an international journal.

Since then, every year at least one case study has been published. There are, however, other indicators that demonstrate an increasing interest in Six Sigma. One of them is the positive evolution on the number of M.Sc. and Ph.D. thesis from Portuguese universities on the subject. Figure 2 was constructed based on the information provided by the thesis and dissertations repositories of the Portuguese universities.

Table 1 – Publications describing practical applications of Six Sigma in Portugal

Reference	Project scope	Company
Matthé (2009)	DMAIC project to reduce the delivery time of produced goods	STA (producer of systems for doors and windows)
Delgado *et al.* (2010)	DMAIC project to speed-up the auto loan process	GE Money Portugal
Riesenberger and Sousa (2010)	DMAIC project to errors during the customer complaints process	Bosch Car Multimedia
Gomes (2010)	DMAIC project to reduce errors in the Printing Systems area	Xerox Portugal
Marques *et al.* (2011)	Integration of Six Sigma with ISO 9001 and execution of a Six Sigma DMAIC project	STML- (engineering services provider)
Baía (2012)	DMAIC project to increase the filling operation capability	Company that sells fertilizer bags
Abreu *et al.* (2012)	DMAIC project to the reduce the response time of the complaints	Bosch Car Multimedia
Ferreira *et al.* (2013)	DMAIC project to	Producer of domestic water heating equipments
Antunes *et al.* (2013)	DMAIC project to improve the raw material supply process	Bosch Car Multimedia
Tenera and Pinto (2014)	Integration of Six Sigma with a project management system based on PMI (Project Management Institute) best practices	Telecommunications company
Marques *et al.* (2014)	DFSS project to design a new transportation service	Transportation and logistics company
Ferreira *et al.* (2014)	DFSS project to redesign a metallic mould	Plastic manufacturing company

The first doctoral theses were published in 2012 and 2013, and the number master thesis started to arise since 2008. Most of these thesis contain practical applications of Six Sigma projects in different types and sizes of organizations.

Another indicator is the increasing number of short and long term training courses on Six Sigma offered in the country. For instance, currently, four post-graduate degrees on the subject are offered, while before 2007 no such type of course existed in the country. Since 2008, a Six Sigma conference has been taking place in Portugal almost every year. Various companies from distinct business sectors have presented communications at this event, showing concrete Six Sigma projects and their results.

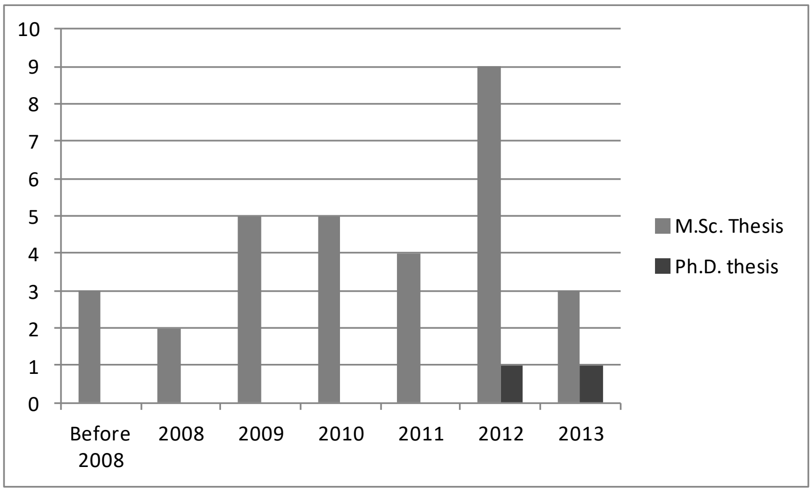


Figure 2 – Evolution of the number of M.Sc. and Ph.D. thesis on Six Sigma in Portugal

To sum up, despite the adoption of Six Sigma by companies operating in Portugal remain very low, there are a set of indicators that reveal an increasing interest from both the academic and professional communities.

CASE STUDY

This section describes a Six Sigma project developed at STA – Sociedade Transformadora de Alumínios, S.A., an organization that is specialized in the design and production of systems for doors and windows, particularly for aluminum profiles.

Evidences have shown that the current rejection rate of a specified manufactured item, a window handle model that is depicted in figure 3, was very high. Moreover, many of the defects are only detected at the end of the manufacturing process. These two related problems lead to significant waste factors and costs, including the following:

- Waste of time and resources resulting from unproductive working hours in defective items and in rework tasks.
- Costs, such as labour, materials, energy consumption, among others, derived from the mentioned waste factors.
- Non-quality costs resulting from the lack of capability of the process in meeting the product specifications.
- Intangible costs, including image and reputation costs.

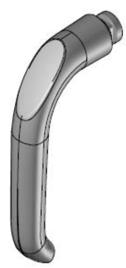


Figure 3 – Window handle, model Ho-2AG

The company decided to conduct a Six Sigma DMAIC project. Each project phase of this roadmap, together with the main activities comprising the Recognize stage, are described in the next subsections, and the set of tools and techniques used throughout the roadmap are summarized in table 2.

Table 2 – Main tools and techniques used during the Six Sigma DMAIC project

Phase	Tools/techniques	Purpose of use
Recognize	Preliminary data analysis	To get a deeper understanding of the situation and enable a better problem statement
	Project Charter	To communicate the problem statement and compile the relevant information about the project
	RACI Matrix	To assign roles and responsibilities within the project team
Define	SIPOC Diagram	To map the production process from high-level
	Affinity Diagram	To group similar types of defects and facilitate the organization of the CTQCs
	CTQC Tree	To display the flowdown of the CTQCs
Measure	Pareto Charts	To identify improvement priorities in order to decide what to work on in the project
	Descriptive Statistics	To obtain a meaningful insight into the collected data
	Six Sigma metrics	To estimate the performance baseline of the process
	Temporal diagram	To visually display the time periods inherent to the cycle of the rotational casting machine
Analyze	Relationship Diagram	To capture and understand the chain of causes and effects that ultimately
	Scatter Plots	To determine the correlations degree among the degree of impurities and the occurrence of: 1) pores; 2) solidification shrinkages; 3) structural abnormalities near the feeding region
	Spaghetti Diagram	To analyze the work-in-process flows of the different types of aluminium alloys in the factory plant
	Process Auditing	To collect evidences of situations and adopted wrong procedures that may or might lead to alloy mixtures and contaminations
	Five Why's	To help to determine the root-causes of the defects generated in the die casting operation
	Design of Experiments	To determine the significant controllable input factors
Improve	Brainstorming	To generate potential improvement actions targeting the significant root-causes previously identified
	Mind Map diagram	To help to organize the ideas that were generated during the brainstorming session
	Five "S"	To better organize the work space in the different working areas of the plant, and foster discipline

	Design of Experiments	To determine which levels of the controllable input factors optimize the quality of the product in the die casting operation
	Improvement Plan	To organize, summarize and communicate the set of improvement actions to be developed
Control	Planned Process Auditing	To monitor the effective adoption of the procedures and good practices defined in the Improve phase
	Control Plan	To organize, summarize and communicate the control activities, including reaction tasks

Recognize. Recognize is a prior stage that takes place before the DMAIC roadmap is initiated. It intends to reach a clear understanding of the problem in hands, and ends with the project planning tasks. The analysis of preliminary data enabled the team to develop the Project Charter, partly exhibited in figure 4, to compile and communicate the relevant information about the Six Sigma project.

The project schedule and a RACI (Responsible for, Accountable for, Consulted, Informed) matrix to assign and communicate the roles and responsibilities within the team, were developed as part of the project planning.

Project statement	This Six Sigma project aims to optimize the current manufacturing process of window handle model Ho-2AG, in order to reduce the high rejection rate
Description of the problem or opportunity	Current results shows that the rejection rate for this product is more than 50% This is due to the high-standards: 1) The surface of the handle needs to be impecable; 2) Invisible region of the surface cannot have objects which can be felt by touch. Currently, the manufacturing process shows major objects only at the end of the process.
Project scope	Manufacturing process of the handle Ho-2AG
Importance of the project	The current process is taking too much time, and it is too costly. This justifies the importance of this project.
Main goals of the project	There are two main objectives for this project: 1) To optimize the current manufacturing process in order to minimize the rejection rate; 2) To determine to which extent a new or redesigned process would be needed in order to elevate its capability to the desired levels.
Main resources for the project	Time of the team members, external consultant.

Figure 4 –Project Charter characterizing and scoping the Six Sigma project (partial)

Define phase. The initial efforts of this phase targeted a deep understanding of the manufacturing process. Process mapping tasks using a SIPOC (Suppliers, Inputs, Process, Outputs, Customers) diagram, depicted in figure 5, were carried out. From experience, it was known that most of the defects have origin in the die casting operation, and are often only detectable after the anodizing stage; this is especially true for pores.

The team then gathered and analyzed data from the manufacturing process, by inspecting handles that were rejected in the previous two weeks of production. At the same time, an affinity diagram as constructed to group similar types of defects into a same class/category of defect. Data depicted in table 3 shows the number and percentage of defects that occurred in both weeks, for each category of defects established in the affinity diagram. Such data enabled the project team to conclude the following:

- More than 50% of the defects that occurred in both weeks had origin in the aluminium die casting operation, since "solidification shrinkages", "pores" and filling errors" are all produced at that stage of the manufacturing process.
- The patterns observed for the die casting defects in weeks 1 and 2 differ; for instance, "filling errors" were much more common on week 1 than on week 2; on the contrary, "solidification shrinkages" and "pores" occurred more often on the second week.
- Grinding errors, with origin at the grinding operations, were the most relevant class of defects on week 2; however, its incidence on week 1 is very small.

Data also unveiled that most of the grinding defects are likely to be generated in the manual grinding operations, so automatic grinding contributes less for the occurrence of defects. This can be seen in table 4. It also shows that the increase in the manual grinding errors is mainly due to errors committed in filing.

Suppliers	Inputs	Process	Outputs	Customers
Ingots supplier	Aluminium alloy ingots Rejected casted materials Furnace temperature Fusion time	**Fusion**	Melted aluminium alloy	"Die casting" operation
"Fusion" operation	Volume of melted aluminium alloy Temperature of the melted alloy Temperature of the mould Type of die coat applied Rotation speed of machine Die casting cycle times	**Die casting**	Solidified casted materials	"Separation of the rigging" operation
"Die casting" operation	Solidified and cooled casted materials Positioning during cut Type of saw	**Separation of the rigging system**	Rigging system separated fron the window handles	"Separation of the extractor pin" operation
"Separation of the rigging" operation	Window handles with an extractor pin Cutting force Positioning of the handles	**Separation of the extractor pin**	Extractor pin separated from the window handles	"Manual grinding" operation
"Separation of the extractor pin" operation	Handles with roughness Type of ribbon used	**Manual grinding (filing)**	Surface of the handles smoothed in the feed region	"Automatic grinding" operation
"Manual grinding" operation	Handles to be smoothed Types of ribbon used Srenght of the robot's claw at the end of the handle	**Automatic grinding (robot)**	Surface of the handles smoothed, except the region of the ellipse	"Manual grinding" operation
"Automatic grinding" operation	Handles smoothed, except in the ellipse region Type of ribbon used	**Manual grinding (final smooth)**	Surface of the handles completely smoothed	"Polishing" operation
"Manual grinding" operation	Handles completely smoothed Polishing time Type of brushes	**Polishing**	Surface of the handles completely polished	"Anodizing" operation
"Polishing" operation	Polished handles Composition of the bath Temperature of the bath Amount of electric charge Voltage	**Anodizing**	Handles anodized	Packaging and expedition

Figure 5 – Mapping of the manufacturing process in a SIPOC diagram format

Table 3 – Occurrences for different categories of defects on weeks 1 and 2

Group of defects	Week 1		Week 2	
	Number of Occurrences	Percentage	Number of Occurrences	Percentage
Solidification shrinkages	156	37,2%	91	15,5%
Pores	89	21,2%	58	9,9%
Filling errors	50	11,9%	146	24,9%
Impurities and inclusions	52	12,4%	12	2,0%
Cutting defects	43	10,3%	46	7,8%
Grinding errors	17	4,1%	169	28,8%
Polishing errors	2	0,5%	0	0,0%
Anodising defects	0	0,0%	0	0,0%
Other types of defects	10	2,4%	65	11,1%

Table 4 – Grinding errors with origin in the automatic and manual operations

Grinding operation	Week 1		Week 2	
	Number of Occurrences	Percentage	Number of Occurrences	Percentage
Automatic grinding	1	5,9%	63	37,28%
Manual grinding	16	94,1%	106	62,72%
• Filing	4	—	68	—
• Final smooth	12	—	38	—

This information, together with team members' expertise about the manufacturing process, led to the following further conclusions:

- Grinding errors tend to increase when the surface of the casted handles, produced in the die casting operation, presents a high degree of roughness, including solidification shrinkages (small cavities on the surface of the handle). Filing operation usually attempts to correct such roughness and shrinkages, but the success very much depends of the skills and experience of the operator.
- If the handles' surface presents more roughness, the chance for failures in automatic grinding also increases.

From the above, it can be concluded that problems in die casting operation are likely to cause an increase in the grinding errors.

Data from table 3 alerted the team to another possible relevant problem, concerning the high number of defects related to impurities, especially on week 1. This type of defect occurs when the melted alloy poured into the mould during, the die casting operation, is somehow contaminated with other metallic or non-metallic particles. This situation can create two problems:

1. The conditions for turbulence when the melted alloy flows into the mould cavities may increase, so the chance for pores to occur can also be greater.

2. The mechanical properties of the aluminium alloy are likely to be jeopardized. Consequently, the transition of the alloy from the liquid to the solid state will not occur properly, resulting in shrinkages or small cavities on the surface of the metallic part. This can explain the higher percentage of "solidification shrinkages" on week 1.

The last activity of this DMAIC phase was the establishment of the critical to quality characteristics (CTQCs) and of their operational definitions. An operational definition is a clear, unambiguous, and observable standard of acceptance. For each group of defects, a document with a similar structure to the one exhibited in figure 6 for "filling errors", was developed to characterize each CTQC and establish its correspondent operational definition.

Type of defect (CTQC)	Filling errors
Number of opportunities for defect	5 subtypes of defect
Origin of the defect	Die casting

1. Subtype of defect 1: rounded edge in the border of the functional and aesthetical regions

Operational definion	
Description of the requirement	**Visual detection**
The handle will conform if: • The edge delimiting the functional and aesthetical regions of the handle does not present a rounded shape.	

2. Subtype of defect 2: Rounded functional edge

Operational definion	
Description of the requirement	**Visual detection**
The handle will conform if: • An edge in the functional region of the handle presents a clear rounded shape.	

3. Subtype of defect 3: Incomplete filling in the lateral surface of the square block

Operational definion	
Description of the requirement	**Visual detection**
The handle will conform if: • The block presents a perfect square shape. • All the four faces of the square block are flat, are absent of any cavity, and do not have any lack of material.	

4. Subtype of defect 4: Filling error on the top surface of the handle

Operational definion	
Description of the requirement	**Visual detection**
The handle will conform if: • The square hole is correctly centered. • There is no lack of material around the square hole. • The surface is flat	

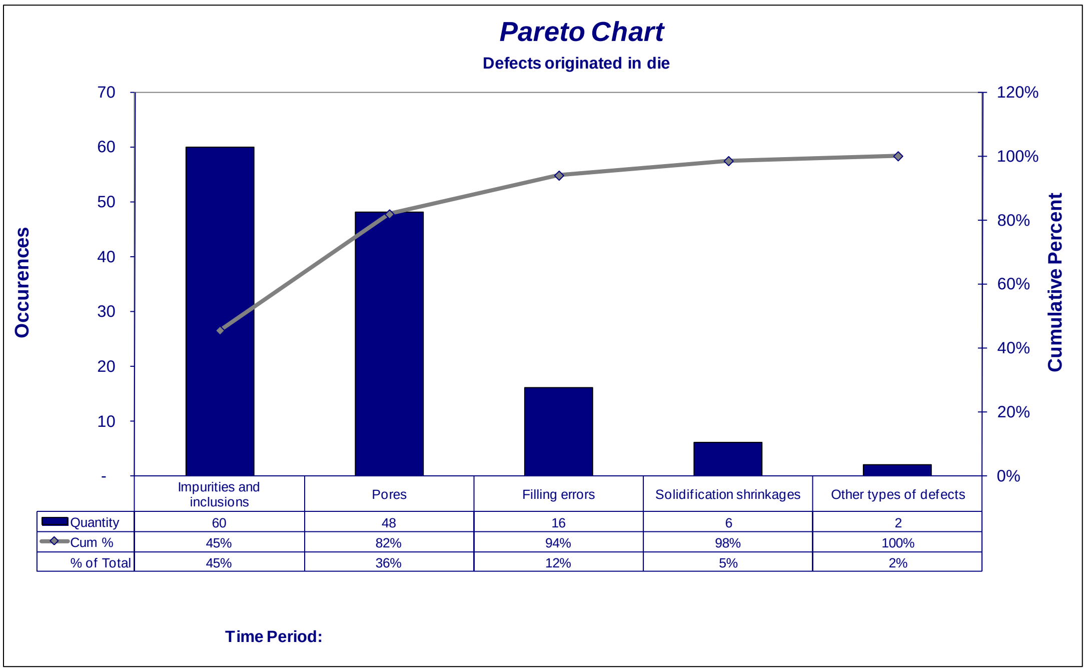
5. Subtype of defect 5: Hole in the square hole

Operational definion	
Description of the requirement	**Visual detection**
The handle will conform if: • The square hole does not have any hole.	

Figure 6 – Description of the CTQC "filling errors" and its operational definition

Measure phase. Production tests were conducted to assess the baseline performance of the die casting operation. In these tests, all key controllable input variables remained constant, at the levels that they are usually used during production. A total of 109 handles were produced in these tests, where 68 of them were labeled as defective. The resulting proportion of defectives was thus around 62%, which is very high.

The results revealed some curious facts. As the Pareto chart in figure 7 illustrates, most of the defects generated in die casting correspond to impurities and other solid inclusions, followed by pores. Again, this evidence suggests that the occurrence of impurities is a relevant problem, and that the larger the presence of impurities in the melted alloy, the higher the number of handles containing pores are expectable.



	Impurities and inclusions	Pores	Filling errors	Solidification shrinkages	Other types of defects
Quantity	60	48	16	6	2
Cum %	45%	82%	94%	98%	100%
% of Total	45%	36%	12%	5%	2%

Figure 7 – Pareto diagram of the die casting defects occurred in the production tests

The Sigma level, symbolized by Z, of performance for the die casting operation was then determined. First, the number of defects per million of opportunities (DPMO) needed to be calculated:

$$DPMO = \frac{D}{P \times O} \times 10^6 = \frac{60 + 48 + 16 + 6 + 2}{109 \times 5} \times 10^6 = 242.202 \qquad (1)$$

In this formula, D is the number of defects detected in the production tests; P is the total number of handles produced in those tests; and O is the considered number of opportunities for defects, which corresponds to the number of groups of die casting defects indicated in the Pareto chart. By consulting a table that converts DPMO into Sigma Levels, it can be concluded that for this DPMO value, the corresponding Sigma Level is approximately 2.2 (i.e. $Z = 2.2$).

Analyze phase. The first activity of this phase was the development of an relationship diagram to study and understand the chain of causes-and-effects that ultimately create the different types of defects in the aluminium die casting operation. The diagram is depicted in figure 8. Then, the following analyses were undertaken:

- Study of the manufacturing process and of its interfaces to gather data and information to determine the reasons for the contamination of the casting alloy by impurities and other solid inclusions.

- Development of a Design of Experiments (DOE) strategy to determine which controllable key input variables have a significant impact on the occurrence of filling errors, solidification shrinkages, and pores.

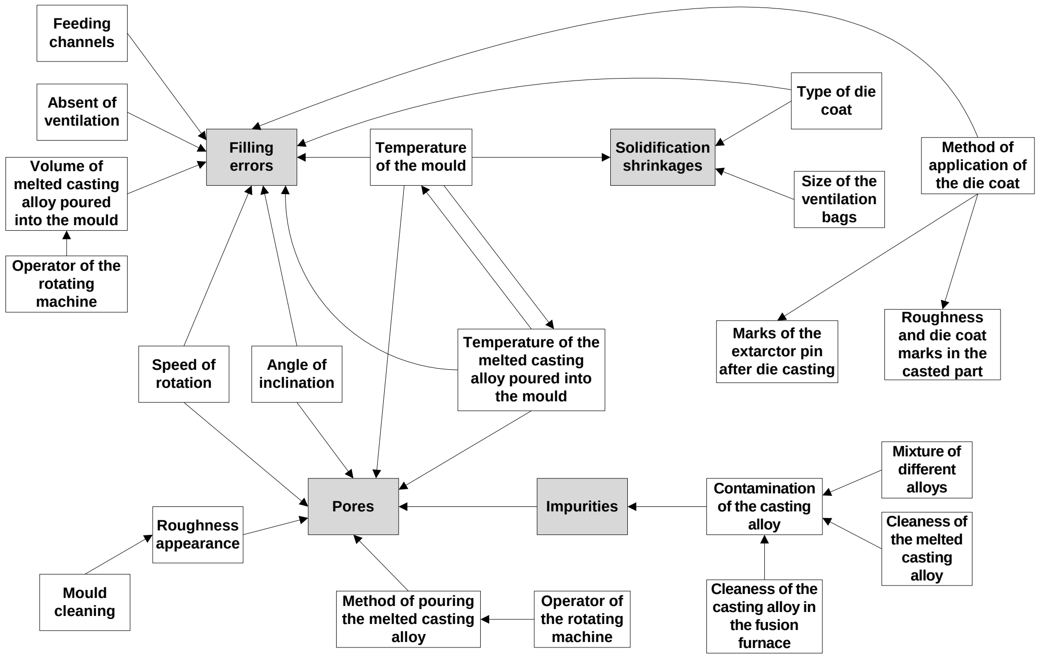


Figure 8 – Chain of cause and effects that lead to the occurrence of die casting defects

Study of the manufacturing process and its interfaces

An audit to the manufacturing process was conducted to collect evidences of wrong procedures that could contribute to the contamination of the casting alloy. Figure 9 depicts the factory plant layout of STA. The working areas where problematic issues were identified in the audit are indicated by a yellow callout.

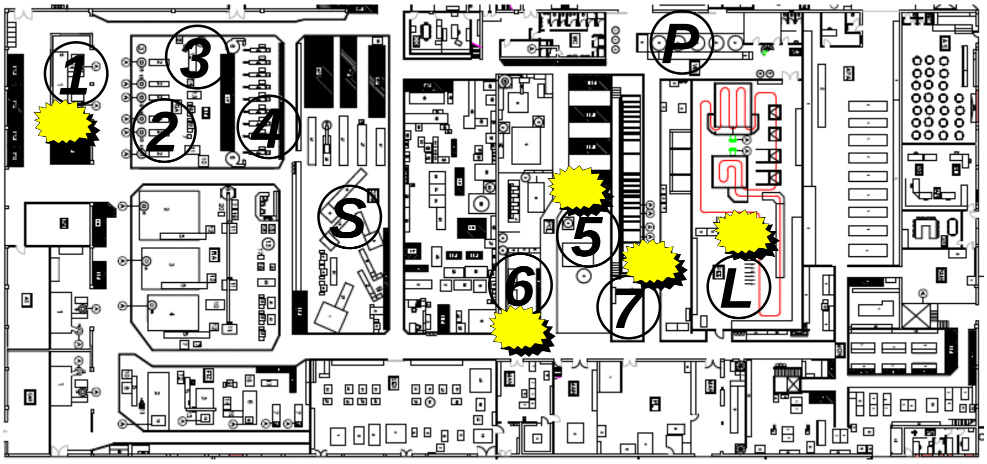


Figure legend:

① **Fusion**
② **Die casting**
③ **Separation of rigging system**
④ **Manual grinding**
⑤ **Automatic grinding**
⑥ **Polishing**
⑦ **Anodization**
Ⓛ **Lacquering**
Ⓟ **Polishing by vibration**
Ⓢ **Stainless steel conformation**
Problems detected

Figure 9 – Factory plant layout, areas where operations of the handle Ho-2AG take place, and points where problematic issues were identified

The main conclusions of this audit, described below, helped the project team to identify a set of situations and events (i.e. the root causes) that explain the contamination of the casting alloy:

- The handle under study is produced using a type of aluminium casting alloy known as AG4Z. At the fusion station of this alloy (point 1 in figure 9), not only ingots are fused, but also rejected parts from downstream operations and rigging systems already separated from the casted products. It was found that rejected materials made of other different aluminium alloys, as well as stainless steel items produced in work station "S" were detected at the fusion operation.
- In addition to the mixture of alloys, non-metallic materials, namely abrasive stones used in operation indicated as "P" in figure 9, were found mixed up with AG4Z alloy rejected parts, in boxes that were going from anodization operation in point to the fusion furnace in point 1.
- Automatic grinding and polishing that take place points 5 and 6 respectively, are performed by robots. Both operations involve other aluminium alloys, not only AG4Z. When a robot detects a shape defect in an item being processed, the robot's claw drops it, so the item falls in the ground; the dropped items are usually not removed from the ground before the next batch to processed starts, the chance for alloy mixtures to occur is high. This is especially true for similar shaped products which are casted in different types of alloys.

The paths of the different types of alloy in the plant were studied using a spaghetti diagram, which enabled the team to determine where in the factory plant the paths of the distinct alloys do intersect; the likelihood for alloy mixtures to occur are much higher in those intersection areas. In work stations where many different types of alloys are processed, preventive actions should exist to avoid undesired mixtures. From the information gathered from the analysis of the spaghetti diagram, together with the evidences collected during the audit, it was possible to conclude that the most problematic areas were the following: lacquering; anodization; automatic grinding; polishing.

Application of Design of Experiments (DOE) to the die casting operation

A DOE strategy was defined to analyze and then improve the die casting operation. In the Analyze phase of DMAIC it was useful to determine which controllable input factors of die casting have a significant impact on the quality of the handles, in terms of:

1. Filling errors (CTQC 1).
2. Solidification shrinkages (CTQC 2).
3. Pores (CTQC 3).

The variables inherent to these three CTQCs are not continuous, since the detection of any of these defects in a handle done through visual inspection. The project team agreed to screen the effect of the following four controllable input factors:

A. Volume of casting alloy poured into the mould (factor A).
B. Temperature of the melted casting alloy (factor B).
C. Rotation speed of the machine (factor C).
D. Type of die coat (factor D).

To investigate their individual and combined influence on the desired quality of the die casted handles, two distinct levels were defined for factor, as shown in table 5.

Table 5 – Input controllable factors and their low and high levels

Controllable input factor	Levels used	High and low levels
Volume of alloy (A)	Small die casting spoon	-1
	Large die casting spoon	+1
Temperature of the alloy (B)	730 °C	-1
	750 °C	+1
Rotation speed (C)	42,5 Hz	-1
	50,0 Hz	+1
Type of die coat (D)	KS 201	-1
	KS 84	+1

To avoid running all the 16 possible combinations among the levels of the four factors, corresponding to 2^4, a two-level fractional factorial strategy was designed. In particular, a 2^{4-1} experimental design was defined, thus only half of the 16 treatments needed to be considered. This is resolution IV design where single factors are not confounded or aliased with two-factor interactions, but some two-factor interactions are aliased with each other (Schmidt and Lausby, 1994). To estimate the experimental error, two replicates were set for each combination. It was also decided that the sample size for each replicate would be of 120 handles. The experimental design strategy is exhibited in table 6. To avoid the negative influence of noise factors on the output during, a set of control procedures were established.

The experimental results in terms of proportion of defectives, for the three CTQCs considered, are depicted in table 7. Proportions follow a Binomial distribution, rather a Normal distribution, which violated important assumptions of the statistical tests used in DOE. The arcsine transformation, usually suggested as an effective way to convert Binomial into Normal distributed data (Ahrens *et al.* 1990), was thus applied. Being p the proportion of defective units for a certain CTQC, the arcsine transformation is computed by the following formula:

$$p = arcsine\left(\sqrt{p}\right) \qquad (2)$$

Table 6 – Experimental design strategy of the screening DOE

Combination of the input factor levels				Sample size	Number of replicates
A	B	C	D		
-1	-1	-1	-1	120	2
+1	-1	-1	+1	120	2
-1	+1	-1	+1	120	2
+1	+1	-1	-1	120	2
-1	-1	+1	+1	120	2
+1	-1	+1	-1	120	2
-1	+1	+1	-1	120	2
+1	+1	+1	+1	120	2

Table 7 – Experimental results of the screening DOE

Replicate	Run order	Combination of the input factor levels				Actual sample size	Proportions of defectives for each CTQC			Arcsine transformation of the proportions		
		A	B	C	D		1	2	3	1	2	3
1	1	-1	-1	-1	-1	112	0,3571	0,0982	0,1429	0,6405	0,3188	0,3876
2	9	-1	-1	-1	-1	132	0,1364	0,1742	0,2045	0,3782	0,4306	0,4693
1	7	+1	-1	-1	+1	116	0,5345	0,0690	0,1121	0,8199	0,2657	0,3414
2	14	+1	-1	-1	+1	122	0,5303	0,3636	0,0152	0,8157	0,6473	0,1234
1	6	-1	+1	-1	+1	108	0,5833	0,1296	0,1667	0,8691	0,3683	0,4205
2	13	-1	+1	-1	+1	120	0,4180	0,2377	0,2705	0,7031	0,5093	0,5470
1	3	+1	+1	-1	-1	106	0,2547	0,0566	0,1226	0,5290	0,2402	0,3578
2	12	+1	+1	-1	-1	123	0,0407	0,0976	0,1545	0,2030	0,3177	0,4039
1	5	-1	-1	+1	+1	114	0,8070	0,4123	0,1053	1,1160	0,6972	0,3304

2	15	-1	-1	+1	+1	120	0,7571	0,2714	0,0571	1,0555	0,5480	0,2414
1	4	+1	-1	+1	-1	122	0,5984	0,0328	0,0574	0,8844	0,1821	0,2419
2	11	+1	-1	+1	-1	128	0,1953	0,0547	0,2500	0,4578	0,2360	0,5236
1	2	-1	+1	+1	-1	112	0,0804	0,0893	0,1607	0,2874	0,3034	0,4125
2	10	-1	+1	+1	-1	122	0,3033	0,1557	0,1967	0,5832	0,4057	0,4595
1	8	+1	+1	+1	+1	100	0,8600	0,4200	0,2700	1,1873	0,7051	0,5464
2	16	+1	+1	+1	+1	124	0,4758	0,1452	0,1935	0,7612	0,3909	0,4555

Unfortunately, it was not possible to get equal sample sizes in all the experiments. In addition, the results for pores were not available for two of the experimental runs. For these reasons, a balanced design was not achieved, so data for each CTQC was analyzed using the General Linear Model available in the Minitab 16 package. A confidence level of 95% was utilized (i.e. a significance level of 5%).

The resulting ANOVA (Analysis of Variance) tables for the three CTQCs, after unusual observations were removed from analysis, are shown in table 7. The R-square values above 70% ensure that the factors and interactions explain at least 70% of the total variation observed on the output of the die casting operation, regarding the mentioned CTQCs. The statistically significant factors and interactions in the ANOVA table are those whose p-value is below the significance level of 0.050.

Table 7 –ANOVA table and determination of the significant factors

CTQC 1: Filling errors

ANOVA table

```
Analysis of Variance for Filling errors, using Adjusted SS for Tests


Source          DF   Seq SS   Adj SS   Adj MS      F      P
Volume           1  0,00004  0,00004  0,00004   0,00  0,973
Temperature      1  0,06821  0,06821  0,06821   2,07  0,178
Rotation speed   1  0,11802  0,11802  0,11802   3,58  0,085
Die coat         1  0,70736  0,70736  0,70736  21,45  0,001
Error           11  0,36270  0,36270  0,03297
Total           15  1,25633


S = 0,181584   R-Sq = 71,13%   R-Sq(adj) = 60,63%
```

Significant factors: Type of ‘die coat’ is statistically significant; ‘rotation speed’ is relevant.

Table 7 –ANOVA table and determination of the significant factors (continue)

CTQC 2: Solidification shrinkages

ANOVA table

Analysis of Variance for Solidification shrinkages, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Volume	1	0,0091562	0,0032684	0,0032684	8,42	0,023
Temperature	1	0,0003045	0,0001875	0,0001875	0,48	0,509
Rotation speed	1	0,0000220	0,0016072	0,0016072	4,14	0,081
Die coat	1	0,0031717	0,0051566	0,0051566	13,29	0,008
Volume*Temperature	1	0,0035814	0,0035814	0,0035814	9,23	0,019
Error	7	0,0027161	0,0027161	0,0003880		
Total	12	0,0189518				

S = 0,0196982   R-Sq = 85,67%   R-Sq(adj) = 75,43%

Significant factors: Type of 'die coat' is statistically significant; the interaction between the 'volume' and the 'temperature' of the alloy is statistically significant (this interaction is aliased with the interaction between 'rotation speed' with 'die coat'); 'rotation speed' is relevant.

CTQC 3: Pores

ANOVA table

Analysis of Variance for Pores, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Volume	1	0,0000192	0,0000002	0,0000002	0,00	0,983
Temperature	1	0,0015497	0,0014159	0,0014159	4,46	0,064
Rotation speed	1	0,0002278	0,0004888	0,0004888	1,54	0,246
Die coat	1	0,0003585	0,0007200	0,0007200	2,27	0,166
Volume*Rotation speed	1	0,0045433	0,0045433	0,0045433	14,32	0,004
Error	9	0,0028552	0,0028552	0,0003172		
Total	14	0,0095537				

S = 0,0178114   R-Sq = 70,11%   R-Sq(adj) = 53,51%

Significant factors: The interaction of the volume of alloy with the rotation speed is significant (this interaction is aliased with the interaction between 'temperature' of the alloy' with 'die coat'); 'rotation speed' is relevant..

The main effects and the significant interaction plots are depicted in figures 10 and 11, respectively. Please note that because the DOE corresponds to a resolution IV design, the effects of some two-factor interactions are confounded or aliased with other two-factor interactions. This is why the combined effect of the alloy volume and temperature on the solidification shrinkages is aliased with the effect due to the interaction between of the rotation speed and the type of die coat. With regard to pores, the effect explained by the interaction among the volume of alloy and the rotation speed is confounded with the temperature of alloy and the type of die coat.

Data collected during the experiments enabled the team to conduct a set of correlation analyses to determine whether the presence of impurities, including scoria, influenced the proportion of the defects generated in the die casting operation. It was found that the no correlation exists between the presence of impurities and the occurrence of pores; however, the correlation scatter plots showed that the number of handles with pores tend to increase when the degree of impurities is higher.

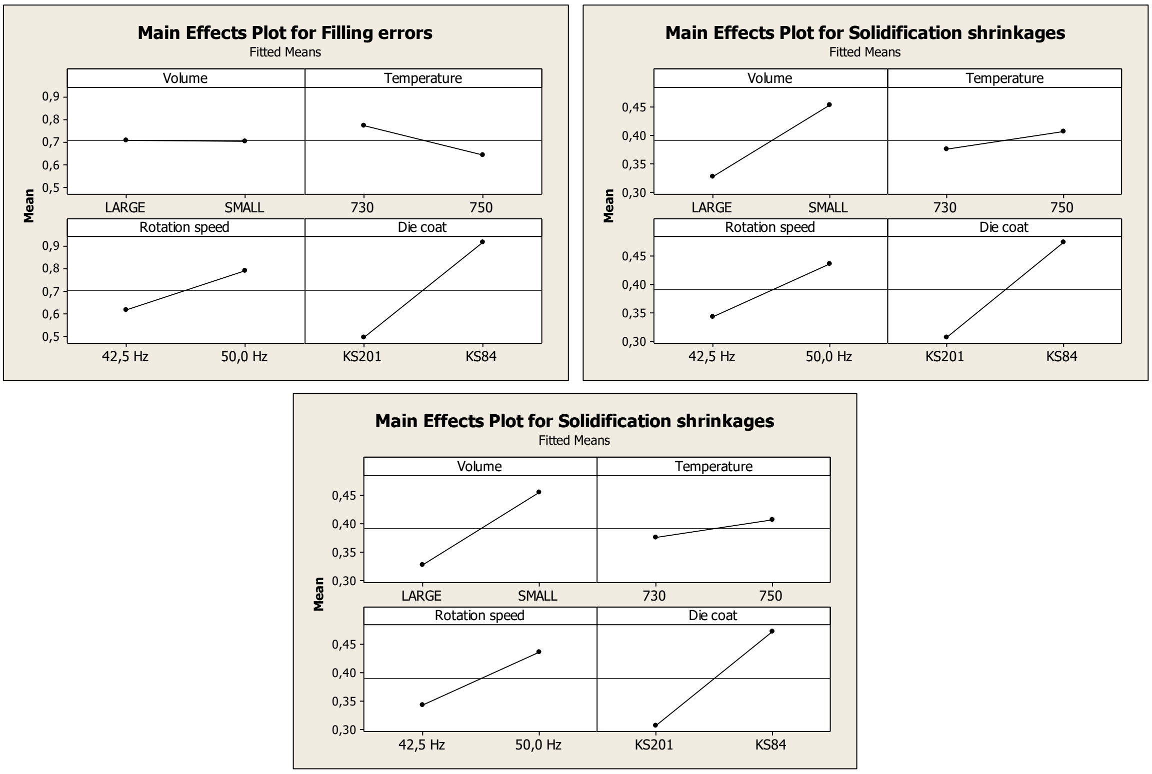


Figure 10 – Main effect plots for filling errors, solidification shrinkages, and pores

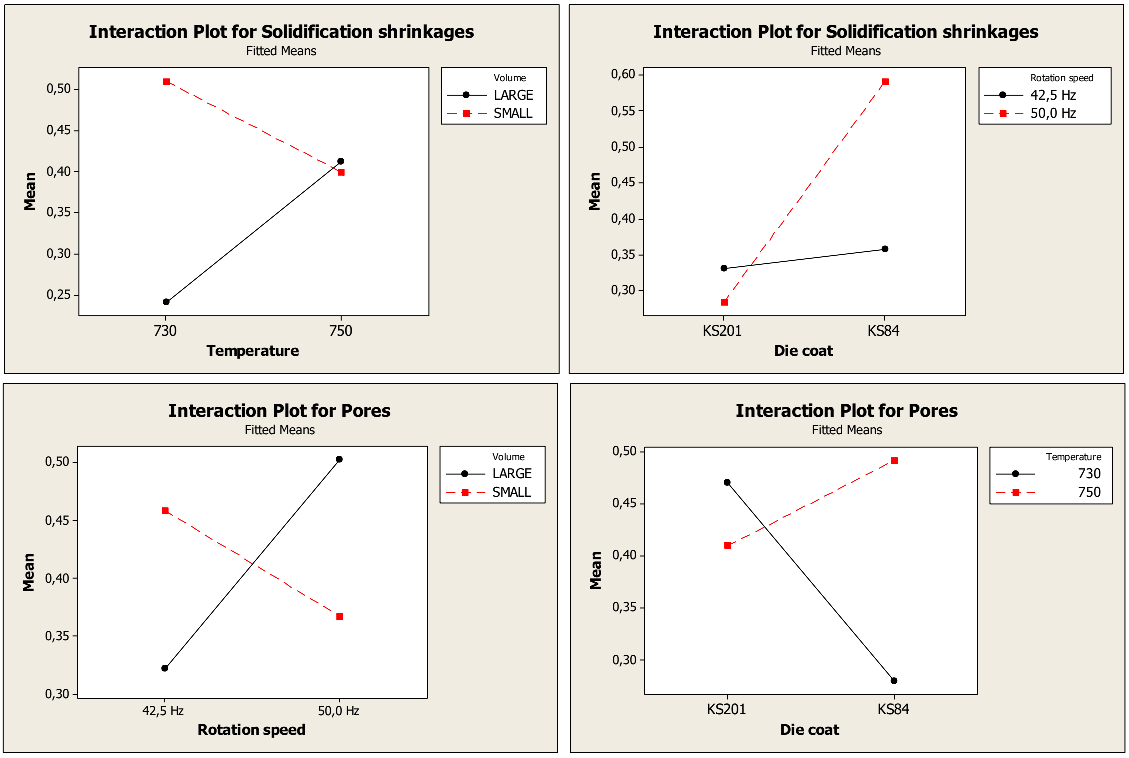


Figure 11 – Interaction plots for solidification shrinkages and pores

IMPROVE AND CONTROL PHASES

The analysis of the main effects and interaction plots depicted in figures 10 and 11 helped the project team to understand which levels of the input factors would minimize the chance of defects to occur. The conclusions are summarized in table 8.

Table 8 – Best levels for the controllable input factors

Type of defect	Volume of alloy	Temperature of the alloy	Rotation speed	Type of die coat
Filling errors	Not significant	Not significant	42,5 Hz	KS201
Solidification shrinkages	Large spoon	730 °C	42,5 Hz	KS201
Pores	Large spoon	730 °C	42,5 Hz	KS84

Two brainstorming sessions were organized to give employees the chance to suggest improvement actions to avoid contamination of the alloys with impurities and other inclusions, and to prevent mixture of different types of alloys. The ideas were organized using mind map diagrams.

An improvement plan was developed which comprises three areas of intervention:

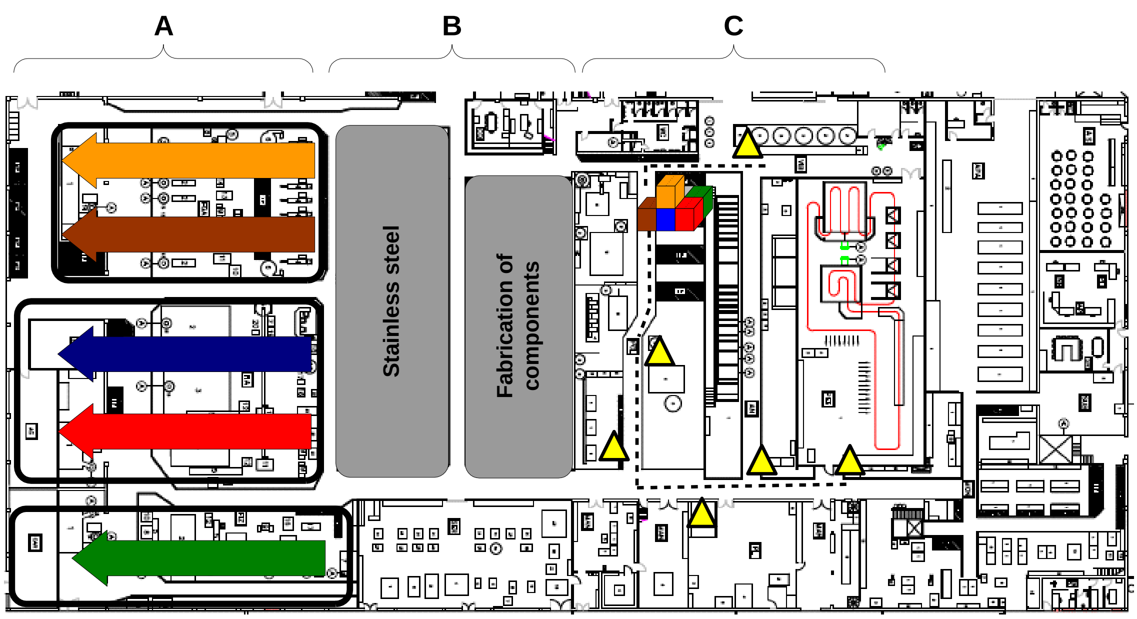
1. Carry out a DOE strategy to confirm the optimal combination of controllable input factors indicated in table 8.
2. Improvement of the process flows and prevention of alloy mixtures.
3. Training and education

In terms of flows improvement, the main objective is to prevent mixture of alloys, as well as their contamination with external elements. With this in mind, the model exhibited in figure 12 was developed and approved. Each colour represented in this figure corresponds to a certain type of alloy. In zone A alloy mixtures rarely happens, while zone C is the most problematic in terms of alloy mixtures. Every work station located in zone C will have a sorting point to place the rejected items per type of alloy; the sorted items will be periodically transported by a stacker the central point depicted in the figure. The locations of the sorting and central points, as well as the path for the stacker to be moved were set to minimize unnecessary transportation. This procedure also intends to increase safety to the personnel in the plant, since currently the stacker moves in an ad-hoc manner along the plant. Zone A involves the straight flow of rigging systems and of the rejected parts coming from the central point directly to the fusion station. Zone B functions as a natural border between zones A and C, where no operations involving aluminium alloys exist.

Five "S" is also planned to be performed in the work stations along the manufacturing process, in order to promote discipline and visual factory. Specific areas for on-job training and visual guides to help operators to distinguish the different types of alloys will be included.

The improvement plan also promotes tasks to construct Value Stream Maps (VSM), a lean tool that is excellent in identifying further improvement areas, bottlenecks and forms of waste. Systems approach to management is an inherent principle to VSM, which is the reason why it is also adopted by the Theory of Constraints (TOC).

The actions included in improvement plan are under development. After being fully implemented, the results can be assessed, and a control plan can be established.



Legend:

Central point to deposit all rejected items coming from work stations, per type of alloy

Work station sorting point to place the rejected items per type of alloy

Permited path for the movement of the stacker in zone "C" of the factory plant

Figure 12 – Developed model to minimize the chance for alloy mixtures to occur

CONCLUSIONS

This paper describes the activities that were carried out to select, plan, and execute a continuous improvement Six Sigma project based on the DMAIC roadmap. The Define phase allowed the team to better understand the problem and determine that most of the defects had origin at the die casting operation. Further data was collected in the Measure phase by means of production tests, which led to the estimation of the performance baseline of the manufacturing problem. In the Analyze phase of DMAIC, a wide set of studies were conducted to identify the root causes of the die casting defects. Interestingly, factual data revealed that some of the root causes of the problems observed in die casting had origin in other work stations and operations of the manufacturing process; this proved the importance of considering the systems approach when developing a continuous improvement project. In the Improve phase, the best levels of the significant input control factors of the die casting operation were determined for each type of defect; in addition, a set of actions were put in place to prevent undesired alloy mixtures and contaminations along the process to occur. The paper also provides a review about the state of implementation of Six Sigma in Portugal.

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Design for Six Sigma (DFSS): An Application to the Service Sector

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ABSTRACT

Purpose. The main aim of this paper is to describe a practical application of a Design for Six Sigma (DFSS) project to conception and development of a new service in the logistics sector.

Design/methodology/approach. A market analysis was first carried out to identify opportunities for innovation, which then led to the identification of potential DFSS projects. Based on the company's strategic priorities, a project targeting the development of a specialized service in providing logistics solutions for campaigns and events was selected. The project was conducted throughout the IDOV (Identify, Design, Optimize, Validate) roadmap. Customers and other relevant stakeholders were identified, and their requirements determined. This was followed by the identification of the high-level functional requirements for the service, which was the starting point to first define the design intent for the service and then to proceed from the conceptual stage to the detail design activities. A service pilot was finally conducted to validate the designed service.

Findings. The case study proves that is possible to successfully apply DFSS in new service design contexts.

Originality/value. This is the first paper describing a practical application of a DFSS project to the service sector in Portugal. Another contribution is the up-to-date literature review on DFSS case studies provided in the paper.

Keywords: Design for Six Sigma (DFSS), IDOV, Service Design

Article Classification: Case study

INTRODUCTION

Design for Six Sigma (DFSS) is a relatively new branch of Six Sigma. It makes use of a structured methodology for product, service or process development based on a stage gate review, being supported by a logical employment of tools and techniques foster conceptual and operational robustness of the entity being designed, in order to meet or even exceed the needs of the customers and of other relevant stakeholders.

In the last few years, an increasing number of DFSS case studies have been reported in the literature, most of them applied to product design contexts, but some also to the service sector and transactional processes. Nevertheless, the number of published DFSS case studies is still much lower when compared to the applications making use of the traditional Six Sigma DMAIC methodology for continual improvement purposes.

In Portugal, DFSS applications have been rarely disclosed. As far as the authors of this paper have knowledge, this article is the first publication about a DFSS project scoping the service sector in the country. The case study herein described was developed at TNT Express Portugal. The project first aimed the identification of relevant opportunities for innovation in the services provided by the company; this then would lead to the design of a new service or to the redesign of an existing one. This preliminary stage enabled to clearly define the project scope: the design of a specialized logistics service targeting the marketing campaigns and the events markets. Then the project was executed according to the IDOV roadmap.

The paper is structured around four sections. In section 2, a literature review on DFSS is carried out. The case study is presented in section 3, from project identification to its completion, together with its main findings and results. Finally, section 4 summarizes the main conclusions of the paper.

LITERATURE REVIEW

The literature search contained in this section is divided into three subsections. First, the similarities, differences, and synergies among DFSS and the traditional Six Sigma methodology based on the DMAIC (Define, Measure, Analyze, Improve, Control) roadmap are identified. Next, the different roadmaps to execute a DFSS project proposed in the literature are identifies and compared. Finally, a list of the case studies describing practical applications of DFSS is provided.

DFSS versus Six Sigma DMAIC. Like traditional Six Sigma, DFSS relies on a project-by-project approach (Jugulum and Samuel, 2008). In both cases, potential projects are first identified and evaluated, being selected those that best suits customer and business needs; each project is then planned and executed according to a well-structured process, called roadmap, where a set of tools and techniques are employed to assist project teams in factual decision-making. Also, in either case, the project is coordinated by the technical leader, called Black Belt.

Six Sigma projects typically scopes the incremental improvement of an existing process (Bañuelas and Antony, 2004), in terms of its effectiveness and/or efficiency. Such projects are performed throughout the five-phase DMAIC roadmap. Effectiveness improvement means the enhancement of the operational performance of the process in terms of its capability in producing according to the specifications, which are the translation of customer needs into clear, unambiguous, and observable standards of acceptance. By its turn, process efficiency is increased by efforts towards the detection and elimination of non-value added tasks within the process, such as waiting times, excessive motion, inventories, unnecessary transportation, overproduction, and rework; this is usually achieved by integrating Six Sigma with Lean Management principles, an approach known as Lean Six Sigma (George, 2002).

On the contrary, a DFSS project is employed when a process needs to be redesigned or designed from scratch. According to Harry and Schroeder (2000), at a certain level of capability (around a sigma-level of 4.8), it is not possible to achieve higher levels of performance by simply improving the current process, so a new process must be created or the existing one needs to be redesigned. Such goal can be reached by means of a DFSS project. This is the reason why the goal DFSS is often compared with that of business process reengineering (Snee and Hoerl, 2003) and of process innovation (Marques *et al.*, 2014).

DFSS is linked to product and service innovation as well. As it will be discussed in the next subsection, the sequence of activities inherent to a DFSS roadmap follows the same reasoning of a product or service design process. DMAIC projects can be applied to improve the functional performance of a product or service. Products perform certain basic and secondary functions, so they can be regarded as processes (Yang and El-Haik, 2003). In the service sector, the tangible or intangible attributes of the service are generally provided at the same time that the delivery process of that service is performed (Yang, 2005).

DMAIC is not a proper roadmap for DFSS contexts (Watson and DeYong, 2010). For this reason, DMADV (Define, Measure, Analyze, Design, Validate) is often adopted, since a “Design” phase is used instead of “Improve”. Many other DFSS roadmaps have been proposed in the literature; thus, on the contrary of the Six Sigma methodology for continuous improvement, various process roadmaps actually exist for DFSS.

Six Sigma DMAIC and DFSS share many analytical tools and techniques, but due to the unavailability of data in the early phases of the design process, DFSS makes much more use of conceptual tools; in addition to this, because DFSS involve substantial and sometimes radical innovation, the utilization of creativity tools is more extensive than in problem-solving or continual improvement DMAIC projects.

Another difference concerns the number of critical to quality characteristics (CTQCs), which represent measurable quality attributes that represent an objective translation of the customer needs and wants. Because traditional Six Sigma methodology aims to improve what currently exists, it focuses on understanding why the product, service or process fails to meet a key customer requirement, thus involving one of few CTQCs (Ginn and Varner, 2004). Gathering and analysing the “Voice of the Customer” is a more demanding task in a DFSS project, since creating a new product, service or process, or even redesigning an existing one, involves multiple requirements that need to be met, which means several CTQCs must be considered.

The main similarities among DFSS and Six Sigma DMAIC are summarized in table 1.

Table 1 – Main differences between DFSS and traditional Six Sigma

	Design for Six Sigma (DFSS)	Six Sigma methodology
Roadmap	Many roadmaps are proposed (IDOV, DMADV, etc.)	A single roadmap (DMAIC)
Toolbox	More use of conceptual and creativity tools	More use of analytical tools for problem-solving situations
Scope of application	Problem-solving or continual improvement contexts	Product, service or process innovation
Degree of innovation	Incremental improvement	Substantial or radical innovation
Number of CTQCs	One or few	Many
Project duration	Short to medium	Medium to large
Amount of investment	Small to medium	Medium to large

DFSS roadmaps. In addition to DMADV, many different DFSS roadmaps have been proposed in the literature, such as the following ones:

- DMADOV (Define, Measure, Analyze, Design, Improve, Optimize, Verify).
- IDOV (Identify, Design, Optimize, Validate).
- DCCDI (Define, Customer, Concept, Design, and Implement).
- I^2DOV (Invention & Innovation, Develop, Optimise, Verify).
- DMEDI (Define, Measure, Explore, Develop, Implement).
- DIDES (Define, Initiate, Design, Execute, Sustain).

Marques (2013) showed that DMADV and IDOV are the most often used DFSS roadmaps. Despite the naming differences, all roadmaps share fundamental strategies and principles (Shahin, 2008). However, some authors have identified differences among roadmaps; for instance, Shahabuddin (2008) and Yang and Cai (2009) point out that DMADV is more suitable for incremental redesign projects, while IDOV is recommendable when a new or a substantially modified design needs to be developed.

Before initiating a Six Sigma project, it is important to choose the methodological approach to be followed, i.e. DMAIC or a DFSS roadmap (Bañuelas and Antony, 2004); however, essential information for proper decision-making is not always available at such early stage. In particular, opting between improving an existing process, product or service, or redesigning it, is often just possible later on in the project when data have already been collected and analyzed. Recognizing this, some authors identified useful synergies between DMAIC and other DFSS roadmaps. It is the case of Cronemyr (2007) who, after studying the differences and similarities between DMAIC and DMADV, merged these two into a single roadmap called DMADC (Define, Measure, Analyze, Design, Control) to be used regardless of the project scope. By their turn, Ginn and Varner (2004) and Lunau *et al.* (2009) provided flowcharts that help to determine whether a project should follow a DMAIC or a DMADV path, and enable teams to move to one to the other of needed. Marques *et al.* (2014) extended such flowcharts to include IDOV for substantial and radical innovation, DMADV for incremental innovation, and DMAIC for incremental improvement.

DFSS case studies. According to Creveling *et al.* (2003), the first Design for Six Sigma application occurred in the late 90s at the Division of Medical Systems of General Electric (GE), which led to the development of a newly computerized tomography scanner. Since then, other case studies have been provided by the literature, especially in the last years.

Most of the DFSS projects that have been described focus on the area of new product development. Buss and Ivey (2001) outlined a DFSS project that was carried out at DOW Chemical to design a new rail delivery system to be used in the manufacturing process, with the aim of increasing the production volume; Kim *et al.* (2003) detailed the activities taken place in a DFSS project to redesign the brake judder of heavy-duty trucks; Drolet (2003) discussed an application of DFSS to technology and product development at Bombardier Aerospace; Cedar *et al.* (2004) depicted how DFSS was incorporated into the product design and development process used by the GE Aircraft Engines, and the benefits that resulted from it; Soderbord (2004) described how Ford Motor Company evolved its product development system with the introduction of DFSS in the company, while Gerhorst *et al.* (2006) presented a specific DFSS project at the same company that increased robustness of an exhaust manifold by modifying its design; Franza and Chakravorty (2007) detailed how DFSS was used to design an electric tie-down for a wheelchair; Hasenkamp e Ölme (2008) explained how SKF improved their product development process by integrating it with DFSS principles and tools; El-Haik and Mekki (2008) described a DFSS case study that led to the development of an automatic dissolving and dosing medical device; Rivera *et al.* (2010) presented a DFSS project at Delphi Powertrain Systems to design a new type of injector; Jahanzaib *et al.* (2013) explored the case of a DFSS project to redesign a bolted joint to optimize its functional performance; El-Sharkawi *et al.* (2014) outlined the main activities undertaken in a DFSS project to improve the design concept of an automotive heat exchanger; Oh *et al.* (2014) introduced a redesign DFSS project to optimize the TPO (thermoplastic polyolefin) airbag cover.

More recently, DFSS case studies under the scope of service design have also been reported. Johnson *et al.* (2006) proved the applicability of DFSS to design a new dormitory concept at the University of Miami; Yun and Chun (2008) presented a DFSS application to redesign a telemedicine service and its delivery process; Kaplan *et al.* (2009) provide an example of a DFSS application to design an employee influenza vaccination process; Mandahawi and Al-Shihabi (2010) showed a DFSS initiative to redesign the triage process of a hospital to reduce the average waiting time; Long *et al.* (2011) described a DFSS project to redesign the existing Information Technology system, in an accounting company, to reduce unplanned downtime; in a recent book edited by Cudney and Furterer (2012), various DFSS case studies for both service and product design were presented; Furterer (2014) outlined a DFSS project to design service processes of a new community hospital's women's center.

CASE STUDY

The case study was conducted at TNT Express Worldwide Portugal. TNT Express is a multinational enterprise that provides a wide range of express delivery services to business around the world, in over 200 countries. The company offers domestic and international express services, together with special services and specific solutions for industry. This section is organized around four subsections. First, the business case is described, then the way that led to the identification of opportunities for innovation, which enabled TNT to develop potential DFF projects and select the best one, is outlined. The planning of the best DFSS project and its execution are detailed in the third subsection. Finally, the post-project procedures are summarized. As far as the authors of this paper know, the case herein described is the first service DFSS project in Portugal being reported.

Business case. In 2007, TNT Express Portugal was already conducting their first continual improvement Six Sigma projects, based on a custom version of the DMAIC roadmap. At this time, the company's top management decided to examine business opportunities that could trigger service innovation initiatives, such as DFSS. If a relevant opportunity for innovation were detected, then a DFSS project could be selected, planned and executed.

So, the starting point was a market research to identify a set opportunities for innovation in the services provided by TNT Portugal. This preliminary task then enabled the company to identify potential DFSS projects, define their scope, and assess the value expected benefits they could bring to the business.

Identification of potential DFSS projects. The methodology towards the identification of potential DFSS projects, which derive from the determination and study of opportunities for innovation, is depicted in figure 1.

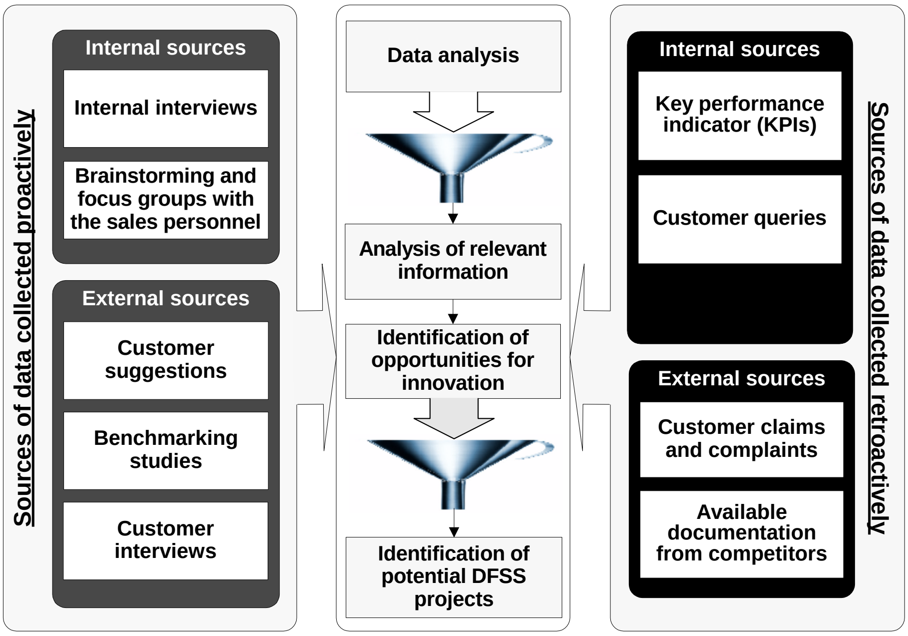

Figure 1 – Methodology towards the identification of potential DFSS projects

The methodology follows the reasoning behind the knowledge creation process. It starts by gathering relevant data from different sources then the analysis of such data provides information that still needs to be further studied, interpreted, and contextualized in order to generate knowledge about the innovation opportunities that arise from the market environment.

Most of raw data was qualitative in nature, so it was translated into more objective statements, including customer requirements, using "Voice of the Customer" (VOC) tables. Table 2 illustrates the structure of this VOC table, together with an example for this case. Each statement could eventually provide clues for one or more opportunities for innovation.

Table 2 – Structure of the VOC table with example

Source	Raw data	Key-point	Translated statement	Opportunity for innovation
Interview	"Nowadays, companies tend to focus in what they do best"	Core business of companies	"Business companies want to focus on the process operations that directly adds value to the products or solutions they sell in the marketplace, which is usually not the case of transportation and logistics"	Companies might be interested in outsourcing transportation and logistics activities to specialized operators
Focus groups	"Customers tend to value more and more proactive information about their shipments"	Track and trace	"Customers tend to value other features of the delivery service, in those related to track and trace"	Special service that provides full and online track & trace of high-value shipped items

The translated statements were then organized by means of an affinity diagram which facilitated the comprehension of interlinked information. A set of preliminary opportunities for innovation could be derived from this effort.

Available data about the evolution of sales of different classes of service offerings over time, allowed their positioning on an S-curve (figure 2). This provided valuable information about the services that were expected to grow more in the medium and long terms, thus helping to determine which of the preliminary opportunities for innovation were the most promising.

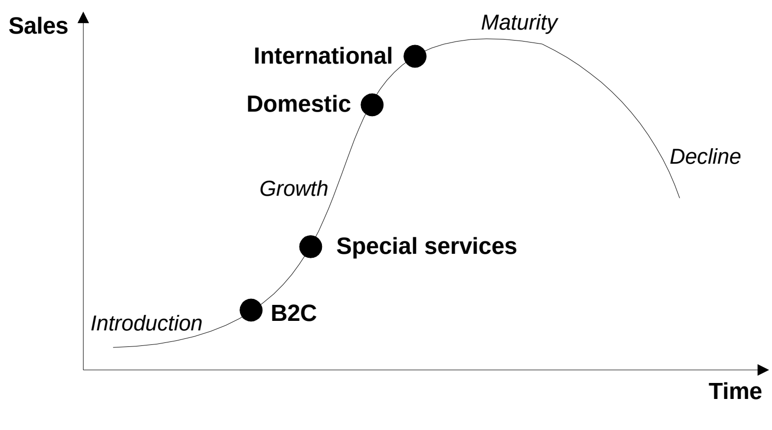

Figure 2 – S-curve of the types of services provided by TNT Portugal

If internal and external interviews provided a good insight into the needs, expectations and some trends of the market, benchmarking studies gave a good picture about what competitors were offering and how well they were performing.

After this work, a list of opportunities for improvement emerged. Based on the corporate priorities and considering environmental analysis that the marketing department had developed, the following two interlinked opportunities were picked up by the company's top management:

1. Development of special transportation and complementary logistics services targeting the marketing campaigns business.
2. Development of special transportation and complementary logistics services for events (sporting, cultural, business, training, and other kinds of events).

A DFSS project was then prioritized with the objective of developing a service, under the offerings provided by the special services area, to take of the mentioned opportunities. The planning and execution of this project are described in the next subsection.

DFSS project planning and execution. A project charter for this DFSS initiative was built and a multifunctional team was formed. The project planning also included the construction of a Gantt chart and of a RACI (Responsible for, Accountable for, Consulted, Informed) matrix. The first tool assisted the project team to depict the project schedule, while the second helped to define and communicate the roles and responsibilities within the project team.
The project was conducted in accordance with the IDOV roadmap. The main activities carried out in each of the four phases, as well as the tools and techniques used, are exhibited in figure 3. The details about how each phase was conducted are explained in the following set of paragraphs of this subsection.

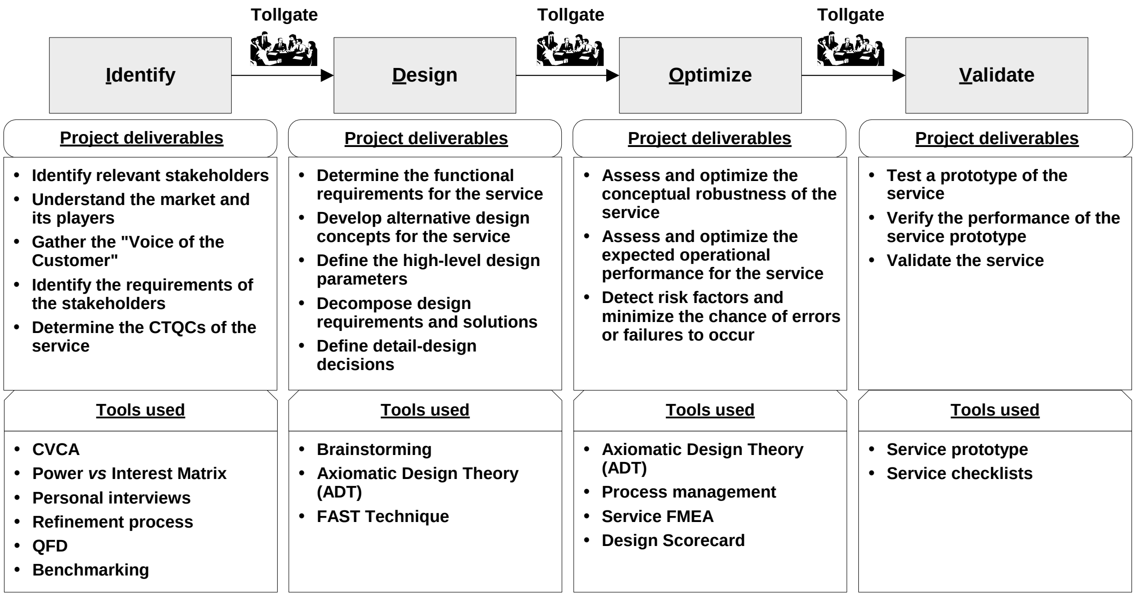

Figure 3 – Specific deliverables of the project and tools/techniques used throughout the IDOV roadmap

"Identify" phase. The project execution began with the identification of pertinent customers and other relevant stakeholders. A Customer Value and Chain Analysis (CVCA), a tool proposed by Ishii (2001), assisted the project team on this task. A CVCA is a tool that allows for the identification of pertinent stakeholders, the relationships among them, and their role in the product or service life cycle. The final version of the CVCA is depicted in figure 4.

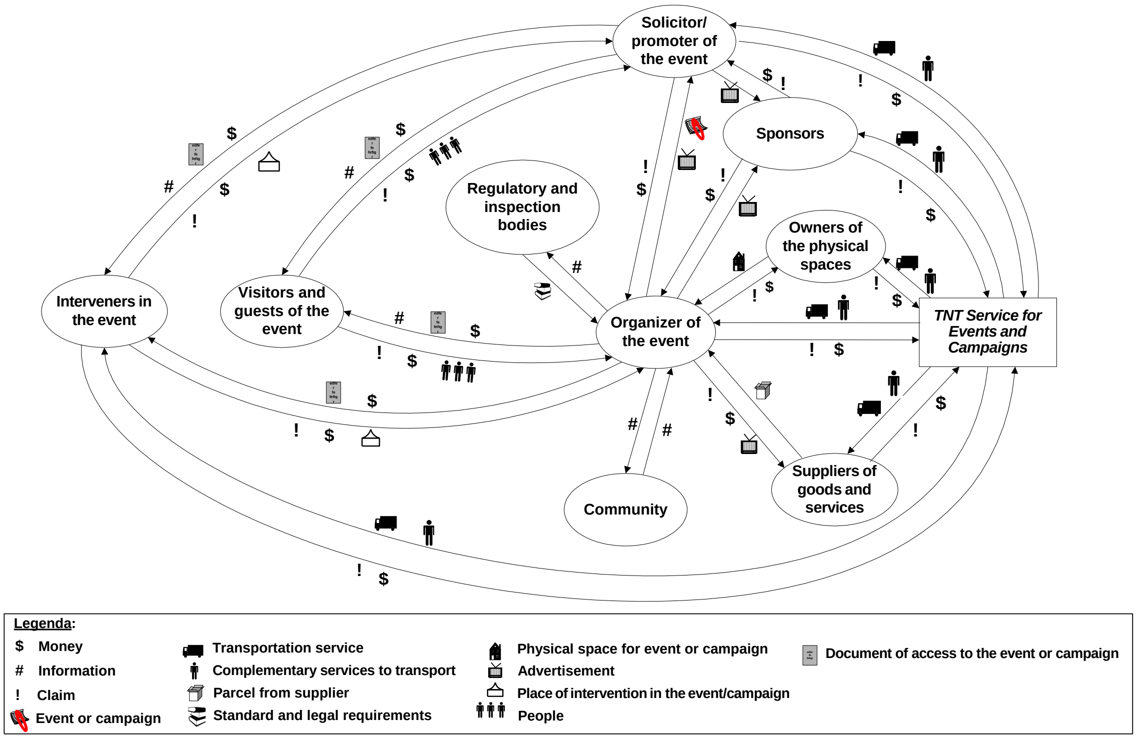

Figure 4 – Final version of the CVCA for the new service to be developed

To determine which of the stakeholders identified in the CVCA diagram are the most relevant in the scope of the service to be designed, a "Power" *versus* "Interest" matrix was employed. Based on the analysis of its results, the following stakeholders were prioritized.

- Organizers of the event or marketing campaign.
- Interveners in the event or marketing campaign.
- Suppliers of goods and services for an event or campaign.
- Promoter of the event or marketing campaign.
- Owner of the physical space where the event or campaign is to take place.

Specific elements belonging to these groups of stakeholders were identified and asked to participate in personal interviews, which were conducted to gather their needs, wants, and expectations regarding the service to be developed. The interviews were conducted after preliminary analyses of existing data (e.g. claims, complaints, customer service data), thus providing a basic understanding of the main customer concerns, thus enabling interviews to be conducted more effectively.

The "Voice of the Customer" gathered from the different stakeholders in the interviews generated a total of 124 requirements. Because this large number of requirements needed to be reduces, the four-step refinement process represented in figure 5 was applied.

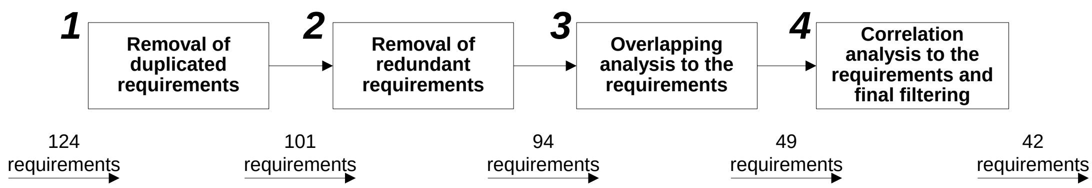

Figure 5 – Application of the refinement process to minimize the number of requirements

The reasoning behind the overlapping and correlation analysis of requirements, performed in steps 3 and 4 of the refinement process, respectively, follow the procedure suggested by Wang and Ma (2007). The definitive set of 42 requirements that resulted from this process was then organized using an affinity diagram.

The Identify phase of the IDOV roadmap ended with the translation of the customer and other stakeholder requirements, which were organized according to the affinity diagram, into specific and measurable or observable CTQCs. This was achieved using the House of Quality framework of the Quality Function Deployment (QFD) approach, which is partially shown in Figure 6. The most relevant CTQCs are identified with an arrow in this figure.

				Transport																			Complementary logistics		
				Pickings and deliveries							Integrity of goods				Tracking		Customer service				Other				
Requirements of the stakeholders			Importance	Service level	Ocorrences of incorrect picking site	Ocorrences of incorrect delivery site	Timely picking	Timely delivery	Successfully critical in time deliveries	Compliance rate of multiple/phased pickings and deliveries	Occurrences of damaged goods	Occurrences of diverted shipped items	RTA incident rate per vehicle	Occurrences rate with special handling items	Number og track & trace available options	Failure rate in the track & trace service	Profissionalism of the courier	Profissionalism in the telephone communication	Average time of submission of proposal	Average time of submission of proposal (critical in time situation)	Territorial coverage of the service	Average CO_2 emission per vehicle type	Compliance rate of the sorage services	Compliance rate of the value-added services	compliance rate of the assembly and dismantling services
Fundamental attributes of the service	Ensure that the desired goods to be shipped are picked and delivered in the required quantities		8,3	9	1	1	1	1	3	1	1	3	0	1	0	0	1	0	0	0	0	0	1	1	0
	Ensure the security, preservation and integrity of the property of the customer		8,6	3	1	1	0	1	3	1	9	9	3	3	0	0	1	0	0	0	0	0	3	1	3
	Compliance with the places of the service	Ensure that the complementary services to transport are performed in the right locations	8,0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3
		Ensure that the goods to be shipped are picked and delivered at the right locations	8,1	9	9	9	1	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Be able to provide services in any areas, places, terrains, and pathways	6,8	1	3	3	3	3	3	0	1	0	1	0	0	0	0	0	0	0	3	0	0	1	3
	Compliance with the timings of the service	Ensure the timeliness required for the picking and delivery activities	8,5	9	3	3	9	9	3	1	0	1	1	1	0	0	1	0	0	0	1	0	1	0	0
		Comply with the phased pickings and deliveries in time	7,9	1	0	0	3	3	0	9	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		Comply with the dates and times scheduled for the starting, execution, and completion of the complementary services to transport	8,2	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Critical in time needs	Ensure respondiveness in presenting a solution to the needs of the customer		7,3	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	9	9	1	0	0	0	0
	Critical in time services	Be able to perfom picking and delivery in the shortest possible time	6,9	0	0	0	3	3	9	1	0	0	1	0	0	0	0	0	0	1	1	0	1	1	0
		Be able to perform complementary services to transport in the shortest possible time	7,0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	3	3
		Be able to perform a same-day delivery when required	8,0	3	3	3	3	3	9	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Flexibility of the service		Be able to provide the service in any dates and times required by the customer	8,2	1	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
		Be able to provide the service in iny part of the world	7,6	0	0	0	1	1	1	0	0	0	0	0	1	1	0	0	0	0	9	0	0	0	0
Provide an "environmentally friendly" service			6,6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0
			Punctuation	349,5	181,1	173,8	233,9	234,3	360,3	157,8	220,0	175,9	100,7	402,7	122,5	114,0	163,8	40,2	86,2	122,1	156,7	59,4	276,3	433,5	280,1

Figure 6 – House of Quality for the new service to be developed (partial)

Benchmarking studies were also conducted and incorporated in the House of Quality, as depicted in figure 7.

"Design" phase

This phase started by the definition of the high-level set functional requirements (FRs) for the service, which derive from the basic functions of the service. Two FRs linked to the service basic functions were defined, as indicated in table 3. Two additional FRs, which correspond to secondary or support functions, were also formulated.

			Transport																		Complementary logistics		
			Pickings and deliveries							Integrity of goods				Tracking		Customer service				Other			
			Service level	Ocorrences of incorrect picking site	Ocorrences of incorrect delivery site	Timely picking	Timely delivery	Successfully critical in time deliveries	Compliance rate of multiple/phased pickings and deliveries	Occurrences of damaged goods	Occurrences of diverted shipped items	RTA incident rate per vehicle	Occurrences rate with special handling items	Number og track & trace available options	Failure rate in the track & trace service	Profissionalismo of the courier	Profissionalism in the telephone communication	Average time of submission of proposal	Average time of submission of proposal (critical in time situation)	Territorial coverage of the service	Average CO_2 emission per vehicle type	Compliance rate of the sorage services	Compliance rate of the value-added services	compliance rate of the assembly and dismantling services
Objectives for the CTQCs		Standard services: *Major Accounts*	99,5%	<0,5%	<0,5%	99,7%	99,7%	NA	NA	<0,1%	<0,1%	<0,01 %	NA	6 - 9	<0,5%	> 9,5	> 9,8	NA	NA	Domstic + international	80 g/km of CO_2	NA	NA	NA
		Standard services: *Medium & Small Accounts*	98,5%	<1,0%	<1,0%	98,7%	98,7%	NA	NA	<0,5%	<0,5%	<0,01 %	NA	3 - 6	<1,5%	> 9,5	> 9,5	NA	NA	Domstic + international	80 g/km of CO_2	NA	NA	NA
		Special services: *All Accounts*	Custom	Custom	Custom	Custom	Custom	Custom	Custom	<0,1%	<0,1%	NA	Custom	Custom	Custom	> 9,5	NA	Custom	Custom	Domstic + international	80 g/km of CO_2	Custom	Custom	Custom
Technical evaluation	Standard services	TNT Portugal	98,7%	0,3%	0,9%	99,0%	98,8%	–	–	0,13%		0,04%	–	8	1,03%	9,6	9,4	–	–	Dom+ Intern	–	–	–	–
		Best-in-class competitor 1	98,5%	–	1,1%	–	98,7%	–	–	0,15%		–	–	7	–	9,6	9,5	–	–	Dom+ Intern	–	–	–	–
		Best-in-class competitor 2	98,2%	–	0,5%	–	98,7%	–	–	0,20%		0,03%	–	8	–	–	9,5	–	–	Dom+ Intern	–	–	–	–
	Special services	TNT Portugal	–	–	–	–	–	Global 96,3%	–	–		–	–	–	–	9,6	–	–	–	Dom+ Intern	–	–	–	–
		Best-in-class competitor 1	–	–	–	–	–	Global 95,0%	–	–		–	–	–	–	–	–	–	–	Dom+ Intern	–	–	–	–
		Best-in-class competitor 2	–	–	–	–	–	Global 96,3%	–	–		–	–	–	–	–	–	–	–	Dom+ Intern	–	–	–	–

Figure 7 – Benchmarking study integrated in the House of Quality (partial)

Table 3 – Set of functional requirements defined for the service to be developed

FR code	Description of the FR	Type of function
FR_1	Transport in proper conditions and on time any type of goods, from the required origin to the desired destination location	Basic
FR_2	Perform properly all the required non-transport logistic services	Basic
FR_3	Schedule and coordinate the operational activities of the service, attending to the specific customer requirements	Support
FR_4	Provide customer care and support	Support

The set of FRs represent the "What?" the service is supposed to do. At this point in the project, the team needed to develop a design concept for the service that could satisfactorily answer "How" will those FRs be fully satisfied. Such "How's" appear under the form of design requirements (DPs). According to the Axiomatic Design Theory (ADT), a one-to-one relationship shall exist among the set of FRs and DPs. For each one of the previously mentioned FRs, the following DPs were defined:

- DP_1: Specialized transportation services for events and campaigns
- DP_2: Complementary logistics services
- DP_3: Domestic and international operations management
- DP_4: Customer service & support, including track & trace solutions

The idea inherent to this concept is illustrated in figure 8. This concept emerged after studying different alternative concepts that were brainstormed by the project team.

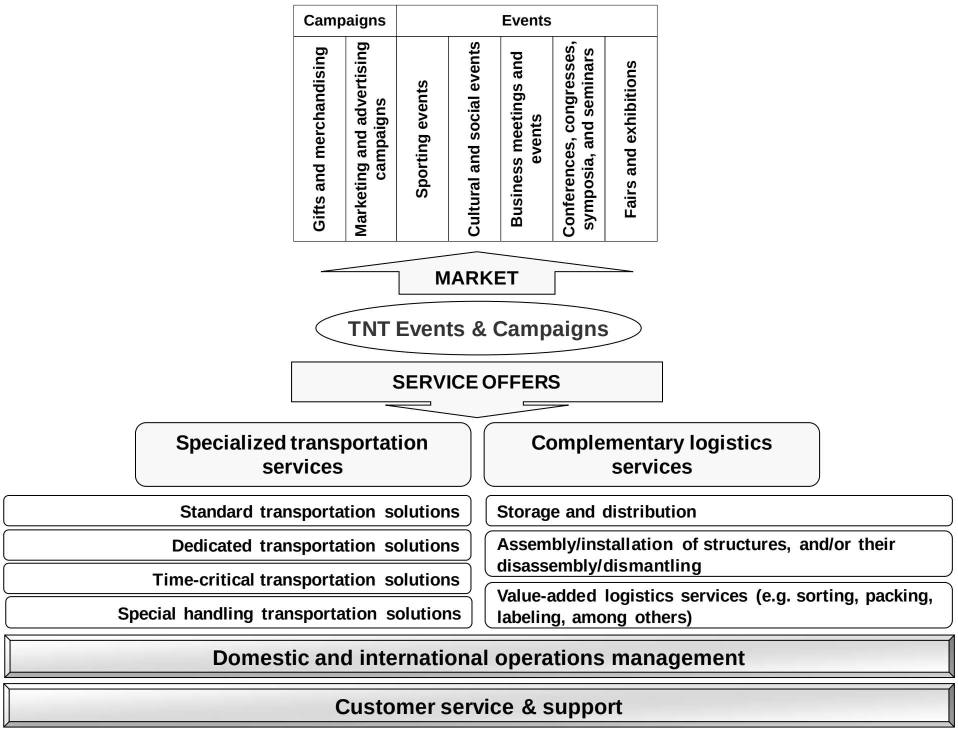

Figure 8 – Design concept for the new service

This concept was then analyzed according to the principles of ADT, developed by Suh (2001). The construction of the design matrix exhibited in equation 1, which relates the set of FRs and DPs, revealed an uncoupled design that is not recommendable:

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ FR_3 \\ FR_4 \end{Bmatrix} = \begin{bmatrix} X & X & 0 & 0 \\ 0 & X & 0 & 0 \\ X & X & X & 0 \\ X & X & X & X \end{bmatrix} \begin{Bmatrix} DP_1 \\ DP_2 \\ DP_3 \\ DP_4 \end{Bmatrix} \qquad (1)$$

According to the ADT principles, a design concept should be either uncoupled (diagonal design matrix) or decoupled (triangular design matrix), which is the only way to ensure functional independency of all the FRs. By reordering the previous matrix, as shown in equation 2, a decoupled design was achieved.

$$\begin{Bmatrix} FR_2 \\ FR_1 \\ FR_3 \\ FR_4 \end{Bmatrix} = \begin{bmatrix} X & 0 & 0 & 0 \\ X & X & 0 & 0 \\ X & X & X & 0 \\ X & X & X & X \end{bmatrix} \begin{Bmatrix} DP_2 \\ DP_1 \\ DP_3 \\ DP_4 \end{Bmatrix} \qquad (2)$$

Equation 2 means that iterations will be avoided as long as the design decisions follow the order provided by the matrix. This signifies that when planning a certain service order requested by a customer, planning decisions should first be made for the complementary logistics solutions, and only then for the transportation services. The content of the matrix also means that when the transportation and logistics activities are fully defined, their sequence in time is then scheduled by the operations management process. The whole service is supported by the customer service system of TNT, including the track and trace solutions

The service design concept was then detailed by decomposing the high-level FRs and DPs into increasing levels of detail until the design could be implemented and tested. To achieve this, the value-based axiomatic decomposition method (Marques *et al.*, 2013a), that combines ADT with FAST (Functional Analysis System Technique) was applied. The full decomposition for the FR_1-DP_1 pair is described in Marques *et al.* (2003b). The results of the decomposition for the FR_2-DP_2 are outlined in figure 9. After decomposition, the final full design matrix was constructed to confirm the consistency of the design decisions throughout the decomposition process.

FR_2: Perform properly all the required non-transport logistic services	DP_2: Complementary logistics services
$FR_{2.1}$: Develop the required value-added logistics operations	$DP_{2.1}$: Value-added service solutions
$FR_{2.1.1}$: Accomplish the formation and packaging of materials according to the specific requirements	$DP_{2.1.1}$: Procedures and resources for formation and packaging tasks
$FR_{2.1.2}$: Execute the labelling of goods and materials according to the specific requirements	$DP_{2.1.2}$: Procedures and resources for labelling tasks
$FR_{2.1.3}$: Conduct the triage and sorting of goods and material according to the specific requirements	$DP_{2.1.3}$: Procedures and resources for triage and sorting tasks
$FR_{2.1.4}$: Perform the preparation and expedition of the goods and materials according to the specific requirements	$DP_{2.1.4}$: Procedures and resources for preparation and expedition tasks
$FR_{2.1.5}$: Coordinate and control the value-added logistics operations	$DP_{2.1.5}$: Operational supervision
$FR_{2.2}$: Develop the required operations for the assembly/installation and/or disassembly/dismantling of structures	$DP_{2.2}$: Procedures and resources for the assembly/ installation and/or disassembly/dismantling of structures
$FR_{2.2.1}$: Prepare the area/place where the assembly/installation will take place	$DP_{2.2.1}$: Procedures and resources for pre-assembly and pre-installation activities
$FR_{2.2.2}$: Execute the assembly/installation according to the requirements	$DP_{2.2.2}$: Procedures and resources for assembly and installation
$FR_{2.2.3}$: Verify/inspect the structure after being assembled/installed	$DP_{2.2.3}$: Procedures and resources for final verification
$FR_{2.2.4}$: Execute the disassembly/dismantling tasks according to the requirements	$DP_{2.2.4}$: Procedures and resources for disassembly and dismantling
$FR_{2.2.5}$: Remove and sort the materials of the structure properly	$DP_{2.2.5}$: Procedures and resources for the post-assembly and post-dismantling of the structures
$FR_{2.2.6}$: Restore the original conditions of the area/place	$DP_{2.2.6}$: Procedures and resources for cleaning and restoring of physical spaces
$FR_{2.2.7}$: Coordinate and control the assembly/installation and disassembly/dismantling operations	$DP_{2.2.7}$: Operational supervision
$FR_{2.3}$: Develop the required operations of distribution necessary to the event or campaign	$DP_{2.3}$: Logistics distribution solutions
$FR_{2.3.1}$: Prepare the materials and goods to be distributed	$DP_{2.3.1}$: Procedures and resources necessary for the preparation tasks
$FR_{2.3.2}$: Comply with the procedural requirements during distribution	$DP_{2.3.2}$: Procedures and resources used during distribution
$FR_{2.3.3}$: Distribute the required goods by the intended recipients	$DP_{2.3.3}$: Data about the recipients
$FR_{2.3.4}$: Coordinate and control the distribution operations	$DP_{2.3.4}$: Operational supervision
$FR_{2.4}$: Develop the required moving operations	$DP_{2.4}$: Logistics moving solutions
$FR_{2.4.1}$: Provide the conditions that ensure the integrity of the goods and materials to be moved	$DP_{2.4.1}$: Preventive actions and protection solutions
$FR_{2.4.2}$: Perform the required moving operations	$DP_{2.4.2}$: Procedures and resources inherent to the moving operations
$FR_{2.4.3}$: Finalize properly and safely the moving operations	$DP_{2.4.3}$: Procedures and resources for discharging the goods and materials
$FR_{2.4.4}$: Coordinate and control the moving operations	$DP_{2.4.4}$: Operational supervision
$FR_{2.5}$: Define the specific complementary services to transport that need to be perform to satisfy the specific applicable requirements	$DP_{2.5}$: Definition of the service process
$FR_{2.6}$: Provide good customer support in the complementary services	$DP_{2.6}$: Customer Service & Support (Special Services)

Figure 9 – Results for the decomposition of the FR_2-DP_2 pair

"Optimize" phase

The optimization phase of IDOV comprises both conceptual and operational perspectives. Due to these, a pilot test aiming to assess the operational/functional performance of the service, as well as to determine whether the relationships among all FRs and DPs, indicated in the final full design matrix, were judged correctly, was conducted. The requirements applicable to the pilot test, which scheme is depicted in figure 10, were the following:

- Pick-up a set of furniture equipments (a total of 37 parts) at a warehouse located in Sacavém (the address was described in the customer order) to be delivered by 9 a.m. at the banking agency located in Pinhal Novo; pick-up and delivery were both required to occur on March 24.

- From 9 a.m. of March 24, prepare and assemble the furniture parts at the temporary facilities of the banking agency.
- From 3 p.m. of March 26, the furniture needs to be moved to the definitive facilities of the banking agency, where each assembled furniture set needs to be placed and installed in the correct space/place of the banking agency facility.
- The installation of the furniture must be concluded until 4 p.m. of March 27.

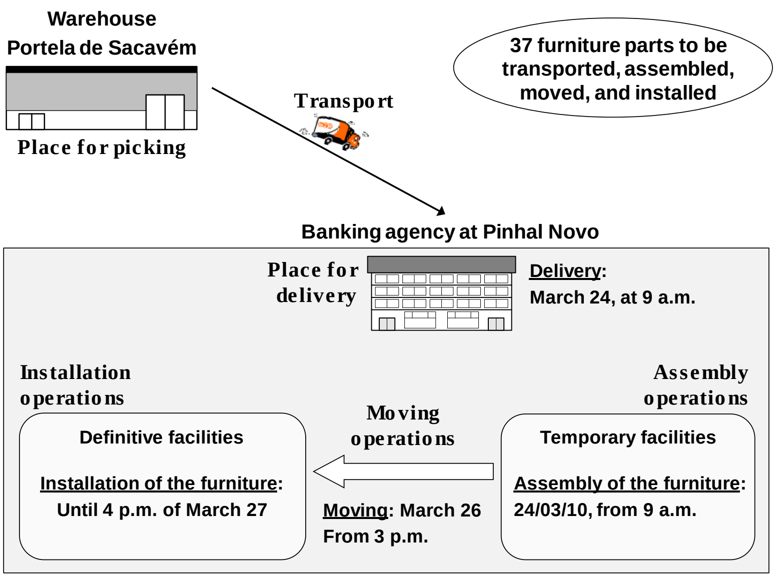

Figure 10 – Scheme of the pilot conducted to test the designed service

The analysis of the pilot enabled the project team to check whether the conceptual decisions made during the Design phase of the IDOV roadmap needed to be improved or not. The team realized some slight adjustments needed to be done. The final full design matrix that resulted from the design decisions was also verified. It revealed that some coupling exist when storing services needs to be provided. To minimize the coupling degree, a reordering algorithm was applied to triangularize the most possible the matrix.

The operational performance of the pilot was assessed and recorded in a Design Scorecard format, illustrated in figure 11. Please notice that the CTQCs are directly linked to the functional requirements defined in the Design phase. The data exhibited in the Scorecard revealed a very reasonable result.

"Validate" phase

After the introduction of conceptual and operational improvements, a final test was developed in order to verify the performance of the service and be able to validate it. To support the service prototype, a set of templates were developed and utilized during its planning and execution.

The results of the prototype were presented and assessed at an executive meeting, together with resume of the entire project path. The service was validated and its framework considered to be incorporated in the service offerings.

<table>
<tr><th></th><th></th><th>CTQC</th><th>Requirements</th><th>Opportunities for defect</th><th>Result</th><th>Comply with requirement ?</th><th>Sigma Level (Z)</th><th>DPMO</th></tr>
<tr><td rowspan="8">Overall performance of the service</td><td rowspan="3">Transportation services</td><td>On-time delivery</td><td>Delivery between as 8.45 a.m. and 9.15 a.m. of March 24</td><td>1</td><td>8.55 a.m. March 24</td><td>Yes</td><td>—</td><td>—</td></tr>
<tr><td rowspan="2">Integrity of the goods transported</td><td>Delivery of all furniture parts</td><td>37 (37 parts)</td><td>37 parts delivered</td><td>Yes</td><td>—</td><td>—</td></tr>
<tr><td>Deliver all furniture items/parts in good conditions</td><td>37 (37 parts)</td><td>37 parts in good conditions</td><td>Yes</td><td>—</td><td>—</td></tr>
<tr><td rowspan="5">Complementary logistic services</td><td>Success of moving operations</td><td>Moving operations from the temporary to the definitive facilities to start from 3.00 p.m. of March 26</td><td>1</td><td>Moving operations started at 3.05 p.m. March 26</td><td>Yes</td><td>—</td><td>—</td></tr>
<tr><td rowspan="4">Success of assembly and installation operations</td><td>Assembly operations need to be concluded before 3.00 p.m. of March 26</td><td>1</td><td>Concluded at 6.00 p.m. March 25</td><td>Yes</td><td>—</td><td>—</td></tr>
<tr><td>Installation operations need to be concluded until 4.00 p.m. of March 27</td><td>1</td><td>Concluded at 3.00 p.m. March 27</td><td>Yes</td><td>—</td><td>—</td></tr>
<tr><td>Assemble the furniture parts in specified sets</td><td>24 (24 sets)</td><td>All 24 sets well assembled</td><td>Yes</td><td>—</td><td>—</td></tr>
<tr><td>Install the furniture sets in the required places of the banking agency</td><td>24 (24 sets)</td><td>1 set was reinstalled</td><td>Yes for 23 of the sets (1 defect)</td><td>—</td><td>—</td></tr>
<tr><td colspan="4">TOTAL</td><td>126</td><td>—</td><td>—</td><td>3,9</td><td>7.937</td></tr>
</table>

Figure 11 – Design Scorecard with the operational results of the service pilot

Post-project activities. After its completion, a report for this DFSS project was prepared. A set of best practices and lessons learnt, including mistakes that were made throughout the IDOV roadmap, was added to this report

CONCLUSIONS

This paper described a practical application of a Design for Six Sigma project to the development of a new service to be provided by a Portuguese company. As long as the authors of this paper know, this is the first paper describing a practical application of a DFSS project to the service sector in Portugal. The decision to start the project was taken after the identification of opportunities for innovation. The company's top management demonstrated interest in developing a new service, under the offering provided by the special services area, providing transportation and other logistics solutions for the industry of events and marketing campaigns. The project was conducted according to the four-phase IDOV roadmap. Each project phase was described, together with the structured employment of tools and techniques. The Identify phase aimed to detect the relevant stakeholders, gather their needs and wants, determine the fundamental set of service requirements, and establish the service CTQCs. The Design phase comprised the formulation of the high-level concept for the service and then the development of its detailed design. A pilot-test of the service was carried out in the Optimize phase, allowing the project team to improve the design decisions and to assess the operational performance of the service. Finally, the service was validated in the last phase of IDOV, after conducting a prototype of the service.

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USE OF SIX SIGMA ESTRATEGY IN THE PLASTIC INJECTION SECTOR TO REDUCE REJECTED PIECES IN A SEWING INDUSTRY OF CARIRI – CE, BRAZIL

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ABSTRACT

The paper describes results obtained using the Six Sigma methodology in an industry of sewing machines located in Juazeiro do Norte - CE, Brazil. The research has shown the importance of the Six Sigma program, demonstrating its applicability (Koksal ET AL, 2011). The company's plastic injection sector stands out as an internal supplier of most of the parts in the production process where the dispatch of pieces with acceptable quality is essential in the assembly of machines produced. The quality audit of the company revealed the existence of a considerable number of rejected pieces because of defects, it is important to reduce these indices, justifying the performance of this paper which followed the sequence of the PDCA in steps DMAIC. The Six Sigma has been successfully applied in various companies: Biopharmaceutical Industry (ABDULLAH ET AL, 2014), in the food industry (MULLER & DROHOMERETSKI , 2013), in the textile industry (Karthi ET AL, 2013) and in the automotive industry (FERNANDES & Turrione, 2007) being applied in the industry focus of this paper and helping to identify items and to reduce them in about 31%. Using the Ishikawa diagram was possible to identify the causes and to point the correctives measures applicable. Then, control measures were carried out and in the end, it was possible to reduce the initial cost of R$ 0.71 per machine month to R$ 0.35 per machine month, which indicates reduction above the established goal and demonstrates the relevance of the Six Sigma methodology to generate value for the company.

Key-words: Six sigma, control, quality improvement.

Classification of the article: Study of case

INTRODUCTION

The quality management has been one of the most important tools for ensuring the competitiveness of companies that look for a reduction in their losses and consequently in their costs.

The importance of quality improvement justifies the evolution of the models proposed by Deming, Juran and Ishikawa, generating new management methods, such as the Six Sigma developed by Motorola company which has been successfully applied in several companies.

Researchs show its successful application in loss reduction and applicability in several businesses as several recent studies: (ABDULLAH ET AL, 2014), (MULLER & DROHOMERETSKI, 2013), (Karthi ET AL, 2013) e (FERNANDES & Turrione, 2007).

This research was developed in a manufacturer of sewing machines in the interior of Ceará, Brazil, in order to reduce refusal rates of pieces in their production and consequently decrease their production costs. The goal of the study was to analyze the results obtained after the implementation of the Six Sigma methodology in view of reducing refuse from plastic injection machines in the enterprise sector.

To achieve the intended objective, it was necessary to: verify the use of the Six Sigma methodology in the studied sector; collect data relatded to products rejected in the period before and after the implementation; define where were the largest waste of refuse; stratify the data related to defects; elaborate diagnosis of the situation; suggest actions for continuous improvement of the sector; collect results from the actions implemented.

To understand more about the method, it is possible to do a methodological classification which are identified:

The type of research, according ARAUJO (2012), is classified as exploratory, because the goal is to enhance the ideas, making the problem more familiar and constructing hypotheses. A conceptual discussion was developed from existing literature about the Six Sigma management strategy. The conceptual discussions were used to know about the Six Sigma strategy, its tools, and critical success factors and then it was possible to build the best way to apply these tools.

In the approach, the study was classified as qualitative research, "where the distinctive characteristic, in contrast to quantitative research, the emphasis is on the perspective of the individual that is being studied." (MICHAEL, 2010. Pg. 50). To Engineering Production, this means to watch the researched organization, to collect evidence, which in this case was carried out observing the productive environment and its variability of production.

Regarding the purpose, the research is explanatory genre, where, according to Ganga (2012), seeks to examine relationships of cause and effect between two or more phenomena, facts or variables, checking if an explanation can be validated, in this paper, it is possible to verify the relationship between the application of the Six Sigma tools, efficiency and effectiveness of the company that applies these tools in a structured way.

The procedure can be classified as a single case study, according to Ganga (2012), the function of the researcher is to obtain information about the phenomenon according to the eyes of the individual, collecting information that allow the correct interpretation of the data that are collected in a context real life. In our study, data were collected on the sewing machine company, located in Brazil Northeastern.

Data collection was conducted through structured interviews with managers and administrator, quality supervisors, direct observation of plant floor information and files and company documents that show the variability of the monitoring process, as well as bibliographies and articles in the field that can add value to the researcher regarding the Six Sigma.

THEORICAL REFERENTIAL

Six Sigma Strategy. The Six Sigma strategy emerged in the 1980's in the United States, when Motorola decided to reduce the failure rate of electronic products in their manufacturing process (Braunscheidel et all, 2011). A philosophy that operates according to the principles of Total Quality Management with an intense use of statistical methods. The goal of the program was to improve the reliability of the final product and reduce the loss or refuse. The popularization of the Six Sigma occurred in the 90s and had as leader John F. Welch, then chairman of General Electric Company (GE). Interesting to note that until to know the methodology, he discredited in any quality program, and used to say that it is only cost and not investment.

The Six Sigma methodology has been the subject of several studies (RODRIGUES, 2006; WERKEMA, 2011; MAST, LOKERBOL,2012).

Rodrigues exposes that the Six Sigma method corresponds to the management of managerial factors with the use of statistical tools with important results in practical use in various industries.

Werkema (2011) explains the Six Sigma as a disciplined methodology focused on business, which uses statistical tools to measure and improve the operational performance of an organization by the elimination of defects and waste, adding value to the product and process, aiming to increase customer satisfaction and reduce costs, dramatically increasing the company's profitability.

Mast and Lokerbol (2012) define the Six Sigma as a systematic and organized method that allows a strategic development and uses statistical and scientific methods to obtain a dramatic reduction in defect rates. Anabi (2002) apud Carvalho (2007), argues that the Six Sigma methodology can be defined by the expression:

Six Sigma =	**TQM +**	**GFC +**	**DFQ +**	**AP**
	Toltal Quality Management	Management focused in the customer	Use of Quality tools	Administration per projects

Basically, the Six Sigma is a methodology that uses statistical methods and tools to define, measure, analyze, improve and control processes and existing products in order to achieve optimal levels for the same, through the systematic elimination of its flaws, leading products and services free from errors that can be delivered in a shorter time and at a lower cost, and having focus on the customer and product.

The Six Sigma has the following characteristics:

- Involvement of all areas;
- Monitoring of processes and results;
- Management based on facts and data;
- Training of specialists in the company;
- Union of various tools with customer focus and continuous improvement;
- Main focus is the process, not the product.

The goal of Six Sigma quality system, as the name implies, aims to achieve a six sigma level of defects in quality or scale of 3.4 ppm in the range of defects per million (MONTEZ, 2011). Standard deviation (or sigma) is a statistical measure that lets know how much the studied characteristic is varying. Therefore, the Six Sigma continually "squeezes" the product's standard deviations between the goal of the company and the goal of the customers, thus ensuring 99.99966% chance of success.

The Six Sigma identifies and eliminates costs of waste, in others words, that do not add value to customers, as opposed to cost cuts without foundations that take into account only the financial value by reducing product without realizing that often these cuts directly affect the quality product, which nowadays has been a differential competitive product in the consumer market.

One of the major impulses in companies that have implemented the Six Sigma has been the development of highly trained teams to organize and to work on the improvement projects specialists. So, for that the Six Sigma be successful in business, is required to train people with appropriate profile that will become program sponsors, or experts in the method and in the Six Sigma tools. These sponsors and experts are presented below:

Six Sigma's Sponsor: defines guidelines for implementation of the Six Sigma**.**

Sponsor facilitator: is a director of the company. This manager has the responsibility of advising the Sponsor of the Six Sigma in the program implementation.

Champions: managers whose responsibility is to support projects and remove potential barriers to its development. Are directors or managers of the company.

Master Black Belts: are professionals who advise the Sponsors and Champions and act as mentors to Black Belts and Green Belts.

Black Belts: leading teams in conducting functional or cross-functional projects, achieving greater visibility in the structure of the Six Sigma.

Green Belts: are professionals who participate in teams lead by Black Belts, or lead teams in conducting functional designs.

Yellow Belts: trained to support Green Belts and Black Belts.

White Belts: are professionals of the operational level of the company, trained in the Six Sigma fundamentals so they can support to the Black Belts and to the Green Belts in project implementation and ensure the quality of information for projects.

The methodology key of the Six Sigma is the DMAIC. The DMAIC model is used to improve an existing business process.

Mast and Lokkerbol (2012) write that even described as a method to reduce the variation, the DMAIC is applied to solve problems through improvements. The DMAIC is a similar function similar to the problem solving method PDCA, developed by Shewhart in the 20s. Like the PDCA, the DMAIC is shown as the figure of a circle, where the actions are sequenced into a continuous loop, Figure 01.

Figure 1. Six Sigma Improvement Cycle, DMAIC.

Source: Adapted from Werkema, 2011.

In the figure 1 are shown the main activities of the DMAIC methodology: the DEFINE "D" is to define priorities. Translate customer requirements into critical quality characteristics. MEASURE "M", how the process is measured and how it runs? The measurement system must be adequate and meet the needs of the process. ANALYSE "A", identify the major causes. Analyze the data collected and the use of statistical software is essential to facilitate calculations and graphic designs. IMPROVE "I", remove the causes of defects. Statistical data should be transformed into process data and staff should consider what improvements should be materialized. CONTROL "C" (control), to maintain improvements. According to ISO 9001 (MARANHÃO, 2006), the whole system tends to entropy, so it is necessary to measure for control, track every improvement implemented, to observe the parameters over time to get up to predict the behavior.

To implement this strategy and achieve reduction of variability are used traditional tools of quality, presented in Table 1 and some changes, improvements and even innovations, plus some of the known techniques applied by the Lean Manufacturing Toyota Production System.

Table 1: Control tools of total quality

Tool	**Characteristic**	**Use of the tool**
Check Sheet	Spreadsheet for data collection	To facilitate the collection of data relevant to a problem
Pareto Diagram	Bar diagram that orders instances from highest to lowest	Prioritize few but vital.
Cause and Effect Diagram	Structure of the method wich expresses, in a simple and easy way, the cause of a series of effects (problem)	Expand the number of potential causes to be analyzed
Scatter Diagram	Cartesian graph that represents the relationship between two variables	Check the correlation between two variables
Histogram	Diagrama de barra que representa a distribuição da ferramenta de uma população	Verificar o comportamento de um processo em relação à especificação
Flowchart	Are flows which allows an overall view of the process where the product goes by	Set limits and know the activities
Control Graph	Graph with boundary control that allows monitoring of processes	Check if the process is under control.

Source: CAMPOS (1999)

The decisions must be taken through an analysis of the statistical data in order to enhance the information that will be used in quality tools:

The Check Sheet are spreadsheets for data collection easy to fill out, where the generated defects can be divided: operator, machine, date, shift, responsible and quantity of refusal inspected pieces.

The Pareto Diagram or Pareto Graph is a bar chart that has an order of occurrence from highest to lowest, and an accumulator that represents the percentage of the cause. This also has a relationship known as 80 - 20, which states that 80% of the consequences stem from 20% of causes. This graph is used to guide the main.

The Ishikawa Diagram, Cause and Effect Diagram or Fishbone is a tool represented by a graph where is possible to make an organization and to describe the cause of every defect and get to the root cause. This tool facilitates the visualization of the causes until to arrive to the problem, and facilitates the creation of an action plan that contains all necessary actions to fill the chart.

The histogram is a bar graph representing the characteristics that allows a process variations general viewing of the data set, or is a tool that serves to inform the location, shape and size of a sample. This tool is most used in the analysis of dimensions. To complete the interpretation of the graph is necessary to know the techniques of reading: when the average of the data be located in the center represents the optimal point; when the average tends to the left or to the right is that the sample is not aligned; and the histogram for peaks means that the samples are mixed well and different.

The Scatter Diagram is a graph typically used to identify cause and effect, it easily shows if there is a relationship between them. It is usually used to show the existence of a relationship between two factors or variables.

The flowchart is a tool that illustrates the flow of operators of a process that identifies various stages of the process where we can view the aspects that can be improved. It is a very important tool for management, since it has an easy and quick reading facilitating the understanding in more detail. The flowchart is summarized in three important points:

a) Home (input) - subject to be considered in planning;
b) Process – consists in the determination and the interconnection of modules that cover the subject. All operations that make up the process;
c) End (output) - end of the process, where there are no more actions to be considered.

Graph Control or Control Chart is a tool for monitoring the viability where are stabilished bands of limits statistically, called upper control limit, lower control limit and a line is drawn in the middle representing the mean interval limits. The percentage has standing ally within the control limits to be within the target.

With the professional well trained and qualified, the use of these and other tools, as well as training for all industry participating in projects, the Six Sigma strategy gets impressive results, with investment returns in very quick time.

THE COMPANY

Currently the company has 311 (three hundred and eleven) employees, with a workday of 40 (forty) hours per week, divided into 8 (eight) hours per day, Monday to Friday, with a break of 1 (one) hour for lunch and two breaks of 20 (twenty) minutes for gymnastics and snack.

The company has a system of production lots, serial production and custom. The distribution takes place according to the models of machines and on schedule. The company manufactures domestic sewing machines and more recently two new products: iron and machine overlock. The other models of industrial and semi-industrial machines are produced in other countries where the company has branches.

The assembly lines are two for sewing machines, one for the model "A" and one for the model "B". A third model "C" goes into production according to orders, with a daily production capacity of 225 (two hundred and twenty five) machines. The production takes place according to the requests made. Currently are produced on average 660 (six hundred and sixty) machines per day.

The Studied Sector. The injection sector was chosen for analysis because has been verified a high refusal product rate and the fact that the industry provides other components for factory production sequence. The sector is the responsible for supplying and installation of parts for sewing machines.

In the description of the sector was noted the existence of 12 (twelve) thermoplastic injection molding of several sizes arranged in line, working with matrices or molds in variety.

In plastic injection sector, the material is heated in the injection molding and then is transformed in plastic parts. After this process, the materials produced pass by a quality audit to be evaluated and then are released to production line or pre-assembly.

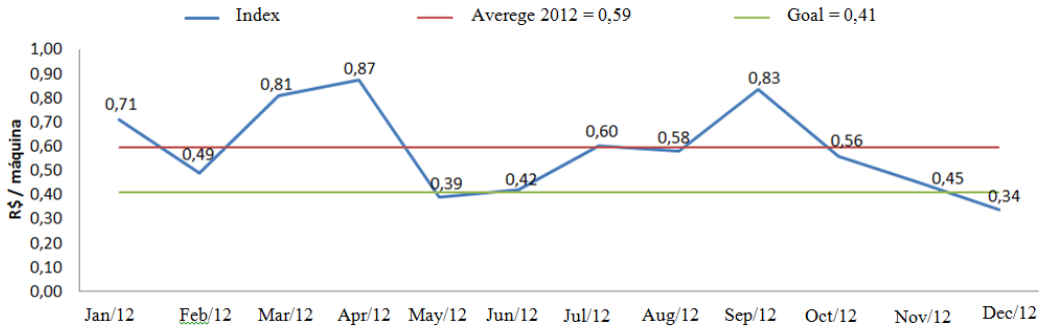
The parts that are not approved by the audit are sent directly to the refuse area, where they are evaluated and taken to grinding. Daily, a worker counts and records in the refuse sheet the observed amount.

For the application of the Six Sigma strategy, it sets up a working group composed by five people directly involved in the plastic injection process. One of the members, graduate, GREEN BELT, trained all the others and the works were initiated to solve the problem using the DMAIC Methodology.

Aplication of the Six Sigma strategy. The process was started with the "DEFINE", phase where the data collection is made to define the problem. The basic data were the related to the total cost of rejected pieces of the sector in 2012. An average percentage of 31% was established as the cost reduction target with the scrap industry.

The graph 1 shows the history of the refuse index per machine generated during the year. It is noticed that there are several peaks not allowing a reliability of the waste generated, by not having an alignment with the production of the month.

Graph 1. Refuse Index Indicator in 2012



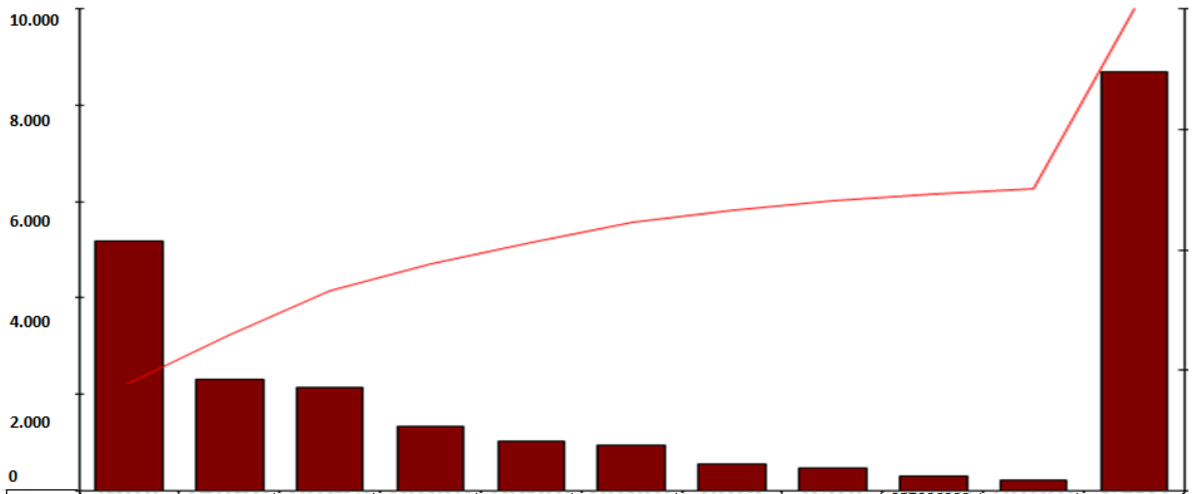
Source: The Company, 2013

Following with the paper, the next step was the "Measure", measurement of non-compliance and its implications. Several measurements were performed in order to identify the criticality of the current problem and understand its root cause.

To perform this task a sheet verification was created, where was possible identify the characteristic part, raw material, quantity, shift, operator, machine and stratification of defects.

To interpret the obtained values was used the Pareto Graph according to Graph 2, which identified the main items discarded.

Graph 2. Main items rejected in the manufacture of sewing machines in the period from january to may 2013.



ITEMS	6758300	357337900	360057910	356053902	358572900	360058900	6680300	6049300	357336900	360060900	ACCUMULATED
$	R$ 5.190,80	R$ 2.304,30	R$ 2.150,30	R$ 1.332,40	R$ 1.028,60	R$ 956,21	R$ 562,68	R$ 481,52	R$ 324,67	R$ 236,05	R$ 8.696,30
%	22%	32%	41%	47%	52%	56%	58%	60%	62%	63%	100%

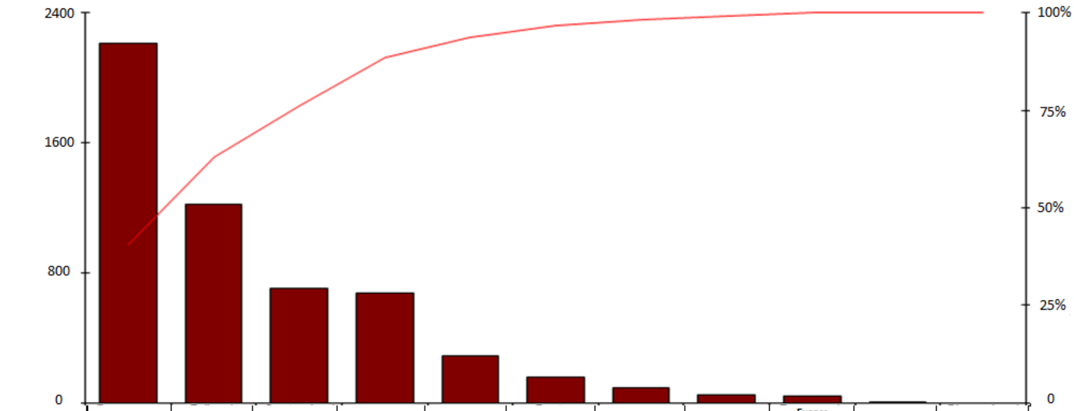
$: value of the refuse in the manufacture of sewing machines in brazilian currency units (R$); %: percentage of refuse in the total waste.

Source: The Company, 2013

It is observed that the sector spending item is returned directly to the White ABS (6758300), most important raw material in the production, with higher cost, and which concentrates more than 22% of the value of the discarded items in the sector.

To identify the main causes of the defects was used the Pareto Graph again showing the main faults found in the refuse during the measurement.

Graph 3. Main defects founds in the manufacture of sewing machines from january to may 2013



	Parts with gas	Injection nozzle	Contaminated	Sucker	Yellowishe	Black dots	Burnt	Scratch	Excess deburring	Others	Dimensional off
Quantity	2210	1220	702	677	285	155	94	46	41	4	0
Accumulative	40,67%	63,12%	76,04%	88,50%	93,74%	96,60%	98,33%	99,17%	99,93%	100,00%	100,00%

Source: The Company, 2013

The main defects found from january to may 2013 are observed in the Graph 3, where the larger defect found is because of the presence of gas in the paint with a perceptual of 40.67%, follow by injection failure with a perceptual of 22.45% and contamination with 12.92% and sucker with 12,46%, being the main problems verified.

In the "ANALYZE" phase, was proposed the further analysis of the data collected to find causes and solutions. Was implemented from weekly meetings with staff, which identified possibles causes of defects after a brainstorming and drafting a cause and effect diagram (Ishikawa diagram) for each of the main problems identified: Gas Flow, Injection Failure and Suck, Contamination and Occurrence of Black Dots.

The graph 3 analysis showed certain similarity of faults and therefore the analysis with three cause and effect diagrams.

The main problem of refuse was concentrate on the flow of gas, more than 40% of defects were concentrated in this item. Possible causes of defects were discussed and then after filtering, it was possible to draw up a cause and effect diagram for each one of these presented defects.

The next stage implemented was the "IMPROVE", which sought to implement actions to eliminate causes. After the measurements, the team, with the aid of the cause and effect diagram of each problem, devised a plan of action to reduce the possibles causes of errors.

Action plans were developed for the major problems identified. The procedure was repeated, initially conducted the discussion in brainstorming and then the preparation of action plans for each one of the problems identified. At this time, the production was more extensively monitored to identify possible failures injection. There were no occurrences of faults during this phase.

The last phase of the study was the "CONTROL", process control. One characteristic of the quality is to discover the "why" and prevent other events. First, were made repairs in the most critical molds where occured rejected parts with brands gas flow.

The second step was to replace the damaged and worn nozzles of the most complex molds and parts, per example front and back cover of model B, as shown in figure 2**.**

Figure 2. Injection nozzle

(a) Injection nozzle damaged (b) New injection nozzle

Source: The Company

A control for checking of temperature of the cylinder (cannon and nozzle) that rises to the incorrect use of resistance was created, deployed a card, figure 3, for verification every 2 (two) months of the temperature in the injection panel.

Figure 3. Card to check temperature real x marker

Card to check temperature real x marker

Check date: ____/____/____ ☐ OK ☐ NOK

Next check date: ____/____/____ ☐ OK ☐ NOK

Note: check every two months

Source: The Company, 2013

Standard procedure statement was prepared to start and to stop the injection and another one for supply of machinery.

As solution was presented the installation of a timer to turn on and turn off automatically the stoves. From Monday to Friday the stove is turned on at 8 pm to prepare the material, then the third shift already start the process with the raw material already heated, facilitating the reduction of parts with gas flow.

Likewise, the whole beginning of the week, the process is continuous powering the unit at 4 pm for business hours now start the process in the best possible way.

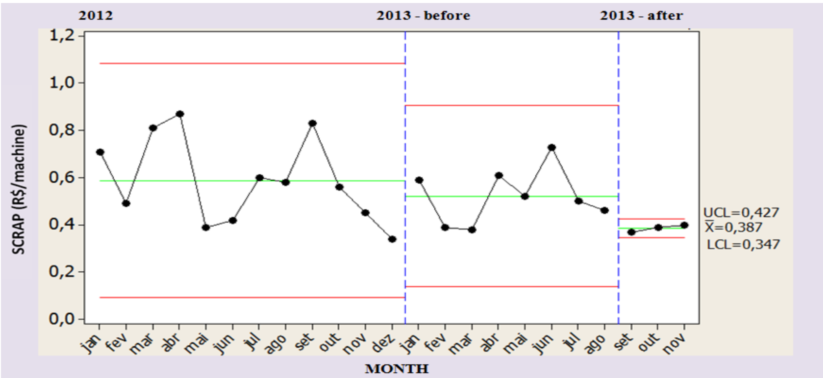
After the implementation of these actions, the team was faced with a deficiency around the weekly control refuse index, going to be controlled with the use of eletronic spreadsheet.

The team created a control to a monthly monitoring, called "actions implemented continuity control" which features guarantee that the actions, once implemented are maintained, thus ensuring the maintenance of the achieved results.

RESULTS

Through the actions of implementation and with operating system was undertaken to evaluate the process. For the evaluation it was necessary to check the results obtained during two months of implementation, being observed high rates of acceptance of the results as shown in Graph 04. The rate of refuse fell significantly in September reducing expenditures on company. It is observed that the drop in Graph 04 is the result of actions aiming at efficiency, demonstrated in the results of index 0.37 R$ / machine in September and 0.35 R$ / machine in October, representing the lowest values obtained since the year 2011.

Graph 4: Control Chart 2012 e 2013



Source: The Company, 2013

Using the control chart was possible to visualize the boundaries of the upper and lower control. From the actions taken, an alignment, approaching ever closer to the average for the year 2013 and getting positioned in the lower level of the index of the year 2012. The results show that the actions taken reproduce positive results. The control chart, graph 4, shows a significant reduction in the rate of refuse and reduction in the variability, which went on to generate a higher return of results and reduction in rejection rates in the industry.

FINAL CONSIDERATIONS

With the use of the Six Sigma methodology was possible to reduce the refusal rate in the company of plastic injection sector, even surpassing the target set at the beginning of the actual process R$ 0.41 per machine.

With the support of the stages of the cycle DMAIC (Define, Measure, Analyze, Improve, Control) was possible to organize the problems, to create ideas for fighting them and put them into practice at the right time.

The steps of the DMAIC cycle begin by **Define** where all the problems and goals were defined, in the **Measure**, was made a stratification of the problems in the production process, in the **Analyze** all causes were tracked and the root problem was identified, as well as the path that would lead to effective results, **Improve** was the step where the project began to show signs of improvement and, finally, **Control** showed the control of the taken actions and how to do the continuous control, for don't return to the current state.

With the application of the Six Sigma strategy, the department of plastic injection company, received index remained below the target set, being the lowest score among all been harvested since 2011, which would be R$ 0.41 per machine where in the first month got the result of R$ 0.37 per machine, result that wowed the staff responsible for the project.

The PDCA and DMAIC methodologies are similar and both use the basic tools of quality, however the DMAIC methodology, which is used by Six Sigma, has a form of stricter implementation with returns within a greater control and a training process improved monitoring and therefore brings greater efficiency in the results, as is this case.

On completion of the paper, the Six Sigma strategy showed how is possible to achieve great results in an organized and safe way, with practical actions based on statistical calculations and methods that can be easily understood. The company had a vision, in economic terms, which became significant with the changes made. In addition to becoming more competitive, the company invested in the experience and the qualifications of her employees, so that improvements in economic terms become increasingly present in the company.

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A systematic literature review on quality management in higher education: a trend towards integration

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ABSTRACT

Purpose. This paper presents the results of a systematic literature review on quality management (QM) in higher education (HE), aiming to understand whether the literature presents a trend towards the idea of integration.

We define integration as the development of QM practices and methodologies within organisations which are part of their global management systems, covering different processes and organisational levels, whilst including the implementation of the principles that underlie the definition of QM.

Our thesis is that the literature about QM in HE is evolving towards this idea of integration and is discussing, more and more, broad and holistic approaches to quality, in which these dimensions appear, reflecting a systematic view of higher education institutions (HEIs) and its processes.

In line with this reasoning, our goal is then to understand: how the literature approaches QM in the HE field; to what extent the practices and methodologies of QM in HE become closer to the broader definitions of QM, reflecting its main principles; and to what extent authors provide an overview of QM in an integrative way.

The literature was analysed by taking into consideration that there are three main levels in HEIs: processes level, organisational level and, since our focus is specifically on the field of QM, QM principles level.

Design/ Methodology/Approach. The research was carried out using Elsevier's Scopus data base. Bearing our goals in mind, we searched for the expressions 'QM and 'HE' in articles from social sciences and humanities, from 1980 to 2013. This search resulted in 195 articles. After the first search, data was exported to Endnote and a first reading of the abstracts resulted in the exclusion of articles outside the scope of our research. The remaining 58 articles were then analysed.

Findings. From the analysis we conclude that the integration at the three levels of analysis is strong. Moreover, we identify a trend towards the development of holistic QM approaches, both in conceptual and empirical research. In this sense, the reviewed literature confirms our main hypothesis that there is a trend towards the integration of QM practices and it relates positively to our research question, which is that QM is becoming integrated in HEIs.

Originality/Value. The most innovative contribution of this work is that it presents a systematisation of management literature on the subject of QM in the field of HE; and it provides insights for a discussion on the idea of the integration of QM in institutions' management systems.

Keywords: quality management, higher education, integration, literature review

Article Classification: Literature review

INTRODUCTION

Quality emerged as a business and industrial concern, and gradually became a 'societal' concern affecting all areas of society, especially public services. This concern has driven a controversial debate about the best way to achieve quality in public services and also about the implications of the application in public services of QM frameworks that were designed for business and manufacturing.

There seems to be an aversion to the subject of management and, as a consequence, even when the literature on public services, and HE in particular, addresses QM, it tends to use a different terminology, namely, 'quality assurance', which is rather odd from the point of view of the field of QM research, as it reduces the scope of QM to its assurance component. Indeed, literature on the study of HE has mainly been based on sociology or educational science, and less on management (Amaral & Magalhães, 2007).

Thus, this paper aims to fill a gap in QM literature in the HE field. We review the literature on QM in HE, aiming to understand whether the literature has been evolving towards integration, as we believe that this is the current tendency in this field.

We define integration as the development of QM methods within organisations which are part of their global management systems, covering different processes and organisational levels, whilst including the implementation of the whole set of principles that underlies the definition of QM. Our thesis statement is that literature about QM is evolving towards this idea of integration, and is presenting and discussing, more and more, broad and holistic approaches to quality, in which these various dimensions appear, reflecting a systematic view of the organisation and its processes.

The need for integration is well stressed by some authors. According to Horine and Hailey (1995: 16), "Quality management must be driven by clearly defined goals and strategic plans and must be planned and managed with the same (...) thoroughness as any other organisational strategy." In the same way, Cruickshank (2003) believes that HEI should interweave quality assurance initiatives closely within the strategic plans of institutions.

In line with this reasoning, the research question that we aim to answer through a systematic literature review is the following: is QM becoming an integrated part of HEI governance and management systems?

Thus, this paper intends to provide a systematic review of literature on QM in HE. Its goal is to then understand the following: how the literature approaches QM in the HE field; to what extent methods of QM in HE become closer to the broader definitions of QM and reflect its main principles; to what extent authors provide an overview of QM in an integrative way, whereby it becomes part of the HEI's overall management and governance systems; and finally, we want to check whether there is a temporal trend towards integration. We believe that literature is increasingly showing an integrative approach to QM in HE.

To our knowledge, this is an innovative study in the field of QM, as the most similar study to ours that we have found, is the literature review on quality management in HE that was made by Pratasavitskaya and Stensaker (2010). This, however, was more centred on the specific literature on HE studies, and was more limited in terms of coverage and time frame.

QUALITY MANAGEMENT IN HIGHER EDUCATION

QM has become embedded in more and more organisations since the beginning of the 20th century, when it gradually began to be recognised that lasting improvement could not be accomplished without paying significant attention to the quality of management practices that are used on a daily basis, i.e., that the 'quality of management' is as important as the 'management of quality' (Rosa & Amaral, 2007: 208).

Although it may be difficult, or even impossible, to find a unique and unequivocal definition of quality management, it can be generally accepted that it is a "philosophy or an approach to management" made up of a "set of mutually reinforcing principles, each of which is supported by a set of practices and techniques" (Dean & Bowen, 1994: 92).

Furthermore, these principles are part of a much-debated integrated paradigm for management - Total Quality Management (TQM) - which defines some general guiding principles and the core concepts of quality (Mehta, Verma & Seth, 2014). Nevertheless, "there is no model that can provide an ideal, one-size-fits-all solution for all organisational requirements" (Berlin Communiqué, 2003).

The concern with quality in HE, covering teaching, research, services and institutional-level approaches (Stensaker et al., 2011), gave rise to the debate about the applicability of QM tools to HE, where the most important challenge throughout, is the "critical rethinking" of quality and improvement (EHEA, 1999), and the design of quality models in a language that is "familiar to the culture of HE" and which "could be adaptable to the mission" of HEI (ENQA, 2009: 16, 17).

The idea of integration. Theoretically, the management literature shows that a more integrative vision of QM practices is being proposed and implemented, as part of a broader system of management practices. In fact, the literature seems to be changing its focus, from that of an approach based on measurement models of quality in organisations, to a total and holistic management approach which promotes quality within organisations (Rosa & Amaral, 2007).

Understanding the integration of QM within the particular case of HE institutions is even more interesting than in the case of other industries, due to the fact that HEIs bring to the fore the issue of integration in traditionally fragmented and loosely coupled organisations, as opposed to for-profit organisations, which have a unique strategy and a strong leadership, and even when compared to some public services which have a strong Weberian regime.

In fact, as Orton and Weick (1990: 207) emphasise, universities have a fragmented internal and external environment, motivated by the existence of "dispersed stimuli or incompatible expectations", and consequently, are loosely-coupled systems and can be seen as "organised anarchies" (Cohen et al., 1972: 16; Weick, 1976; Orton & Weick, 1990; Deem, 1998).

However, there are indications that universities are increasingly interested in integrating their main activities and consequently their management practices. A good example is the development of instruments for classifying and ranking HEI and also for adopting a broad range of dimensions and performance indicators (Duque, 2013; van Vught & Westerheijden, 2010).

Moreover, the management context of universities seems to be more and more integrated, leading to the centralisation of power in a small number of decision-making and governance bodies (Melo et al., 2010).

Accordingly, one could argue that universities are, in practical terms, in the process of following the trend found in QM literature and in the daily life of organisations from other sectors – aiming for a stronger integration of various management practices within a global management and governance system.

In our literature review, there are three 'levels' where we look for integration: processes, organisation and QM principles. Following the literature, these three different levels are the most significant in terms of understanding the different approaches to QM in HE, as well as for making conclusions about the degree of integration of QM within the overall governance and management systems of HEIs.

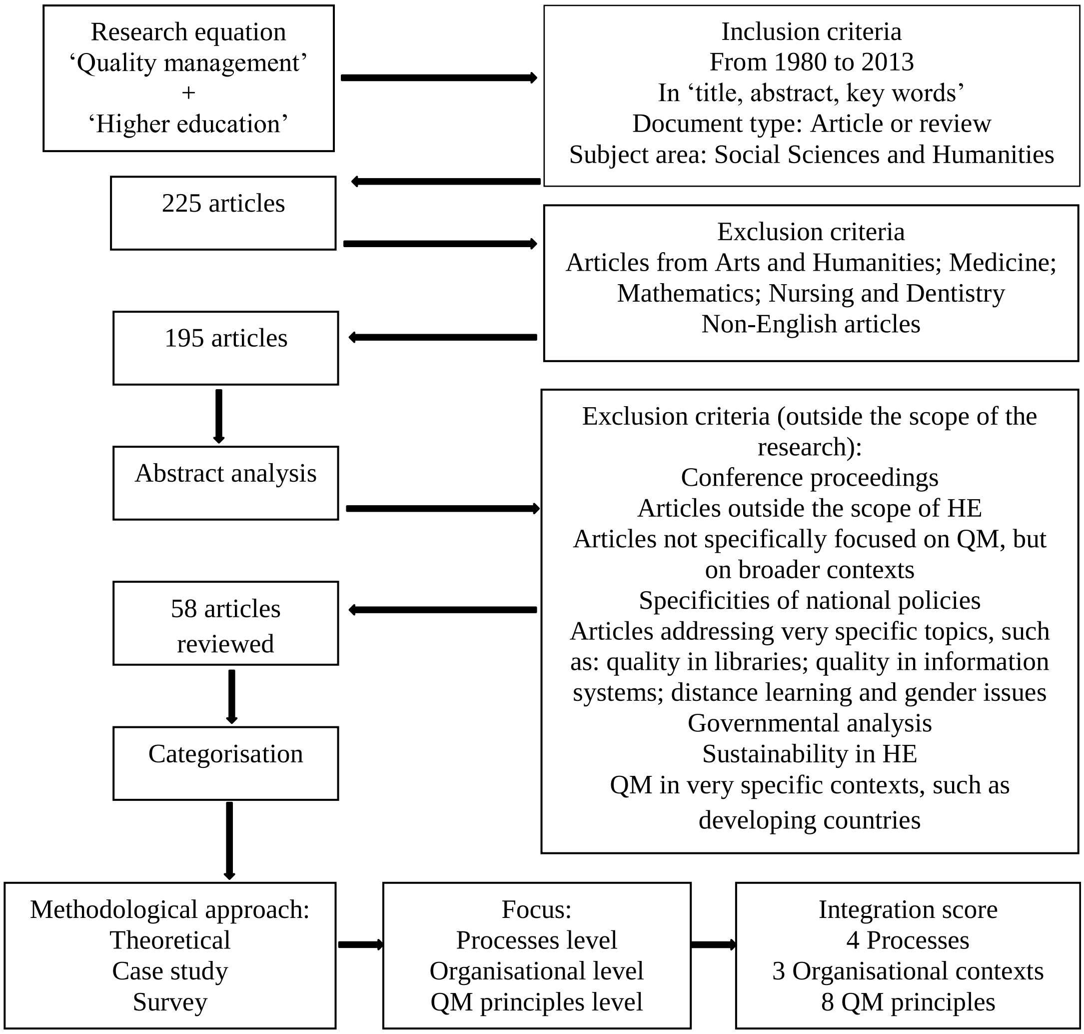
According to the literature of HE studies (Barnett, 1990), there are four main dimensions of the processes level: teaching and learning, research and scholarship, third mission and support processes. In turn, the literature on quality in HE (Brennan & Shah, 2000), refers to three organisational levels: programme, unit and institutional. Finally, the literature on quality management (Evans & Lindsay, 2004) consensually presents eight principles of quality management: customer focus, leadership, involvement of people, process approach, system approach, continual improvement, factual approach to decision making and mutually beneficial supplier relationship (ISO, 2012).

RESEARCH DESIGN

The research was carried out using Elsevier's Scopus data base to collect data, as it is the largest abstract and citation database of peer-reviewed literature and it contains the most important journals in terms of our research topic. Bearing our goals in mind, we searched for the expressions 'quality management' and 'HE' in articles from social sciences and humanities, from 1980 to 2013. This search resulted in 195 articles. This literature review does not include all the results of the search, because we did not have access to some of these articles.

After the first search, based on the above mentioned criteria, data was exported to the bibliography management software Endnote and a first reading of the abstracts was made, which resulted in the exclusion of some articles (see Figure 1), as they were outside the scope of our research. The remaining 58 articles were then read and an in-depth analysis was carried out.

Figure 1 – Research design



Then we content-analysed the 58 articles, based on an analysis grid that categorised them according to their methodological approach and their focus.

In terms of methodological approach, the articles were classified as: conceptual or theoretical; single and multiple case study; and survey. With regards to the focus of the articles, we considered three sub-categories of analysis: processes, organisation and QM principles.

As processes, we considered not only the three main processes of HEIs (teaching and learning; research and scholarship; and third mission), but also support processes. Teaching and learning, together with research and scholarship, are core activities within a HEI. The third mission reflects the engagement of universities in business-related activities, local and regional development, economic growth and societal development in general (Laredo, 2007). The support processes cover all sorts of services and processes, ranging from administrative services to other support processes and activities (Yeo & Li, 2014).

As organisational levels, we considered programme - if the article was focused on one or more study programmes offered by HEIs; unit - if the focus of the article was a department, a faculty or other basic unit of HEIs; and institutional - if the article had a broader focus in terms of the organisational structure of HEIs.

Finally, we categorised the articles according to QM principles. Since 'QM' is the key expression of our research, and as one of our goals was to understand the evolution of the QM literature in HE, we thought that it would be relevant to analyse whether literature on QM in HE addressed the QM principles.

Overall, we aimed to understand the following: whether authors approach the quality of processes separately or in an integrated way; whether quality practices exist at the three organisational levels and whether they are managed in an articulated and integrated way; and finally, whether the different dimensions associated with QM principles are implemented separately, or whether they take a holistic and integrative perspective into account.

To facilitate the analysis of the level of integration found in each of the reviewed articles, we used an 'integration score', which is a result of the sum of the number of focused dimensions (4+3+8) in the three levels of analysis in each article, 15 being the highest possible integration score.

RESULTS AND DISCUSSION

Analysing the literature, the first observation is that there were no articles written on the subject from 1980 to 1993. The first article is from 1994 and the majority of the articles are from after 2000. This shows that the notion of QM in HE only started to appear in the literature in the early '90s. Obviously the topic of quality in HE was already being discussed, but with other designations, such as quality assurance or quality improvement, or simply, quality.

Methodological approach. Methodologically, literature about QM in HE is based mainly on theoretical or conceptual analysis (see Table 1). Several surveys and case studies have also analysed this topic.

Table 1 – Categorisation according to the methodological approach

Approaches	References
Conceptual/ Theoretical	(Burkhalter, 1996; Ho & Wearn, 1996; Owlia & Aspinwall, 1996; Herbst, 1999; Willis & Taylor, 1999; Jensen, 2000; Mergen et al., 2000; Grant et al., 2002; Srikanthan & Dalrymple, 2002; Widrick et al., 2002; Cruickshank, 2003; Calvo-Mora et al., 2005; Srikanthan & Dalrymple, 2005; Meirovich & Romar, 2006; Eagle & Brennan, 2007; Houston, 2007; Srikanthan & Dalrymple, 2007; Venkatraman, 2007; Becket & Brookes, 2008; Juhl & Christensen, 2008; Van Kemenade et al., 2008; Ehlers, 2009; Pratasavitskaya & Stensaker, 2010; Rosa et al., 2011; Zineldin et al., 2011; Rodman et al., 2013; Sahu et al., 2013)
Single case study	(Burgar, 1994; Macy et al., 1998; Hergüner & Reeves, 2000; Davies et al., 2001; Spencer-Matthews, 2001; Rusinko, 2005; Becket & Brookes, 2006; Achcaoucaou et al., 2012; Kettunen, 2012)
Multiple case study	(Scott & Hawke, 2003; Lomas, 2007)
Survey	(Horine & Hailey, 1995; Evans, 1996; Barnard, 1999; Kanji & Tambi, 1999; Rosa et al., 2001; Montano et al., 2005; Osseo-Asare et al., 2005; Calvo-Mora et al., 2006; Rosa et al., 2006; Bayraktar et al., 2008; Trivellas & Dargenidou, 2009; Papadimitriou & Westerheijden, 2010; Van Kemenade & Hardjono, 2010; Flumerfelt & Banachowski, 2011; Kleijnen et al., 2011; Papadimitriou, 2011; van Kemenade et al., 2011; Barandiaran-Galdós et al., 2012)
Combination of survey and case study	(Rosa et al., 2003; Papadimitriou & Westerheijden, 2010)

Turning to the theoretical articles, of which there are 27 in total, we can identify different approaches: discussions about the applicability of the QM approach to HE (e.g. Cruickshank, 2003); analyses of existing quality frameworks for QM in HE, or the development and proposal of new ones (e.g. Ho & Wearn, 1996; Owlia & Aspinwall, 1996); theoretical discussions and literature reviews about QM in general, or about specific topics (e.g. Burkhalter, 1996); conceptual reflexions about the concept of quality (e.g. Van Kemenade et al, 2008; Ehlers, 2009); or the analysis of national QM frameworks (e.g. Jensen, 2000; Juhl & Christensen, 2008).

In relation to empirical studies, the survey is the most common methodological approach (19), followed by single and multiple case studies (9 and 2, respectively). There are also two articles which combine the two approaches (see Table 1). In general, empirical studies address topics as: the application of QM frameworks to HE (e.g. Rosa et al., 2001, 2003); quality culture (e.g. Horine & Hailey, 1995; Hergüner & Reeves, 2000); and external quality control, accreditation and certification systems (e.g. Papadimitriou & Westerheijden, 2010; Van Kemenade & Hardjono, 2010).

Processes Level. In terms of the processes level, the literature has a strong focus on the level of teaching and learning. Analysing Table 2 and 3, we see that 51 of the 58 articles talk about this activity.

Table 2 – Classification by focus

Level	Focus	Total
Processes level	Teaching and learning	51
	Research and scholarship	20
	Third mission	20
	Support processes	24
Organisational level	Programme	16
	Basic unit	19
	Institution	41
Quality management principles level	Customer Focus	38
	Leadership	35
	Involvement of people	46
	Process approach	39
	System approach	40
	Continual improvement	43
	Factual approach to decision making	38
	Mutually beneficial supplier relationship	36

In fact, authors are especially concerned with what Brennan and Shah (1976) designate as the "academic" and the "pedagogic" facets of HE. Thus, several QM approaches in HE seem to be learning-oriented, with an emphasis on students' learning experience and on educational development (e.g. Shrikantan & Dalrymple, 2002, 2005, 2007; Pratasavitskaya & Stensaker, 2010).

Table 3 – Categorisation according to the processes level

Articles	Processes level			
	Teaching and learning	Research and scholarship	Third mission	Support processes
Burgar, 1994	✓			
Horine & Hailey, 1995	✓	✓		✓
Burkhalter, 1996	✓	✓	✓	✓
Evans, 1996	✓			
Ho & Wearn, 1996	✓			
Owlia & Aspinwall, 1996	✓			
Macy et al, 1998	✓			
Barnard, 1999	✓			
Herbst, 1999				
Kanji & Tambi, 1999	✓			✓
Willis & Taylor, 1999	✓			
Herguner & Reeves, 2000	✓	✓		
Jensen, 2000	✓	✓	✓	✓
Mergen et al, 2000	✓			
Davies & Casey, 2001	✓	✓	✓	✓
Rosa et al, 2001	✓	✓	✓	✓
Spencer-Matthews, 2001	✓			
Grant et al, 2002	✓	✓	✓	✓
Shrikanthan & Dalrymple, 2002	✓			✓
Widrick et al, 2002	✓	✓		
Cruickshank, 2003	✓	✓		✓
Rosa et al 2003	✓		✓	✓
Scott & Hawke, 2003	✓	✓	✓	✓
Calvo-Mora & Roldan, 2005	✓		✓	
Montano et al, 2005				
Osseo- Asare, et al, 2005	✓	✓	✓	✓
Rusinko, 2005	✓	✓	✓	✓
Shrikanthan & Dalrymple, 2005	✓			✓
Becket & Brookes, 2006	✓		✓	
Calvo-Mora et al, 2006	✓		✓	
Meirovich & Romar, 2006	✓			
Rosa et al, 2006	✓	✓	✓	✓
Eagle & Brennan, 2007	✓			
Houston, 2007	✓			
Lomas, 2007	✓			
Shrikanthan & Dalrymple, 2007	✓	✓	✓	✓
Venkatraman, 2007	✓			
Bayraktar et al, 2008	✓			
Becket & Brooker, 2008	✓		✓	
Juhl & Christensen, 2008	✓	✓	✓	
Van Kemenade et al, 2008	✓			
Ehlers, 2009	✓			
Evans, 2009				
Trivellas & Dargenidou, 2009				✓
Papadimitriou & Westerheijden, 2010	✓	✓		✓
Pratasavitskaya & Stensaker, 2010	✓		✓	
Van Kemenade & Hardono, 2010				
Flumerfelt & Banachowski, 2011	✓		✓	✓
Kleijnen et al, 2011	✓			
Papadimitriou, 2011	✓	✓		✓
Rosa et al, 2011	✓	✓	✓	✓
Van Kemenade et al, 2011				
Zineldin et al, 2011				✓
Achcaoucaou et al, 2012	✓			
Barandiran-Galdós et al, 2012	✓			
Kettunen, 2012	✓	✓		
Rodman, et al, 2013	✓	✓	✓	
Sahu, et al, 2013	✓	✓		✓

The dimension of research and scholarship is addressed in 20 of the articles (e.g. Widrick et al. 2002). Despite being a core process in HEIs, this dimension seems to be put into second place when it comes to quality management.

The dimension of third mission, is also mentioned in 20 articles (Table 3). Srikanthan and Dalrymple (2007: 174) propose a “generic model addressing QM in education, considering teaching and learning, research and scholarship and “service to community.” Also Rodman et al (2013) embrace “research activity” and “community service activity” in a model of institutional quality in HE.

The dimension of support processes is, after teaching and learning, the most mentioned dimension of processes level (covered in 24 articles), showing that QM in HE is also applied at the level of administrative and management processes (Table 3) (e.g. Kanji & Tambi, 1999); support activities for students (e.g. Horine & Hailey, 1995; Burkhalter, 1996); support facilities and infrastructures (e.g. Srikanthan & Dalrymple, 2002, 2005, 2007) or student advice (e.g. Montano et al., 2005).

Considering integration in the processes level, we observe that it is rather weak, as shown in Table 4. Only 4 articles integrate all four processes, albeit 10 articles do cover 3 different processes. Globally, the literature analysed approaches the core activities of HEIs separately, rather than holistically, despite the fact that there are some articles with a good level of integration.

Organisational Level. In respect to organisational level, we can see clear emphasis on the institutional level (with 41 articles), followed by basic unit level (with 19 articles) and then programme level (with 16 articles). (Table 5). Thus, the focus of the literature is stronger in larger and broader levels in terms of the organisational structure of HEIs.

In terms of integration, the articles rarely address more than one dimension. Analysing Table 4, only five articles integrate the three levels. More often, we find articles which address two levels, normally, a more focused one (programme or basic unit), and the broadest level, which is that of the institution.

Quality Management Principles level. Considering the QM principles level, the literature frequently addresses the different principles of QM. Nevertheless, even when articles mention several of them, the emphasis is quite often only put on one of the principles, such as: leadership, customer focus, process approach, or involvement of people.

The principle of customer focus is addressed by 38 articles, as we can see on Tables 2 and 6.

Table 4 – Integration levels

Year	Authors	Processes level (from 0 to 4)	Organisational level (from 0 to 3)	Quality management principles level (from 0 to 8)	Integration score (from 0 to 15)
1994	Burgar, 1994	1	1	8	10
1995	Horine & Hailey, 1995	2	1	8	11
1996	Burkhalter, 1996	3	3	8	14
1996	Evans, 1996	1	1	8	10
1996	Ho & Wearn, 1996	1	2	4	7
1996	Owlia & Aspinwall, 1996	1	3	0	4
1998	Macy et al, 1998	1	1	8	10
1999	Barnard, 1999	1	2	4	7
1999	Herbst, 1999	0	0	0	0
1999	Kanji & Tambi, 1999	1	1	8	10
1999	Willis & Taylor, 1999	1	1	2	4
2000	Herguner & Reeves, 2000	2	1	5	8
2000	Jensen, 2000	4	1	4	9
2000	Mergen et al, 2000	1	1	8	10
2001	Davies & Casey,, 2001	4	1	8	11
2001	Rosa et al, 2001	4	1	8	13
2001	Spencer-Matthews, 2001	1	1	3	5
2002	Grant et al, 2002	4	3	0	7
2002	Shrikanthan & Dalrymple, 2002	2	2	8	12
2002	Widrick et al, 2002	2	1	8	11
2003	Cruickshank, 2003	3	1	8	10
2003	Rosa et al 2003	3	1	8	12
2003	Scott & Hawke, 2003	4	1	3	8
2005	Calvo-Mora & Roldan, 2005	2	1	8	11
2005	Montano et al, 2005	1	1	8	10
2005	Osseo- Asare, et al, 2005	3	1	8	12
2005	Rusinko	1	1	0	3
2005	Shrikanthan & Dalrymple, 2005	2	2	8	12
2006	Becket & Brookes, 2006	1	3	8	12
2006	Calvo-Mora et al, 2006	2	2	8	12
2006	Meirovich & Romar, 2006	1	1	8	10
2006	Rosa et al, 2006	4	1	6	11
2007	Eagle & Brennan, 2007	1	1	8	10
2007	Houston, 2007	1	1	8	12
2007	Lomas, 2007	1	1	1	3
2007	Shrikanthan & Dalrymple, 2007	4	2	8	14
2007	Venkatraman, 2007	1	1	8	10
2008	Bayraktar et al, 2008	1	2	8	11
2008	Becket & Brooker, 2008	2	3	8	13
2008	Juhl & Christensen, 2008	3	1	5	5
2008	Van Kemenade et al, 2008	1	1	8	10
2009	Ehlers, 2009	1	1	0	2
2009	Evans, 2009	1	1	8	10
2009	Trivellas & Dargenidou, 2009	1	1	3	5
2010	Papadimitriou & Westerheijden, 2010	3	2	8	13
2010	Pratasavitskaya & Stensaker, 2010	2	1	3	3
2010	Van Kemenade & Hardono, 2010	1	1	8	10
2011	Flumerfelt & Banachowski, 2011	3	1	8	12
2011	Kleijnen et al, 2011	1	1	0	2
2011	Papadimitriou, 2011	3	2	8	13
2011	Rosa et al, 2011	4	1	8	13
2011	Van Kemenade et al, 2011	1	1	2	4
2011	Zineldin et al, 2011	1	1	8	10
2012	Achcaoucaou et al, 2012	1	1	4	6
2012	Barandiran-Galdós et al, 2012	1	1	0	2
2012	Kettunen, 2012	2	1	8	11
2013	Rodman, et al, 2013	3	1	8	12
2013	Sahu, et al, 2013	3	1	8	12

Table 5 – Categorisation according to the organisational level

Articles	Organisational level		
	Programme	Basic unit	Institution
Burgar, 1994		☑	
Horine & Hailey, 1995			☑
Burkhalter, 1996		☑	☑
Evans, 1996	☑		
Ho & Wearn, 1996		☑	☑
Owlia & Aspinwall, 1996	☑	☑	☑
Macy et al, 1998		☑	
Barnard, 1999	☑	☑	
Herbst, 1999			
Kanji & Tambi, 1999			☑
Willis & Taylor, 1999			☑
Herguner & Reeves, 2000		☑	
Jensen, 2000	☑		
Mergen et al, 2000			☑
Davies & Casey,, 2001			☑
Rosa et al, 2001			☑
Spencer-Matthews, 2001		☑	
Grant et al, 2002	☑	☑	☑
Shrikanthan & Dalrymple, 2002	☑		☑
Widrick et al, 2002	☑		
Cruickshank, 2003			☑
Rosa et al 2003			☑
Scott & Hawke, 2003		☑	
Calvo-Mora & Roldan, 2005			☑
Montano et al, 2005			☑
Osseo- Asare, et al, 2005			☑
Rusinko, 2005	☑		
Shrikanthan & Dalrymple, 2005	☑		☑
Becket & Brookes, 2006	☑	☑	
Calvo-Mora et al, 2006		☑	☑
Meirovich & Romar, 2006			☑
Rosa et al, 2006			☑
Eagle & Brennan, 2007			☑
Houston, 2007			☑
Lomas, 2007			☑
Shrikanthan & Dalrymple, 2007	☑		☑
Venkatraman, 2007	☑		
Bayraktar et al, 2008	☑	☑	☑
Becket & Brooker, 2008	☑	☑	☑
Juhl & Christensen, 2008		☑	
Van Kemenade et al, 2008			☑
Ehlers, 2009			☑
Evans, 2009			☑
Trivellas & Dargenidou, 2009		☑	
Papadimitriou & Westerheijden, 2010		☑	☑
Pratasavitskaya & Stensaker, 2010			☑
Van Kemenade & Hardono, 2010			☑
Flumerfelt & Banachowski, 2011			☑
Kleijnen et al, 2011		☑	
Papadimitriou, 2011			☑
Rosa et al, 2011			☑
Van Kemenade et al, 2011			☑
Zineldin et al, 2011			☑
Achcaoucaou et al, 2012	☑		
Barandiran-Galdós et al, 2012			☑
Kettunen, 2012			☑
Rodman, et al, 2013			☑
Sahu, et al, 2013	☑		

Table 6 – Categorisation according the Quality Management Principles level

Articles	Quality management principles level							
	Customer focus	Leadership	Involvement of people	Process approach	System approach	Continual improvement	Factual approach	Mutually beneficial supplier relation
Achcaoucaou et al, 2012			☑	☑	☑		☑	
Barandiran-Galdós et al, 2012								
Barnard, 1999	☑		☑		☑	☑		☑
Bayraktar et al, 2008								
Becket & Brooker, 2008	☑	☑	☑	☑	☑	☑	☑	☑
Becket & Brookes, 2006	☑	☑	☑	☑	☑	☑	☑	☑
Burgar, 1994		☑	☑	☑	☑	☑	☑	☑
Burkhalter, 1996	☑	☑	☑	☑	☑	☑	☑	☑
Calvo-Mora & Roldan, 2005	☑	☑	☑	☑	☑	☑	☑	☑
Calvo-Mora et al, 2006	☑	☑	☑	☑	☑	☑	☑	☑
Cruickshank, 2003	☑	☑	☑	☑	☑	☑	☑	☑
Davies & Casey,, 2001	☑	☑	☑	☑	☑	☑	☑	☑
Eagle & Brennan, 2007	☑	☑	☑	☑	☑	☑	☑	☑
Ehlers, 2009								
Evans, 1996	☑	☑	☑	☑	☑	☑	☑	☑
Evans, 2009	☑							
Flumerfelt & Banachowski, 2011	☑	☑	☑	☑	☑	☑	☑	☑
Grant et al, 2002								
Herbst, 1999								
Herguner & Reeves, 2000	☑		☑	☑		☑	☑	
Ho & Wearn, 1996	☑		☑				☑	☑
Horine & Hailey, 1995	☑	☑			☑	☑	☑	☑
Houston, 2007	☑	☑			☑	☑	☑	☑
Jensen, 2000				☑		☑	☑	
Juhl & Christensen, 2008			☑	☑	☑	☑	☑	
Kanji & Tambi, 1999	☑	☑	☑	☑	☑	☑	☑	☑
Kettunen, 2012	☑	☑	☑	☑	☑	☑	☑	☑
Kleijnen et al, 2011								
Lomas, 2007	☑							
Macy et al, 1998	☑	☑	☑	☑	☑	☑	☑	☑
Meirovich & Romar, 2006	☑	☑	☑	☑	☑	☑	☑	☑
Mergen et al, 2000	☑	☑	☑	☑	☑	☑	☑	☑

In HE, the concept of the customer can be complex, due to the “difficulty of identifying customers and their expectations” and to the “diversity of customers and stakeholders [which] is by no means a situation unique to HE” (Meirovich & Romar, 2006: 325). In this sense, there is a continued debate regarding “who the customer actually is” (Becket & Brookes, 2006: 125). However, other authors do have a clear idea of the concept of the customer in HE and about who the customers are, albeit, and in line with what was discussed previously, they consider different types of customer (e.g. Burkhalter, 1996; Evans, 1996).

Since leadership has “a strategic role in sustaining quality and performance improvement” in HEI (Osseo-Asare et al., 2005: 148), it is not surprising that it is the focus of a number of articles (Table 6). In some articles, leadership is not the main focus when seen in the context of QM frameworks (e.g. Cruickshank, 2003; Calvo-Mora et al., 2005, 2006; Houston, 2007); in others, leadership is highlighted and its importance in QM is discussed more deeply (e.g. Burkhalter, 1996; Davies et al., 2001).

The principle of the involvement of people is the most focused principle, with 46 of the 58 articles addressing it. In the literature reviewed, the involvement of people was taken to mean the involvement of the different stakeholders of HE in the quality process (e.g. Rosa et al., 2003; Calvo-Mora et al., 2005); the perspectives of the stakeholders in respect to QM, whether they be of employers (e.g. Willis & Taylor, 1999; Rodman et al., 2013), students (e.g. Zineldin et al., 2011) or academics (e.g. Rosa et al., 2006).

The process approach is stressed in 39 articles, in order to highlight its integrative and interactive facet (e.g. Horine & Hailey, 1995; Burkhalter, 1996). As stated by Kettunen (2012:184), the process approach of QM means that “an integrated system is representative of how an organisation is structured, and how each process is related to other processes (...) forming a total system” (Kettunen, 2012: 520, 521).

In this sense, the systemic approach, addressed in the literature reviewed (by 40 articles), also stresses the integration, alignment and inter-relation of processes as a system (e.g. Barnard, 1999; Achcaoucaou et al., 2012).

Continuous improvement of organisations’ performance is the second most focused principle, and is discussed in 43 articles. Authors stress the importance of continuous improvement in the QM process overall and “in achieving customer satisfaction and business excellence” (Kanji & Tambi, 1999: 136). In some articles this principle even has a prominent place in the discussion (e.g. Montano et al., 2005).

The principle of factual approach is addressed by 36 articles, which is to be expected, as a significant number of quality-related practices are based on the analysis of data, indicators and other types of information (e.g. Achcaoucaou et al., 2012; Rodman et al., 2013).

The principle of mutually beneficial supplier relationships is addressed by 36 articles and reflects the development and management of “dynamic relationships with internal and external stakeholders (Venkatraman, 2007).

At the quality management principles level, overall we find several articles integrating all the principles of QM, especially those focusing on ‘holistic’ and ‘total’ management frameworks.

However, we also observe, in Table 4, that six articles do not address any of the quality management principles. Since they are a small part of all the articles reviewed and their focus is outside the scope of our review, their content will not be analysed here.

Quality Management in HE: towards integration? The most significant trend in the articles reviewed seems to be the development of QM frameworks and their specific dimensions either in conceptual or in empirical elements of research (e.g. Rosa et al., 2003; Achcaoucaou et al., 2012; Srikanthan & Dalrymple, 2002, 2005, 2007), which seems to be the main reason for the high degree of integration in the QM principles level.

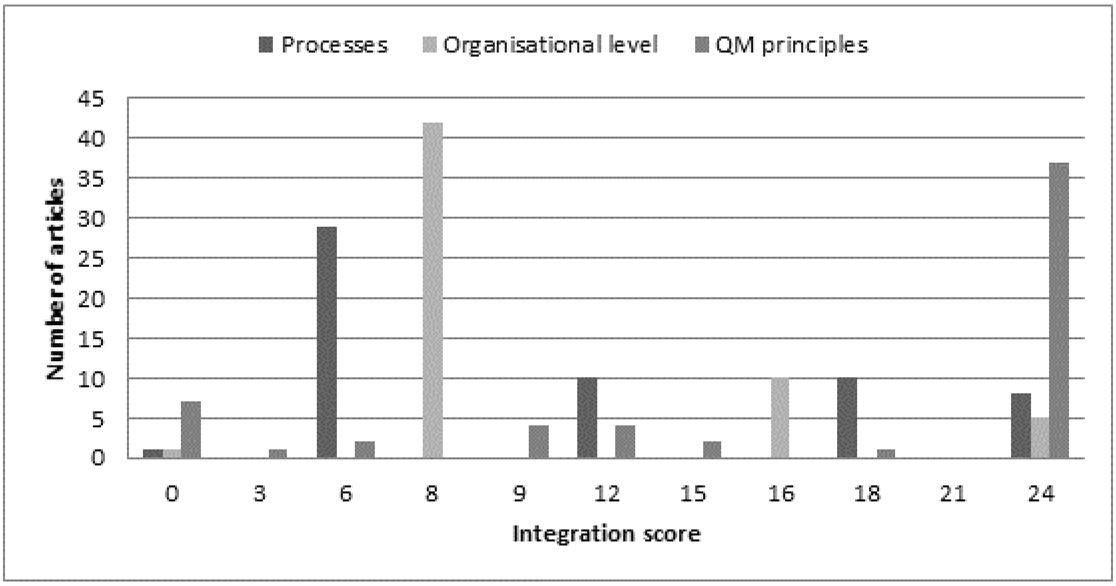
Thus, the research of Rodman and colleagues (2013: 74) is an example of the integration of different quality dimensions, since they "integrate the quality dimensions identified into a model of institutional quality of HE and then incorporate the model into the HEI's strategic planning."

In turn, Srikanthan and Dalrymple (2002: 216) develop a "holistic model" with particular emphasis on the integration of two of the core functions of HE: education and services. In terms of integration, it is also interesting to analyse how authors, such as Horine and Hailey (1995) or Hergüner and Reeves (2000), explore an integrative quality model, based on the concept of quality culture, where quality culture is considered as a holistic and integrated organisational model in universities.

In relation to the methodological approach, and on comparing integration in both empirical and theoretical literature, we did not observe any major differences between the two literatures; instead they present a similar pattern with high integration scores.

Considering integration in the three levels analysed, we observe in Figure 2 that the majority of the articles on processes and organisational levels are concentrated in the lowest integration levels, whilst in the quality management principles level, articles are concentrated in the highest integration levels.

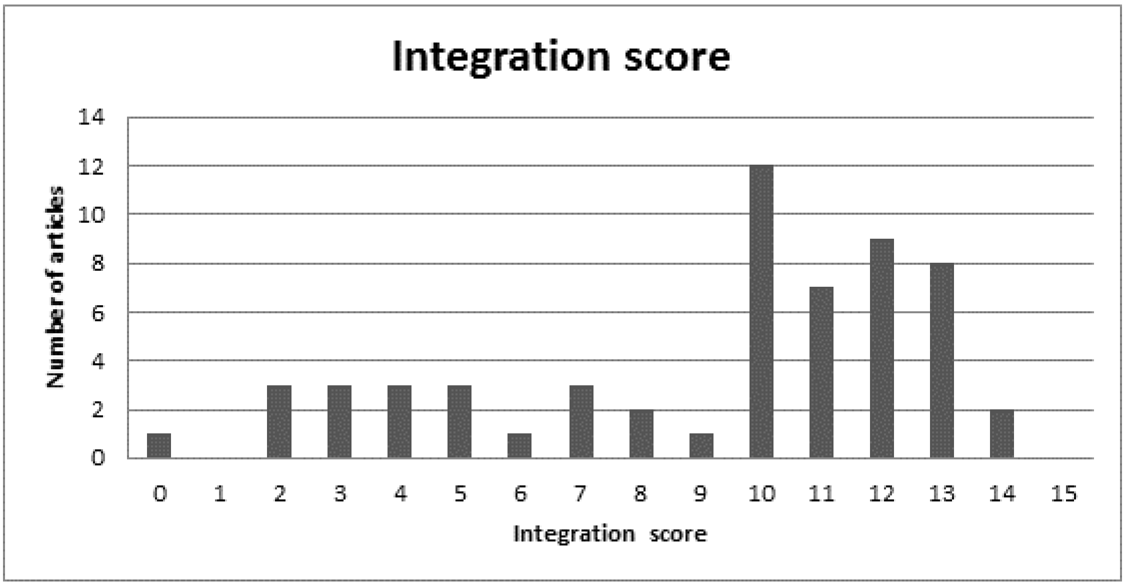
Figure 2 – Integration level in the three levels of analysis



Notwithstanding, the content analysis overall shows us positive results in terms of integration.

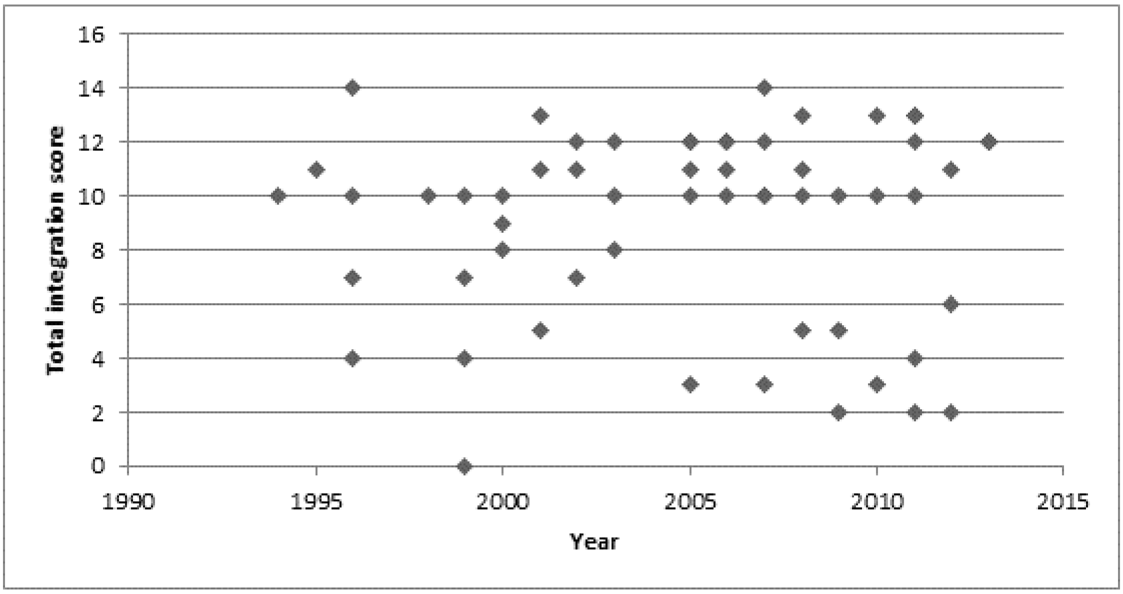
Analysing the integration score in Figure 3, we see high integration scores in the majority of the articles, some of which almost achieve the highest integration score. 38 articles present an integration score of 10 or more, which is noteworthy. This means that in general, articles use a comprehensive and interactive approach to QM.

Figure 3 – Integration score



However, the hypothesis stating that levels of integration would be stronger in recent years is not confirmed in our review, as there are no significant differences between the articles from the late 90s and those from most recent dates (Figure 4).

Figure 4 – Temporal analysis of the integration score



CONCLUSIONS

The goal of this systematic literature review was to understand how literature has approached QM in HE and also how the main QM principles are being addressed and integrated.

In our review, conceptual studies prevail, despite a trend towards a more empirically-based debate, which we believe is the most beneficial direction for this debate. Only empirical research can enable an advance in the knowledge and understanding about some still-unanswered questions, specifically related to the role of QM systems in improving HEIs, which relates these QM systems to the broader management context of institutions.

The literature also becomes more and more concerned with the development of QM frameworks in a more holistic way, combining different aspects of quality, which reflects a high level of integration of the dimensions analysed. Still, some of these approaches, despite being dubbed 'holistic', tend to be 'partial' and 'limited' holistic approaches, if we consider the possibilities in terms of those levels and dimensions that can be integrated within a HEI.

However, 'total integration' is present a few times in both the processes and organisational levels, and is very often in the QM principles level. Furthermore, the tendency for holistic approaches appears to be connected with the discussion and development of QM frameworks (Rosa et al., 2001, 2003; Srikanthan & Dalrymple, 2002, 2005, 2007), which have been imported and adapted from industry; but also with the implementation of national models, internal and external quality models, or accreditation systems, although these are less visible (Hergüner & Reeves, 2000; Rosa et al., 2011).

In this sense, this literature review confirms our main hypothesis that there is a trend towards the integration of QM practices and it relates positively to our research question, which is that QM is becoming integrated in HEIs.

However, the 'total' integration of QM in HEIs does not yet seem to be a 'total' reality. It appears that the QM field is still treated as a separated field, run by a separate department within a HEI, and is not yet integrated in the organisation as a whole. On this point, we believe that the discussion about the importance of the concept of integration could have a strong contribution. We believe that integration is not only restricted to QM systems or frameworks. In other words, QM practices could be more integrated in the broader management context of HEIs. However QM literature is still missing a description of the next step in the direction of an effective integrative approach in HE.

It is also important to highlight the weaknesses of this review. The first weakness is associated with the systematisation process, which itself has limitations concerning the range of the research. The definition a priori of a research equation and other inclusion and exclusion criteria, can nonetheless leave out some important articles, although it is extremely helpful, of course, to confine the research in accordance with our goals.

We were also aware that the definition of 'QM' as a mandatorily included expression in the article excluded some important articles in the field of quality in HE (as is obvious when we use the 'quality assurance' keywords instead of 'QM'). However, and as we emphasised at the beginning, this was a conscious choice, since our focus is specifically 'QM', and we aimed to understand the role of this specific field in relation to quality in HE.

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Accreditation Model for Local Health Trusts – a case study

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ABSTRACT

Purpose. The aim of this study is to design an accreditation model for Primary HealthCare units - Local Health Trusts - according to the guidelines of the Portuguese Health Plan and of the National Accreditation Plan. This model is an adaptation of the model from *Agencia para la Calidad Sanitaria de Andaluzia* (ACSA), in order to properly address the specificities of Local Health Trusts.

Design/methodology/approach. A literature review was complemented with observation and analysis of the usual working methods in the Western Oporto Health Trust.

Findings. The National Model for Accreditation of HealthCare Institutions is not easily nor directly applicable to Local Health Trusts since these include not only clinical management units but also non-clinical administrative units. The model under development incorporates the ISO 9001 and EFQM principles, widely accepted regarding organizational management. The success of the application of this model is highly dependent on the ability of public Primary HealthCare organizations to deal with potential problems like resistance to change, lack of leadership and inadequate people management and involvement.

Originality/value. The present study is expected to contribute to boost the gradual and systematic transformation of UCSP (traditional Health Centers) into USF (Family Health Units), and also to encourage the remaining functional units and services to embrace quality management and continuous improvement as key elements of their own identity, leading Local Health Trusts, Primary Care and HealthCare in a global perspective towards sustainability.

Keywords: quality management, accreditation, public healthcare system, health clusters

Article Classification: Case study

INTRODUCTION

To overcome the economic and social crisis that Portugal is going through, it's mandatory that Portuguese healthcare institutions realize that they can no longer take their sustainability for granted. Therefore the only possible strategy is to assume that generating value in healthcare by assuring a quality service - always keeping their focus on the (constantly changing) stakeholder demands - will improve their organizational efficiency and consequently increase their chances of survival. Although this may seem quite simple for private organizations, it isn't as simple in public healthcare units since this requires a significant adaptive capacity and a profound commitment on continuous improvement of all professionals without exception.

This focus on the search for quality services is clear on the Portuguese legislation regarding healthcare (Lei nº 48/90, altered by Lei nº 27/2002), and the primary healthcare reorganization - which resulted on the birth of Local Health Trusts (ACeS) – opened the necessary opportunity for change.

To maximize the cohesion and quality of healthcare, the Portuguese Governmental Board for Healthcare defines in its National Health Quality Strategy (ENQS) the following strategic priorities: clinical and organizational quality; transparent information to citizens; patient safety; qualification and accreditation of national healthcare units; integrated innovation and disease management; patient international mobility management; evaluation and orientation of complaints and suggestions.

The basis of the present study is that the fulfillment of these strategic priorities will assure quality and consistency in healthcare services, not only through the accreditation of some of the units of a healthcare cluster, but essentially through the certification and accreditation of the entire Local Health Trusts, responsible for the general management of all the units.

This study aims to answer, at the primary healthcare level, to what was defined as a priority in the health quality policy of the ENQS – to adopt and adapt a national and independent accreditation model that might be officially implemented on the Health Clusters, through a national health accreditation plan.

It is therefore intended to design an accreditation model for the entire ACeS, including and responding to all the particularities and questions of each unit, assuring healthcare service quality while respecting legal, environmental and safety issues, as well as attending to social responsibility principles. The accreditation model, to be valid for all the functional units of the Local Health Trust, should be based on the uniformization of proceedings, and on the clear definition of functions and responsibilities. The model under development is expected to be a contribution to drive the ACeS towards a sustained and sustainable management through the continuous improvement of the quality of the healthcare service, with a special focus on patient's and professionals' safety.

LOCAL HEALTH CLUSTERS

In Portugal the first Health Centers (referred in literature as 1st Generation Health Centers), created by legislation in 1971, aimed to protect the population, to prevent the most significant contagious diseases (the first vaccination campaigns were created at that time) and to assist the most vulnerable society groups.

A decade later, as result of the new health definition from the World Health Organization (WHO), together with the foundation of the National Health Service (SNS), the 2nd Generation Health Centers were created, under the management of the Regional Health Administrations (ARS), as the SNS's main responsibility for health promotion and disease prevention.

The Health Centers are defined in the Portuguese Law as "integrated, polyvalent and dynamic units, primary healthcare providers, aiming to promote and to monitor health, and to prevent, diagnose and treat disease" (Despacho normativo nº 97/83 – Health Centers Ordinance). A geographic sphere of actuation was designed to provide proximity between users and the healthcare services.

A new and significant reform in the primary healthcare occurs in 2003 with the creation of the Primary HealthCare Network, resulting in the aggregation of resources and management structures directed to the population's real needs and expectations. This restructuration reveals the importance given by the government to primary healthcare as the basis of the entire Health System.

Health Centers should then be understood as the base point for citizens' primary healthcare, assuring higher accessibility, shorter waiting periods and higher quality. To work properly, Health Centers depend on effective team work. Those teams are composed by doctors, nurses and administrative workers, but can also include other professionals (psychologists, social workers, nutritionists, dentists, etc.), depending on the target's population specific needs.

In 2007, the 2nd phase of this reform begins, with the creation of small autonomous functional units (USF) – primary healthcare providers, close to the users, and assuring higher quality of the service provided, managed through internal contracts (National Health Plan 2004-2010). The USFs that resulted from this reform are totally different from the classical Health Centers: composed by small self-organized multi-professional teams, with organizational, functional and technical autonomy, with a management system based on productivity, accessibility and quality.

The primary healthcare reform proceeds in 2008 (Lei nº 31/2007) through the consolidation of the organizational restructuration of the Health Centers, the promotion and creation of more USFs, the design and implementation of continuous improvement quality projects, the technological modernization and the development of people involvement strategies, encouraging high performance levels among teams. Therefore organizational framework and support structures are created, resulting in an increase in the quality of the service provided through resource improvement and identity preservation (Pisco, 2011).

In this reconfiguration process, the Health Clusters (ACeS) were created. These can be defined as management units integrating one or several Health Centers that are responsible for the organization, integration and articulation between the various primary healthcare levels and for the coordination and connection to the community.

Presently in Portugal there are 74 ACeS, with an organizational structure based on 5 types of functional units (Table 1). The ACeS have administrative autonomy to choose and implement the most adequate solutions with the available resources and accordingly to the specific community demands. These units are based on multi-professional team work, with complementary and cooperative specific missions. Each ACeS has its own management structure and instruments, with specific leadership systems, as well as specific technical and clinical governance, supported by citizen and community participation mechanisms.

Table 1: Organizational structure of the Portuguese Health Clusters (ACeS)

(adapted from Pisco, 2011)

ACeS – Local Health Clusters: primary healthcare providers for a given geographic area, with administrative autonomy, organized in different functional units with multi-professional teams.	
USF	**Family Health Unit:** Unit that provides personalized primary healthcare services for families and individuals, with multidisciplinary teams and organizational autonomy. These units are regulated by specific laws.
UCSP	**Personalized Health Care Unit:** Unit that provides personalized primary healthcare services for families and individuals. They have the same scope as USFs, but different management system and team dynamics. These units are hierarchically dependent on the Executive Director and the Clinical Council of the ACeS.
UCC	**Community Care Unit:** Multidisciplinary unit, providing primary healthcare and support

	(including social and psychological attention), to individuals or families with higher health vulnerability and/or risk.
USP	**Public Health Unit:** This unit monitors the local health status, and is responsible for the gathering of relevant health and epidemiological information for the geographical area on the scope of the ACeS.
URAP	**Shared Assistance Resources Unit:** This unit coordinates specific assistance which is shared by all the other units in the scope of the ACeS (like dentists, therapists, psychologists, etc.).
UAG – Management Support Unit: This unit provides logistic support to all teams and management organs.	
Citizens Office and Complaints Management Unit: working very close to the citizens, this unit has responsibilities regarding the providence of adequate information regarding rights and obligations of the health services' users, the management of suggestions and complaints about healthcare services and the verification of the users' satisfaction regarding healthcare.	

The functional units of the ACeS are managed by 4 administrative organs:

The executive director, nominated by the government, responsible for activities and human, financial and equipment resources management.

- The executive council, composed by the executive director, the clinical council president and the community council president, with specific management skills, concerning activities, internal regulations and ACeS dissemination.
- The health and clinical council, responsible for promoting ACeS health and clinical governance, assuring articulation and participation of all functional units.
- The community council, composed by community representatives from several areas, such as municipalities, schools, users associations, nearby hospitals, etc.

The ACeS Executive Director and the ARS Directive Council engage periodically a contract in which the qualitative and quantitative objectives are defined, as well as the resources and rules for their accomplishment.

QUALITY IN HEALTHCARE

On the last decades it was observed a worldwide trend to analyze error in medicine, practices variations, cost's control and lack of resources, turning this issue in one of the most discussed among governments and society in general around the world.

Following the evolution of concepts like Quality, Health and Primary HealthCare, the concept of Quality in HealthCare has also evolved in the recent past: it was originally determined and evaluated by the professionals and now it also depends on the patients' needs and expectations and on the amount of resources that are spent to achieve a given quality pattern.

But quality in healthcare is not easy to define. The most consensual definition comes from the Institute of Medicine, and considers quality of care as the measure in which health services provided to individuals and patient populations improve desired health outcomes (Institute of Medicine, 2001). Still according to this source, quality healthcare should be based on strong clinical evidence and provided in a technically and culturally competent manner with good communication and shared decision making (Institute of Medicine, 2001).

No matter the scope of the definition, the concept of quality of care varies from individual to individual according to the variables that assume the most relevant importance, whether patient, healthcare professional or manager. Patients give more importance to issues as accessibility, relationship and health improvement than to issues as profitability, performance and efficiency evaluation (significant for managers), or clinical results (significant for professionals), and this turns quality of care in a complex issue to determine and assess (Pisco & Biscaia, 2001). To manage quality of care there's no other way than to merge those three perspectives, reducing conflict of interests, and inadequate management approaches or evaluation processes. And that is precisely what Donabedian intended to assure with the definition of the 7 predicates characterizing complexity when analyzing quality of care, which are: efficiency, effectiveness, acceptability, legitimacy, optimization and equitability (Donabedian, 1980). Following Donabedian's ideas, other authors use, to define quality care, attributes such as technical performance, personal relationship management, care service situation, patients' preferences response, efficiency and effectiveness (Ransom *et al.*, 2008).

As stated above, the users' perspective is different from the professionals' perspective, and different from the managers perspective and so, quality of care must be observed through 3 dimensions:

I. User evaluated quality – what users, individually or in group, expect from the service;

II. Professional quality – the service's ability to satisfy professionals' needs, and assess if procedures and techniques are adequately performed;

III. Management quality – efficient and productive resource usage in order to respond to user's needs, according to the authorities' limits and good practice recommendations.

But why is society so committed with quality of care? In spite of its several definitions, it is something felt and recognized by everyone, and considered a strategic element for governments, despite the level of development and the health service system adopted. The main problems associated with a low quality of care service are: lack of safety for patients, inefficiency and excessive costs of clinical procedures and technologies; unsatisfied users; unequal access to healthcare; long waiting lists; reduced effectiveness.

To solve this quality care problems, healthcare units need to adjust their activities in order to incorporate quality management on their management systems in order to assure adequate care organization, efficient resource allocation and a continuous evaluation process, balancing the increasing service quality with cost control.

For this, the healthcare user/patient must be treated as a client, the central element in all healthcare process. Management systems must be implemented (similarly to what has been happening in other activity sectors), and the quality of care analysis must be observed under 3 different dimensions: technical-scientific; professional/patient relationship and site and equipment characteristics.

Until the 80's quality of care was mostly focused on the technical-scientific dimension – the professional's ability to choose the most adequate solution. Meanwhile, the importance of evaluating quality through organizational and management processes items came to the governments' attention– and quality of care started to be analyzed not only in terms of good clinical practices, but also in terms of the way that healthcare services are provided, changing the users' image of the organization.

From then, the healthcare management system has been analyzed as a system used by healthcare organizations to promote an integrated approach to inputs, structures and processes management in order to obtain better results in health, in an environment of higher accountability for clinical quality – the so called clinical governance (Campos *et al.*, 2010).

The implementation of quality management systems in healthcare units started in the hospital environment, but has been gradually gaining importance in primary healthcare services. To assure continuous improvement, essential in any quality management system, it is necessary to define the adequate quality standards in which the quality management system will be based. After that, process and work flow systemization, critical process identification, quality diagnosis and definition of quality indicators must take place allowing the identification of the most important problems to solve as well as of the best methods to solve them. As in all quality management systems, a continuous PDCA cycle must take place.

The success of any healthcare management system depends on the adequate engagement of all health professionals, sharing responsibility and aiming excellence in healthcare. But that is not enough. Patients (as central elements of this process) must also be implicated due to their particular quality perception and assessment. This means that, no matter how hard it is to deal with change, quality care and patient safety goals must be faced as shared responsibilities of all, from users, to health professionals, administrative staff and managers. And they all will contribute for the clinical governance process, combining accountability, excellence, adequate training, clinical auditing, investigation and innovation, clinical effectiveness and risk management. Systematic and rigorous quality care evaluation and adequate resource usage mechanisms are required in order to verify if the best possible quality is being obtained.

In the last decade there has been a significant evolution in Health Quality Policies, in order to assure consistent quality improvement. It is commonly accepted that the self-assessment and continuous improvement of quality in healthcare should be complemented with external evaluations according to universally recognized standards (allowing benchmarking between healthcare organizations) – in other words, an accreditation process.

According to the International Society for Quality in Health Care (ISQua), accreditation is an auto-evaluation and external evaluation method, used by healthcare organizations as a way to rigorously evaluate their performance level in comparison to previously defined standards in order to define and implement improvements. It's a formal and external evaluation process, for which institutions volunteer periodically, performed by a non-governmental, independent and acknowledged organism, that evaluates accordance between the healthcare service's practices and the standards requirements, therefore encouraging a continuous improvement culture (Rooney & Ostenberg, 1999).

The Portuguese government, in its National Health Plan, defines accreditation as an important strategy, especially in primary healthcare. After the WHO report about the deficiencies of the National Health Plan 2004-2010 (WHO EUROPE, 2010), the National Quality Care Strategy (defined to last from 2009 to 2019) aims to promote excellence on healthcare, through quality assurance and its continuous improvement in order to provide better services to patients and promote professionals' satisfaction. And that is why and how the National Health Accreditation Program (PNAS) starts to be faced seriously in primary healthcare.

The first PNAS (1999) was based on the association between the Portuguese Health Quality Institute (IQS) and the King's Fund Health Quality Service (KFHQS), and was directed to hospitals, resulting in the accreditation of 13 hospitals. In 2004, the National Health Plan defines the Joint Commission International (JCI) as the official accreditation model, but it wasn't very well accepted by the healthcare community. The ENQS published in 2009, defined a new accreditation model for all healthcare organizations – the model from Agencia para la Calidad Sanitaria de Andalucia (ACSA). This model is presently widely accepted due to its transversal and easy appliance on the different types of healthcare units, and it has already been successfully applied (Almuedo-Paz *et al.*, 2012).

The ACSA model is based on: process management, clinical management, and skill management, and is applicable to all health services and organizations whether belonging to primary, hospital or continuous care. It's a volunteer program, based on inter-paired auditing, supported by a self-assessment methodology that instigates team work and knowledge sharing (Almuedo-Paz *et al.*, 2012).

The ACSA model features 5 sections of standards, divided in 11 criteria (Table 2). This model considers 3 levels of complexity for the accreditation program, for which a group of standards is applicable (Almuedo-Paz *et al.*, 2012 and Ministério da Saúde, 2011):

- Group I – Standards corresponding to priority elements in the quality management of the clinical unit: patients' and professionals' safety and rights and ethical principles. Some of the standards in this group are mandatory to achieve any level of accreditation.
- Group II – Standards corresponding to further development of the organization (including for example new technologies and information systems).
- Group III – standards related with the innovation generated by the clinical unit and its contribution for society in general.

Table 2: Structure of the ACSA Model for clinical units

(adapted from Almuedo-Paz *et al.*, 2012 and Ministério da Saúde, 2011)

I. Citizen - centre of the Healthcare System
1. Users' satisfaction, participation and rights;
2. Accessibility and continuity of care;
3. Clinical information;
II. Organization of Patient centered activity
4. Integrated healthcare plans and processes;
5. Health promotion in the community;
6. Clinical unit management;
III. Professionals
7. The professionals' competence and professional development;
IV. Support Processes
8. Structures, equipment and suppliers;
9. Communication and information systems and technologies;
10. Continual improvement;
V. Results
11. Clinical unit results.

The accreditation process may occur progressively for a clinical unit, and is classified in three possible accreditation levels - Advanced, Optimal or Excellent - depending on the standards that are addressed by the quality management system.

The ACSA model was translated and adapted to the Portuguese Healthcare System in 2011 (Ministério da Saúde, 2011), but due to the economic crises (and the costs involved in the accreditation process), the accreditation program is being slowly implemented – official data from the National Association of USFs combined with data from the Portuguese governmental board for healthcare shows that presently there are 10 accredited USF in a total of 353 units.

HEALTH CLUSTERS ACCREDITATION MODEL

The current management theories treat organizations' quality management as a complex system that guides, monitors and improves quality in an integrated way in all the organization sectors.

So, if a Local Health Cluster (ACeS) can be seen as an organization and the remaining health services and units can be seen as departments inside that organization, it seems logical, instead of performing 20-30 accreditation processes in one ACeS, to merge the entire management system and perform only one accreditation that would be valid for the entire cluster.

Theoretically, the ACSA model could be used for this purpose; but the ACSA model was not built for non-clinical units, such as Management Support Units (UAGs) that have no direct contact with patients, making it impossible for these units to be integrated in an accreditation process using this model.

Therefore it is necessary to adapt the ACSA model and create a new model that could be used for this purpose. This new model, which is currently under development and implementation through a case-study, is based on the following assumptions:

- The Local Health Cluster is an organization with several different departments (health units and services, non-clinical units) and some of its departments perform their activity in geographically distinct places;
- All of the Local Health Cluster units and services must have their own Quality Management Plans, properly integrated and articulated with the Quality Management System designed for the Cluster;
- The model must include standards suitable both for clinical and non-clinical units or services;
- Having units in different quality maturity stages should not compromise the accreditation of the entire Cluster;
- All units must implement a Quality Management Plan based and oriented by the ACeS Quality Management System.

However, there are some issues that must be carefully addressed in this accreditation model, in order to maximize its acceptability and practical application:

- Some USFs were created before the AceS in which they are integrated, and therefore their quality management system can be in a more developed stage than the one to be implemented with this accreditation model. Therefore some USF units might resist to the implementation of a uniform model that could be considered a 'step behind' in quality management, since they have already a reliable quality management system, have already developed their own identity in quality management, and are used to work independently of the other units in the ACeS;

- There are units in the ACeS that have never been submitted to any kind of quality management, and therefore have no quality habits or culture;
- Some units and services still have some difficulties in accepting their integration in an ACeS, and sometimes do not clearly recognize the legitimacy of the ACeS's governance structure;
- The ACeS autonomy from the central administration is in some cases difficult to achieve;
- A good part of the health professionals (clinical or non-clinical) do not recognize the importance of quality management in public services.

The accreditation model that is under development in this study uses the ACSA model on the ACeS, as a clinical management unit, and the classification of the accreditation level will be set by the unit with the lowest performance. For example: when evaluating standard 01.09 – The Clinical Management Unit has and publishes a patient guide with information about its operation – if any unit does not have this standard accomplished, it will be assumed that the ACeS does not accomplish this standard; as this is not a mandatory standard, it will not compromise the ACeS accreditation, but it may have influence on the accreditation level achieved. On the other hand, the accreditation process may be compromised if a mandatory standard is not fully implemented in the entire ACeS. Although this may seem penalizing for the clinical units that have a good performance level, in the long term the promotion of cooperation between the different units, uprising quality levels and improving the adequate articulation between the different levels of healthcare, will bring relevant benefits to the ACeS, to the National Health Service and especially to patients and society in general.

The particularities of the non-clinical units – UAG and Citizens' Office – will have to be dealt by stipulating that some of the standards do not apply to these units, and therefore the accreditation process will not be compromised by the non-compliance of these units. Nevertheless, the possibility of including new standards specifically for these non-clinical units, based and inspired on EFQM and ISO 9001, is presently under analysis.

For now, a case study is being developed in the Western Oporto Health Trust through the application and further development of the proposed model.

CASE-STUDY: THE WESTERN OPORTO HEALTH TRUST

The Western Oporto Health Trust (ACeSPOc) is a primary healthcare cluster that was created by Portaria 273/2009. The main building (where the Executive Director, Clinical Council, Executive Council and UAG are based) is located on the Lordelo do Ouro Municipality. Its scope is to manage healthcare services of the West Oporto area (municipalities of Aldoar, Cedofeita, Foz do Douro, Lordelo do Ouro, Massarelos, Miragaia, Nevogilde, Ramalde, São Nicolau, Santo Ildefonso, Sé and Vitória) – Figure 1.

Figure 1: Geographic distribution of the municipalities on the scope of the ACeSPOc

The ACeSPOc serves more than 170 000 individuals, and its activity is developed by 504 professionals organized in 29 units (23 healthcare service units and 6 support units). The healthcare units have the following characteristics: 9 Family Health Units (USF), 6 Health Centers (UCSP), 3 Community Care Units (UCC), 1 Public Health Unit (USP), 1 Shared Clinical Resources Unit (URAP) and 2 service units that are CDP (Pulmonology Diagnostic Center) and CAD VIH/SIDA (HIV Early Detection and Counseling Centre), plus 1 non-clinical unit (UAG) that assists the management of all other units.

The services provided by the ACeSPOc include:

- Vigilance, health promotion and disease prevention, management of Acute disease's situations, Family Planning, Maternal Health, Child Health, Adult and Elder Health, Domiciliary Care (medical and nursing), articulation with other units and Hospitals – activities performed by USF and UCSP;
- Preventive and curative domiciliary care, Rehabilitation, Birth and parenting preparation, Integrated continuous care – activities performed by UCC;
- Nutrition, Paediatrics, Clinical psychology, Oral health and Social service – under the URAP responsibility;
- Population health monitoring, Health needs identification, Plans and information on Public Health, Epidemiologic vigilance investigation, Vaccination, Occupational and environmental health programs, Health authority; Investigation – USP domains;
- Smoking cessation program, Educational health program, Children and young at risk support, Training – under all units' responsibility.

The governance structure of the ACeSPOc is presently organized in a traditional vertical hierarchy (Figure 2).

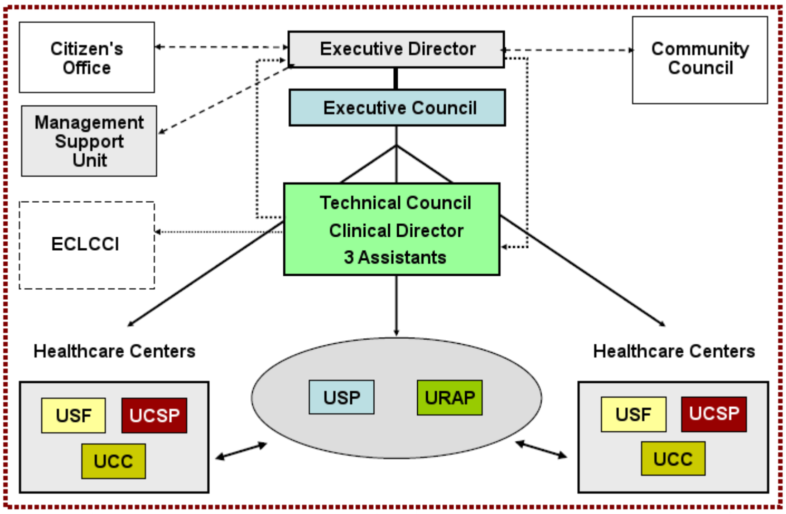

Figure 2: Governance structure of the ACeSPOc

The application of the accreditation model that is being developed in this study would require a change in the governance structure, which should be a patient-centred integrated circular managing structure, as proposed in Figure 3.

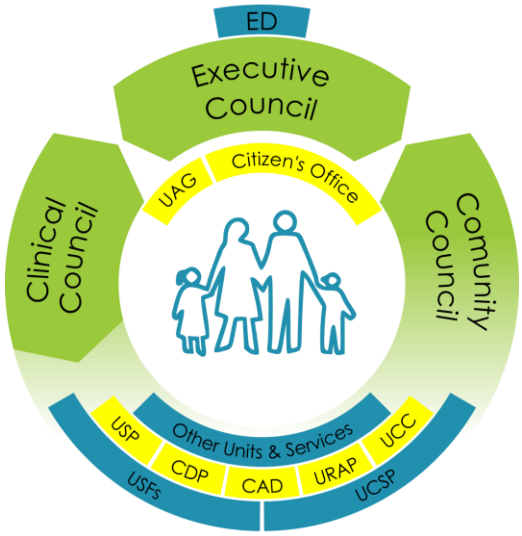

Figure 3: Patient-centred integrated circular managing structure

The ACSA model demands that the healthcare unit is organized in an integrated view of processes. The process map proposed for the ACeSPOc is shown in Figure 4.

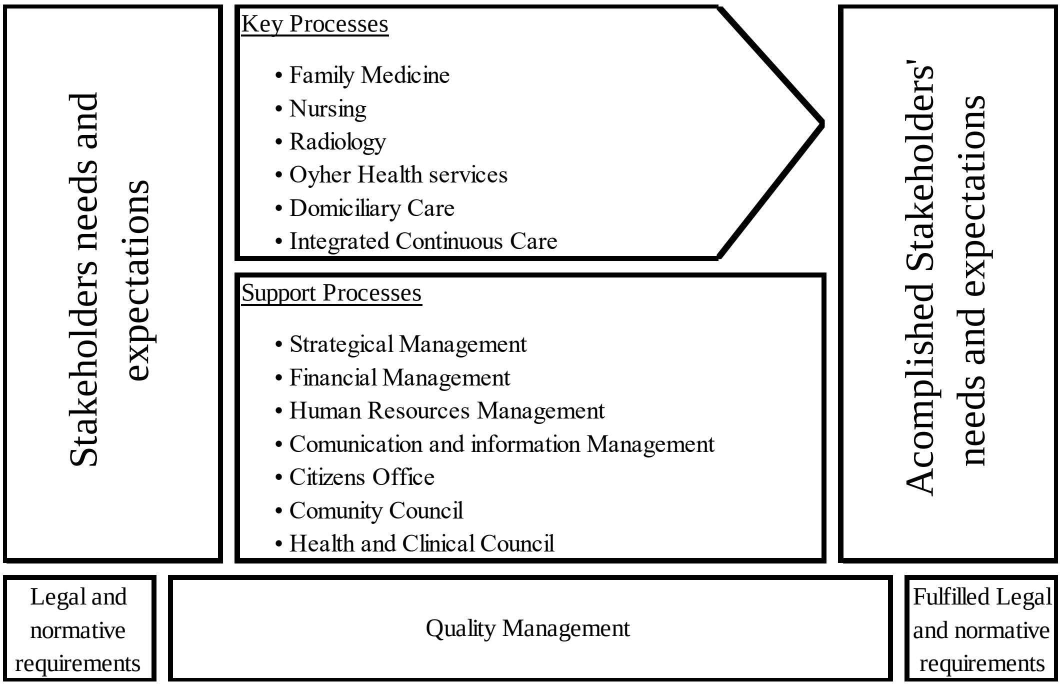

Figure 4: Process Map proposed for the ACeSPOc

This process map will lead to the definition of new standards to include in the accreditation model, related with:

- non-clinical professionals;
- results regarding the organization's performance
- organizational management
- management of patients' personal information
- management of complaints
- articulation between all units and other care level units.

The definition and implementation of these new standards is presently under discussion in the ACeSPOc.

CONCLUSION

This study intends to contribute to answer, at the primary healthcare level, to what was defined as priority in order to achieve the health quality policy at the ENQS – adopt and adapt a national and independent accreditation model that might be officially implemented on Health Clusters, through a national health accreditation plan.

The model under developed in the present work is based on the statement that healthcare units' management should be seen similarly to any other organization's management: in an integrative way, attending to economic, quality, environmental, and safety (both of users and professionals) criteria. Ideally the model under development should also incorporate social responsibility issues and innovation issues – future work to be developed in this field.

The major difficulties associated with this project are related with the (clinical and non-clinical) healthcare professional's motivation for quality management, who sometimes see this all process as a "menace" to their autonomy and to the established hierarchies.

Although the general statement of all involved in primary healthcare is that it is essential to assure healthcare quality, to implement and maintain quality management systems and to get involved in accreditation programs, sometimes those statements have no practical effects since there are organizational deficiencies either in the leadership abilities, or in the adequate communication and training on quality management and its importance for the organizations and for professionals. In these cases, no matter the quality, the scope or the intention of the management system designed for the ACeS, it will never achieve its goals of improving the quality of services provided and patient care. So, particular attention is recommended on those issues.

The integrated accreditation process in Local Health Trusts could be an important contribution to encourage all its functional units and services to embrace quality management and continuous improvement, contributing effectively to assure the sustainability of the entire ACeS. To potentiate the success of this accreditation process, the effective autonomy of the ACeS must be assured, recognized, accepted and naturally faced by all the units under its scope.

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Innovation, Total Quality and Performance: a study of ISO 9001 certified organizations in Portugal

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ABSTRACT

Purpose: Our general purpose is therefore to evaluate the effects of the joint and integrated adoption of TQM and innovation on organization's performance.

Design/methodology/approach: The paper presents a conceptual model designed to study the join implementation of quality and innovation. It can also be seen as an adequate tool for supporting improvements on organizational performance. The model incorporates a set of causal relationships between TQM, innovation and financial, organizational and operational performance.

Findings: Data was gathered from a total of 218 organizations certified according to the ISO 9001:2008. A PLS approach was used to analyze these data. Results suggest that TQM has a direct impact on non-financial performance and an indirect impact on financial performance. In turn, innovation has a direct impact on financial and organizational performance. Good results in terms of organizational performance have impact on financial performances.

Originality/value: The importance given to the development of organizations, particularly on issues related to improving the competitiveness and development of more appropriate management models, justify the importance of this research that seeks to find some answers about a topic and provide some additional contribution to the existing literature.

Keywords: total quality management, innovation, financial performance, organizational performance, operational performance

Article Classification: Research paper

INTRODUCTION

The influence of TQM and innovation on organization's performance has been subject to a diverse range of research projects. Their results have not enabled definitive conclusions to be reached but have paved the way for new research projects. A research project studying the simultaneous effect of both dimensions on organization's performance may provide an additional contribution to this research field.

Our general purpose is therefore to evaluate the effects of the joint and integrated adoption of TQM and innovation on organization's performance.

Beyond this introductory section, this paper contains four further sections. Section two presents a review of the literature including a reflection on the impact of TQM and innovation on organization's performance before putting forward our conceptual model. Section three deals with the methodological approach applied in this research. In section four, we detail the analytical procedures and discuss the results. Finally, in section five, we advance our conclusions alongside some future research perspectives.

LITERATURE REVIEW

TQM is a management approach involving the application of the quality management principles throughout every aspect of the organisation whilst focused on improving both efficiency and the capacity to meet client needs within the framework of the overall objective of organisational excellence (Kangi, 2002; Han et al., 2007).

Innovation may be defined as a result of an interactive and non linear process between the organization and its environment (Silva, 2003; Silva and Leitão, 2009; Silva et al., 2012). This is an interactive process resulting from internal cooperation between the various different departments in conjunction with external cooperation with other organisations (Kaufman and Todtling, 2001). This is a non linear process that may be stimulated by many different actors and sources of information.

The relationship between TQM and innovation has been the focus of different empirical research projects. In general terms, the influence of TQM on innovation depends both on the TQM principles taken into consideration in addition to the type of innovation (Perdomo-Ortiz et al., 2009 a,b; Prajogo and Sohal, 2001, 2004 a, b; Fernandes, Lourenço and Silva, 2012). Furthermore, the outputs of innovation encourage the adoption and implementation of TQM principles (Fernandes, Silva and Lourenço, 2012 a, b). A convergent commitment between both dimensions may establish an ideal platform for organisations seeking to raise their performance standards.

The effects of TQM and innovation on organization's performance have been the subject of study by many different research projects, over the course of a significant period of time, applying different methodological approaches to a diverse range of organisations. Based upon a review of the literature, we formulate eight research hypotheses in the following sections.

TQM and Performance. There is no generalised consensus as regards the conclusions of researchers approaching the relationship between TQM and organization's performance (Sila and Ebrahimpour, 2002). In the findings reached by Han et al. (2007), the importance of TQM practices to the direct and immediate improvement of performance is thrown into question. Arguments favourable to a direct and positive relationship between TQM and organization's performance posit that TQM may prove determinant across many aspects of an organisation and reflect in improved performance levels (Easton and Jarrell, 1998; Lai, 2003; Costa and Lorente, 2004; Cho and Pucik, 2005; Pinho, 2007; Prajogo and Sohal, 2006).

Costa and Lorente (2004), in a research project bringing together 14 organisations with experience in TQM implementation, find that this management philosophy generates major influences in terms of the product quality, customer service, fast response, customer satisfaction, employee satisfaction and employee motivation, fewer defects and higher stock price. The relationship between quality and various different aspects such as innovation, growth, profits and company value was studied by Cho and Pucik (2005) through empirical data on 488 companies from ten different sectors of activity. Their results show that TQM impacts directly on the level of company profits while the level of growth is shaped by innovation. In an extensive review of the research literature on this area, Kaynak (2003) concludes that TQM does wield an influence at the operational performance level, market performance and financial performance. Given the different impacts that TQM may have on various different aspects of performance, and as demonstrated by this literature review, we consider it inappropriate to perceive organization's performance from a unidimensional perspective. Hence, and contrary to other empirical research projects, Pinho (2007), for example, this project adopts three dimensions for performance of organizational: financial performance (associated to a return on assets, market share, increased sales and profits); organisational performance (associated to the satisfaction of clients, employees, shareholders and financial entities); and operational performance (associated to product quality, delivery times, production flexibility) (Metts, 2007).

Despite some authors (Han et al., 2007; Sila, 2007) calling into question the importance of TQM as a factor able to enhance financial performance, for a large group of authors (Kaynak, 2003; Escrig-Tena, 2004; Costa and Lorente, 2004; Cho and Pucik, 2005; Sila, 2007), the implementation of the principles underlying TQM may prove determinant to improving financial performance. According to Fullerton and McWatters (2001), organisations that carry out significant efforts in terms of raising quality standards obtain high levels of financial reward. Easton and Jarrel (1998) testify to a significant relationship between a company's share price and the implementation of TQM. Accordingly, we arrive at our first research hypothesis:

H1: TQM generates a direct and positive influence on financial performance

The literature review points to the existence of a positive influence of TQM on organisation`s performance (Costa and Lorente, 2004; Sila, 2007). McAdam and Bannister (2001) suggest that the implementation of TQM contributes positively to improving working environments and results in the reduction of employee absenteeism. Forza and Filippini (1998) meanwhile propose that TQM practices have a positive influence on client satisfaction. Sila (2007) empirically confirms a direct and positive relationship between TQM practices and organisational efficiency. Hence, we propose our second research hypothesis:

H2: TQM generates a direct and positive influence on organisational performance

The literature review supports the utilisation of TQM having positive implications in terms of operational performance (Forza and Filippini, 1998; Elg, 2007; Han et al., 2007; Lee et al., 2008) and we therefore present our third research hypothesis:

H3: TQM generates a direct and positive influence on operational performance.

Innovation and Performance. The rise in competition and uncertainty in the environment correspondingly render innovation as an increasingly relevant factor to the survival and growth of organisations (Gronhaug and Kaufman, 1988), which periodically review their innovation strategies to obtain competitive advantages (Hult et al., 2003). According to McAdam and Keogh (2004), innovation is the key to success, growth, sustainability, and organisational competitiveness. The influence of innovation on improving performance standards may be explained by how such innovations effectively respond to the challenges and dangers the organisation is subject to (Han et al., 1998), to the extent that they facilitate better products, processes and procedures (Damanpour, 1996). Innovative organisations would thus seem inherently better positioned to respond to the external pressures associated with changes in the market and internal pressures associated with more efficient organisational models. The results of innovation may therefore be perceived as impacting jointly across the performance of an organisation. Sampson (2007) studies 463 cooperation partnerships in the telecommunications sector and verified that they had a positive impact on generating innovation and improving performance. In the study undertaken by Pinho (2007), we find that administrative innovation, state of the art technology and the capacity to produce differentiated products bears an influence over the improvements attained in organisation's performance. Accordingly, we are able to put forward our fourth research hypothesis:

H4: Innovation generates a direct and positive influence on financial performance

Li (2005) affirms how advances, in terms of productive capacities, are able to boost client satisfaction levels. The results of innovation would therefore seem to wield a positive influence on the satisfaction of clients, employees, shareholders and financial entities and thereby founding our fifth research hypothesis:

H5: Innovation generates a direct and positive influence on organisational performance

Operational flexibility and a reduction in costs may also derive from innovation related efforts across administrative processes, production processes and new product development (Koufteros and Marcoulides, 2006). The results of innovation may thus drive a positive influence on organisation's operational performance, and we thereby arrive at our sixth research hypothesis:

H6: Innovation generates a direct and positive influence on operational performance

Organisational Performance, Operational Performance and Financial Performance. Turnow and Wiley (1991) report significant correlations between employee satisfaction levels and various measurements of client satisfaction. These authors furthermore note that employee contentment, as expressed through lower rates of absenteeism, impacts on financial performance. Das et al. (2000) find how the adoption of quality based practices positively relates to consumer satisfaction, with the latter, in turn related to financial performance. Demirbag et al. (2006) reveal how the indirect effects of TQM on financial performance, measured by non-financial performance, have greater influence than any direct effect of TQM on financial performance. The authors conclude that TQM practices provide a better explanation of financial performance when approached through non-financial performance. In the research findings put forward by Han et al. (2007), three positive causal relationships between client satisfaction and financial performance are identified. Wang and Wei (2005) refer to how the innovation performance associated with the success of new products contributes towards raising sales and market share through satisfying current clients and attracting ones. These arguments all suggest that client satisfaction and other interested parties hold an influence over the level of financial performance and we therefore come to our seventh research hypothesis:

H7: Organisational performance generates a direct and positive influence on financial performance

Fuentes-Fuentes et al. (2004) refer to how operational performance indicators interlink with financial performance indicators. Meanwhile, the research findings of Han et al. (2007) verify a positive causal relationship between the competitiveness (that these authors relate to cost, quality, product delivery and flexibility) and financial performance. Hence, we correspondingly arrive at our eighth research hypothesis:

H8: Operational performance generates a direct and positive influence on financial performance

Proposed Conceptual Model. Figure 1 details our proposed conceptual model for evaluating the eventual effects of TQM and innovation on each performance dimension.

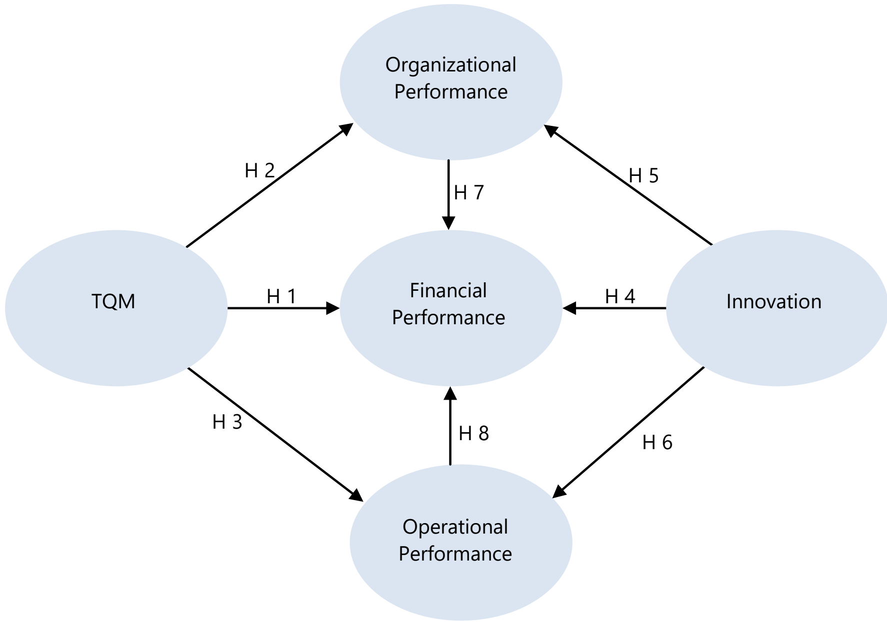

Figure 1: Proposed conceptual model

LITERATURE REVIEW

Development of the Structural Equation Model. The conceptual model in figure 1 reflects a structure and a set of causal relationships between its five constituent concepts. It is plausible to think the model as a Structural Equation Model (SEM) and with this multivariate statistical analytical technique test the significance level of each causal relationship between the five constructs (latent variables). The term construct is applied to represent a theoretical concept where, due to an inability to directly measure the phenomenon in question, such is measured through indicators (manifest variables) (Hair et al., 2006). Of the five constructs incorporated into the model, three are endogenous (dependent), and hence are determined by one or more of the others while two are exogenous (independent) and not caused by any of the other constructs included in the model.

Given the fact that the conceptual model remains at an initial stage of development and the relationship between the constructs under consideration have yet to be extensively tested, we adopted PLS as the most appropriate statistical process for this study (Fornell and Bookstein, 1982; Chin, 1998 b). We deployed Software SmartPLS 2.0 applications that estimate the outer efficient model parameters as well as structural model inner coefficients and thereby generate a matrix of construct correlations, the determinant coefficients for each endogenous construct and the statistical t-Student values providing for the evaluation of the statistical causal relationship significance established between the constructs.

The five constructs were measured with reflective indicators. We deemed this the best approach and considered each TQM indicator (the construct indicators) as representative of TQM practices. As regards the constructs for innovation, financial performance, organisational performance and operational performance, was considered that the indicators for each construct reflect the results attained and therefore due manifestation of their respective associated construct.

Development of the Structural Equation Model. An e-questionnaire was applied in order to gather information on the perceptions of senior management about the different aspects related to TQM, innovation and performance. For each indicator (statement) the respondents reported their level of agreement across ten possible alternatives (from 1 – total disagreement to 10 – total agreement). The adoption of a ten-point scale is in accordance with the studies by Kanji and Wallace (1998) and

Fornell and Cha (1994). We pre-tested the questionnaire with a group of senior managers in order to identify any shortcomings, gain a perception as to the questionnaire size and to undertake some improvements, particularly in terms of aiding in the interpretation of some statements. The model's latent variables were measured in accordance with the set of indicators we present below:

Measuring TQM: Despite TQM having already been taken up by many researchers, there is not only no single measurement tool for its evaluation but also no agreement over just which variables should be subject to study (Sila and Ebrahimpour, 2002). The generally adopted variables for measuring TQM are drawn either from the eight EFQM Fundamental Concepts or from and the ISO 900 quality management principles (Han et al., 2007; Pinho, 2007; Abrunhosa and Sá, 2008; Hung et al., 2010; Satish and Srinivasan, 2010). Among the TQM associated indicators deployed in different empirical research projects (Han et al., 2007; Pinho, 2007; Hung et al., 2010; Satish and Srinivasan, 2010), we take eight indicators into consideration in this instance: leadership (LEA); customer focus (CUF); involvement and development of people (IDP); process management (PRM); continuous improvement (COI); suppliers relationship (SUR); results measurement through quality statistical tools (RMQ); utilisation quality tools on product design (PRD). Various items were analysed for each indicator (questionnaire statements). We carried out confirmatory factor analysis (SPSS software) in order to ascertain the indicators and the respective items in accordance with the literature review and the assumptions made when drafting the questionnaire (Abrunhosa and Sá, 2008). Compliance with the reference value (a minimum of 0.500) according to the Kaiser–Meyer-Olkin (KMO) test (Hair et al., 2006) ensured verification that factor analysis was appropriate to handling this data. Based on the results of this analysis it is possible to conclud that we are dealing with unidimensional indicators. In every case, the Eigenvalue (the total variance explained by the factor) was greater than one (Hair et al., 2006). Through factor analysis, we calculated the component scores for each indicator before then applying the PLS approach.

Measuring Innovation: The innovation construct was measured through six indicators that represent diverse dimensions to the presence of innovative activities at organisations. We considered the five indicators adopted by Satish and Srinivasan (2010) (research and development and technological innovation (RTI); product innovation (PRI); process innovation (PCI); organisational innovation (ORI); management innovation (MGI)) and one additional indicator, marketing innovation (MAI) to incorporate the implementation of new marketing methodologies (OECD, 2005). As was the case with measuring TQM, some indicators took more than one item into account. In these cases, we followed the same methodological approach as in the factorial analysis and calculated the respective component scores.

Measuring Financial Performance, Organisational Performance and Operational Performance: The three constructs related with organization's performance were measured by the indicators proposed by Metts (2007). We adopted three indicators for financial performance, return on assets (FI1), return on sales (FI2) and average profit before tax (FI3), four indicators for organisational performance, customer satisfaction (OR1), worker satisfaction (OR2), shareholders satisfaction (OR3) and satisfaction of financial partners (OR4) and three indicators for operational performance, product quality (OP1), product delivery (OP2) and product flexibility (OP3).

Sample. We studied data gathered from 218 Portuguese organisations certified according to the ISO 9001:2008 in order to ensure a certain level of interest in the quality management as well as familiarity with the concepts contained within the framework of the questionnaire (Curry and Kadasah, 2002). As regards the numbers of employees, 43.1% of respondent organisations employed between 10 and 49 members, 28.9% between 50 and 250, 15.1% had over 250 employees, while 12.8% of entities had less than 10 workers. Around 47% of respondent were industrial organizations while 53% were service based organisations.

According to Chin (1998 a) and Barclay et al. (1995), the recommended PLS application sample size should be ten times greater than each of the following situations: 1) the block of the largest number of constituent indicators, thus, the largest measurement equation; 2) the dependent latent variable with the largest number of independent latent variables impacting upon it, thus, the largest structural equation. Given this research project does not include constituent indicators, the first condition proves irrelevant. As regards the second, the financial performance construct has the largest number of impacting constructs with a total of four. Hence, the sample should contain a minimum of forty observations and given our total of 218 valid respondents, the PLS approach is deemed duly applicable.

RESULTS

SEM Analysis and Interpretation. SEM analysis and interpretation takes place across two sequential steps: evaluation of the reliability and validity of the measurement model and evaluation of the structural model (Hulland, 1999). Evaluation of the reliability and validity of the measurement model was carried out by recourse to analysis of the individual indicator reliability, the reliability of each construct, the convergent validity and the discriminant validity. The reliability of the reflective indicators was established according to their respective loading values (Chin, 1998 a; Barclay et al., 1995) as detailed in table 1.

Table 1 – Loading values

Indicator	*Loading*	Indicator	*Loading*	Indicator	*Loading*
LEA	0.836	RTI	0.707	FI1	0.953
CUF	0.905	PRI	0.756	FI2	0.953
IDP	0.902	PCI	0.797	FI3	0.950
COI	0.906	ORI	0.846	OR1	0.871
PRM	0.909	MGI	0.719	OR2	0.891
SUR	0.905	MAI	0.751	OR3	0.813
RMQ	0.851			OR4	0.917
PRD	0.700			OP1	0.911
				OP2	0.893
				OP3	0.816

Analysis of table 1 demonstrates that all indicators report loading values in excess of the 0.70 reference point (Chin, 1998) enabling the conclusion that these indicators do appropriately measure the construct to which they are associated.

Analysis of the reliability of each construct returns a measurement of the internal consistency of all of the indicators through measuring the respective construct and carried out according to various measures: composite reliability; discriminant validity; comparison of the loading and cross-loading values (Chin, 1998 a). A construct attains reliability when associated with a set of indicators with composite reliability readings in excess of 0.70 (Nunnally and Bernestein, 1994). Analysis of table 2 shows how the composite reliability level is above 0.90 for all constructs and hence guaranteeing the existence of inter-correlation between the indicators belonging to the same construct.

Table 2 – Composite Reliability Values

Construct	Composite Reliability	AVE
TQM	0.957	0.7372
Innovation	0.893	0.5834
Financial Performance	0.967	0.9070
Organizational Performance	0.928	0.7639
Operational Performance	0.907	0.7647

Analysis of discriminant validity evaluates where the constructs are different from each other and may be carried out through comparing the square root of the average variance extracted (AVE) and the inter-construct correlation coefficients (Chin, 1998 a). By analysing table 3, we find out that all diagonal values are higher than the correlation coefficient between the respective construct and the other constructs, the constructs hence differ among themselves.

Table 3 – Discriminant Coefficient Analysis

	TQM	Innovation	Financial Performance	Organizational Performance	Operational Performance
TQM	0.858720				
Innovation	0.512004	0.763806			
Financial Performance	0.278986	0.454867	0.952365		
Organizational Performance	0.728040	0.497881	0.432673	0.874001	
Operational Performance	0.732004	0.435100	0.299253	0.713321	0.874447

Structural model evaluation may be undertaken through analysis of the level of robustness of each causal relationship and the combined predictive level of the endogenous constructs. Figure 2 presents the structural model, indicating, alongside the arrows interlinking the constructs and that represent the respective causal relationships, the structural coefficient values estimated by the PLS algorithm. These results open up an insight into the intensity of the relationships between the model variables. The explained variance values (R^2) for each endogenous construct are also reported.

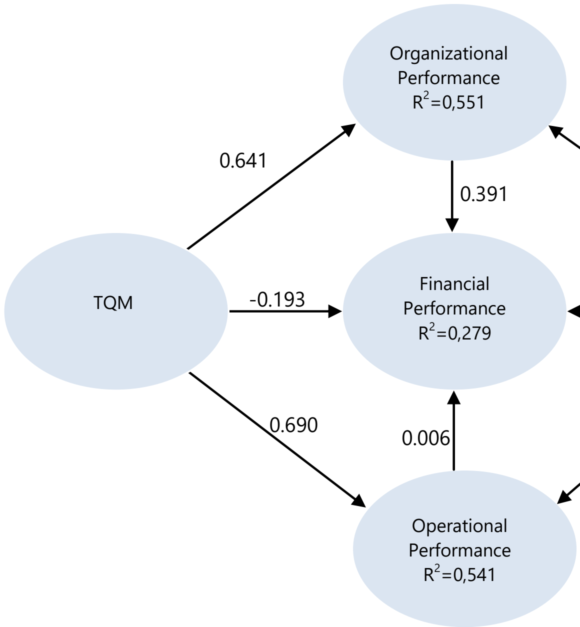

Figure 2: Proposed conceptual model

In order to ensure the causal relationships may be deemed robust, they need to return structural coefficient values of greater than 0.20 (Chin, 1998 a). The four causal relationships return results in excess of this reference point. The coefficient values resulting from each endogenous construct return R^2 values above the 0.25 reference point (Barclay et al., 1995) for all endogenous constructs and we may thereby confirm that the model appropriately fits the empirical data.

Hypotheses Test. The hypotheses were tested based upon the level of significance of the structural coefficients. We applied the bootstrap methodology (with 500 sub-samples) as proposed by Chin (1998 a) and the Student's t values calculated for each causal relationship.

According to a 5% (t(0.05;499)=1.960) level of significance, we find that the structural coefficients for hypotheses H2, H3, H4, H5 and H7 are statistically significance. We may thereby conclude that the empirical findings support the five aforementioned hypotheses and thus TQM impacts directly and positively on organisational performance and on operational performance, and innovation has a direct and positive impact both on financial performance and on organisational performance, and, finally, organisational performance impacts directly and positively on financial performance.

The results suggest that TQM does not directly improve the organisation's financial performance. Furthermore, the literature review did highlight some discordance as regards the direct relationship between these two variables. However, it is also important to note that TQM contributes positively to organisational performance and this factor, in turn, has a direct and positive influence on financial performance. We are therefore able to confirm the literature review finding that TQM bears an indirect impact on the financial performance of organisations.

The weak impact of innovation on organisational performance (returning a structural coefficient below the reference point) and the fact that the empirical data does not support a direct relationship between innovation and operational performance does not prove especially surprising to the extent that, and particularly for service organisations, the existing literature does not prove especially explicative as regards these two causal relationships.

Contrary to expectations, data did not provide support for the initial idea about the influence of operational performance on financial performance. One possible explanation for this result derives from how half of the sample was made up of service based businesses. In all likelihood, some of the operational performance related statements are downplayed by this type of organisation in favour of statements related to organisational performance that service based firms might be more attentive to and aware about.

Table 4 summarises the results obtained as regards the effects each dependent variable has on each independent variable.

Table 4 –Independent Variable Effects on Dependent Variables

	Direct effect	Indirect effect	Total effect
Financial Performance (R^2=0.279)			
H1: TQM	No sig.	0.251	0.251
H4: Innovation	0.356	0.066	0.422
H7: Organizational Performance	0.391	—	0.391
H8: Operational Performance	No sig.		No sig.
Organizational Performance (R^2=0.551)			
H2: TQM	0.641	—	0.641
H5: Innovation	0.170	—	0.170
Operational Performance (R^2=0.541)			
H3: TQM	0.690	—	0.690
H6: Innovation	No sig.	—	No sig.

From analysis of table 4, we would stress that despite the empirical data not advocating a direct causal relationship between TQM and financial performance, our findings do demonstrate the existence of an indirect effect of the independent variable on the dependent variable and, thus, TQM explains financial performance through the organisational performance dimension. This result is in line with the conclusions of Demirbag et al. (2006), where the authors reported an indirect impact of TQM on financial performance measured through non-financial performance and returning greater influence than the direct effect of TQM on financial performance.

CONCLUSION

The research results substantiate three broad ideas: 1) TQM bears a direct impact on aspects relating to non-financial performance and an indirect impact on financial performance; 2) Innovation has a direct impact on financial performance and a weak but direct impact on organisational performance; 3) Good results in terms of organisational performance do impact on financial performance.

This research presents a particular relevance because it contemplates a set of causal relationships between TQM, innovation and financial, organisational and operational performance tested simultaneously with data from Portuguese organizations. It can be concluded that focusing on innovation with quality as well as focusing on quality with innovation allows the integration of these two important aspects for the development of organizations and produce better results than the sum of separate approaches. In addition, the two dimensions have different direct impact on the performance variables considered.

This research does contain some limitations. Firstly, the empirical data refer to organisations from different sectors of activities and hence the generalised results obtained may not apply to specific individual sectors. Secondly, the collection of data considers only the perception of senior management and may not completely correspond to the realities actually prevailing in the organisation. Thirdly and finally, the existence of purely transversal data does not allow for any analysis of the potential bi-univocal relationship between TQM and innovation.

As regards future research, it would be of importance to divide up the sample (whether by sector of activity or organisational size) and study eventual differences whether in terms of hypothesis confirmation or the level of robustness revealed in the causal relationships between the variables.

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Recommending actions criteria in FMEA: A Survey in Brazilian Automotive Companies

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ABSTRACT

Purpose. Unlike other procedures for risk assessment, FMEA can evaluate a potential risk. This is accomplished setting the Risk Priority Number (RPN), by combining the scores of Severity, Occurrence and Detection. When the RPN is identified as high, actions should be recommended to minimize it. The criteria for recommending actions in FMEA is specific in each company, but since the guidance included in the fourth edition of Automotive Industry Action Group (AIAG) FMEA Manual, which recommends that the cut value in RPN should not be the only criteria for recommending actions, an increase in the diversity of criteria has been noticed.

Design/methodology/approach. A Survey was done in around 4% of Brazilian companies with ISO/TS16949 certification in order to understand how the diversity of the criteria for recommending actions is.

Findings. Such criteria, in some instances, are not clearly defined and known by the staff, which has contributed significantly to the subjectivity increasing in decision about the need for taking action.

Research limitations/implications. Data collection was conducted in two stages, first a personal invitation was made by telephone and then a specific questionnaire was sent.

Originality/value. Cases with more than one criteria and also cases with no fixed point values were observed, with a total of 16 different combinations. Considering the point values that make the rules, each situation was observed only once, highlighting the variety of criteria within the survey sample.

Keywords: FMEA, RPN recommending actions, Survey, Brazilian Automotive Indurtry

Article Classification: Research paper

INTRODUCTION

The Automotive Industry in Brazil has grown significantly in recent years, due to the installation of new vehicle manufacturers and consequently supply chain increasing. In order to become an automaker supplier, companies need to have the quality management system certified according to ISO / TS 16949. One of the requirements of this certification is the application of Failure Mode and Effects Analysis (FMEA) during the development phase of their products and process. Unlike other procedures for risk assessment, FMEA can evaluate the criticality of a potential risk, being therefore characterized as a preventive tool.

Structurally, FMEA can be divided into three distinct phases, in the following sequence: Building FMEA Model Structure; Scoring and Prioritization and Decision and Action (Lee, 2001). These phases and their descriptions are shown in Table 1. Each stage has its subjective aspect. Researches have been developed regarding these subjective aspects with a focus on Brazilian Automotive Industries, such as a study based on ISO9001 Process approach regarding FMEA model structure (Aguiar et. al, 2015) and an AHP (Analytic Hierarchy Process) application to evaluate scoring criteria (Aguiar et. al, 2010), which are respectively related to phases 1 and 2 of Table 1.

Table 1 – FMEA Modeling and Decision Process

FMEA Phase	Description
1- Building FMEA Model Structure	Elaborate “casual chain” failure dependencies (Causes -> Failure Modes -> Effects)
2- Scoring and Prioritization	Assess Risk Priority Numbers (RPN) (effects severity X causes frequency X detection difficulty)
3- Decision and Action	Optimize design improvements, trade-offs, test plans, manufacturing changes, etc.

In order to complete this approach, this paper develops a study related to Decision and Action phase. This is accomplished setting the Risk Priority Number (RPN), by combining the scores of Severity, Occurrence and Detection. In situations where the potential risk is identified as higher, action should be recommended to minimize it. The criteria for recommending actions in FMEA is a specific condition in each company, but since the guidance included in the fourth edition of Automotive Industry Action Group (AIAG) FMEA Manual, which recommends that the cut value in RPN should not be the only criteria for recommending actions, an increase in the diversity of criteria has been noticed. Such criteria, in some instances, are not clearly defined and known by the FMEA team, which has resulted in a large subjectivity in decision making regarding taking action. In this scenario, a research was done in about 4% of Brazilian companies with ISO/TS16949 certification in order to understand how this variation occurs and if there is any consensus point between the companies.

Data collection was conducted in two stages, first a personal invitation was made by telephone and then a specific questionnaire was sent. Due to the previous contact, the return rate was over 90%, characterizing sufficient for representation of the units of analysis in the Survey method. From what has been ascertained, several specific criteria are adopted, taking into regard several types of combination between the scores of Severity, Occurrence, Detection and RPN. Cases with more than one criteria and also cases with no fixed point values were observed, with a total of 16 different combinations.

Considering the point values that make the rules, the same situation was not observed for more than one company, highlighting the variety of criteria within the survey sample.

The paper is organized as follows. In Section 2, a literature review is presented specifically regarding RPN features in FMEA, where some weakness points were identified as a concern to be discussed. Focusing this concern, Section 3 presents a descriptive Survey in Brazilian Automotive Companies regarding recommending actions criteria in FMEA, where were identified many different situation, classified in three categories. A detailed analysis of the survey data is presented in Section 4. Finally, the results and conclusions drawn from this analysis are presented in the last Section.

FMEA AND RPN INDICES

In FMEA, the sequence of scores for Severity, Occurrence and Detection is applied to assign a weight to each failure mode in analysis (Silvestri et al., 2012). For such scoring, reference tables that report the typical scales of judgment in assigning valuesranking from 1 to 10 are used (Braglia et al., 2006). Data for Risk Priority Number (RPN) are made by multiplying the values of Severity, Occurrence and Detection (Estorilio and Posso, 2010), whose purpose is to indicate the priorities for recommended actions (Braglia et al., 2006).

High RPN values are interpreted as potential failure modes that require greater attention from the staff (Tanik, 2010). The RPN is the basis for classifying the risk and also to prioritize actions, helping managers to make decisions. (Silvestri et al., 2012). For all failure modes with RPN beyond certain limit value level, actions should be recommended in order to improve the process (Keskin and Ozkan, 2009). Failure modes with higher RPN are prioritized in relation to lower values (Murphy et al., 2011). Moreover, even lower RPN values being less urgent, recommending action may still be required (Sawhney et al., 2010).

Based on this risk assessment, it is expected that the necessary actions are taken to address the main causes of failure, thus increasing the process reliability (Sant'Anna, 2012). The goal of recommending actions is to remove or minimize the critical failure modes that show a high Severity, Occurrence and Detection rankings. RPN must be recalculated after the implementation of actions to determine whether the risks or even decreased the efficiency of action (Xiao et al., 2011).

Assuming an equivalent importance to the reduction of risk according to each criteria, the combination of these probabilities in an overall probability is done by simple multiplication as in classical computing RPN (Sant'Anna, 2002). In FMEA, decisions on how to improve an operation are based on the RPN, and this is a very powerful and useful method for risk assessment (Xiao et al., 2011). Due to its intrinsic facility, RPN method is widely adopted in industrial practice (Braglia et al., 2006). RPN calculation has been largely used to manage risk, highlighting the advantages: It is easy to use and understand due its simplicity; The actions are well documented and properly formatted; It has a systematic for fast decision making (Silvestri et al., 2012). However, sole RPN dependence can induce FMEA team to waste valuable resources, setting priorities in no critical points and leaving critical failures away. (Keskin and Ozkan, 2009).

The risk measurement based on the multiplication of the three scores and expressed as RPN values has been widely criticized in the literature (Barends et al., 2012). One point that has been criticized highlights that the method for RPN calculating does not assign different weights for Severity, Occurrence and Detection, being all components considered equivalent (Bradley and Guerrero, 2011), for example, the value of Severity 3 represents the same level of significance as the value 3 in Occurrence and Detection scoring. Another way to exemplify this point is where RPN (S, O, D) = (6, 3, 1) has the value 18, and another RPN (S, O, S) = (4, 2, 3) has the value 24. Even being a discussion point, in accordance with the traditional practice, the priority is to treat the second RPN, despite the Severity of the first RPN being higher than the second, what may result in an undetected high-risk event (Keskin and Ozkan, 2009). In this way, the same amount of risk priority number may indicate totally different risk implications (Yang et al., 2008) and different scores for Occurrence and Detection can result in the same RPN, despite quite different situations for involved risks (Segismundo and Miguel, 2008).

Another weakness is related to the fact that scales of Severity, Occurrence and Detection are only qualitative. Severity score 8 is not twice a Severity score 4 in RNP composition, nevertheless the multiplications are treated as being numerical quantities (Chang and Sun, 2009). Additionally, Severity score can not provide a direct association to the cost of failure, since the cost of a failure mode with Severity score 10 is not always ten times a failure mode with Severity score 1 (Dong, 2007). Thus the multiplication can be classified as an arbitrary combination of three scoring factors (Bradley and Guerrero, 2011). It is still needed attention to the fact if there is a high sensitivity to small changes in the values of factors caused by the effect of multiplying factors RPN (Silvestri et al., 2012; Yang et al., 2008).

Regarding the combination of results, the product of the RPN factors produces some holes in scale (Silvestri et al., 2012). These holes in scale are classified as non-intuitive statistical properties. Beginning at 1 and ending at 1000, it can lead to incorrect assumptions regarding the intermediate points of the scales (Chang and Sun, 2009). There are only 120 unique RPN, as some are repeated. For example, RPN 120 appears 24 times from combination of SOD. Other extreme 1 123 and 1000 appear only once. Moreover, some hypothetical numbers do not occur, for example, 13, 17, 19, etc..

Within this uncertainty and subjectivity scenario, the recommending actions criteria in Process FMEA becomes a very specific condition in each company. The AIAG FMEA Manual (2008), which defines FMEA rules within the automotive intustries, it is also not clear about the rules for recommending actions, allowing different situations in different companies. In a study conducted in Brazilian automotive industries, Estorilio and Posso (2010) observed that some companies recommend actions when the RPN is 40, others when Severity is 7. This highlights the fact that rules for the automotive industry in Brazil are unclear, and suggest the existence of a very wide range of criteria. Based on this condition, a Survey research was conducted in this study in order to get a sense of the size of such diversity.

SURVEY IN BRAZILIAN AUTOMOTIVE COMPANIES

The number of ISO/TS16949 certified companies has grown considerably in Brazil. The ISO SURVEY (2012) has reportedly the number of companies with this certification increased from 299 in 2004 to 1180 in 2012. It indicates that the number of people who know and use FMEA has also increased significantly, which makes the subject ever more relevant due to the greater spread in technical teams and also the relationship between customers and suppliers. With this widespread application, it is assumed that the diversity for recommending actions criteria is also extensive in FMEA. In order to identify such diversity, it was developed a Survey where 48 Brazilian Automotive Companies were consulted, 44 responses were obtained, and 1 was not considered to have been classified as "no criteria".

A Survey can be classified as exploratory, descriptive or explanatory (Forza, 2002). Being in a condition in which the units of analysis are clearly and appropriate for the research questions and hypotheses, respondents are representative of the unit of analysis, the sample size is sufficient to represent the population of interest and the high level of response rate, this Survey is classified as descriptive. Table 2 shows the detailed points relating to the characteristics of a descriptive Survey.

Table 2 – Detailed points relating to the characteristics of a descriptive Survey

Survey element	Characteristics	Detailed points
Unit(s) of analysis	Clearly defined and appropriate for the questions/hypotheses	The recommending actions criteria in FMEA is an opened aspect that may result in different results and interpretations
Respondents	Representative of the unit of analysis	People who work in ISO/TS 16949 certified companies and use FMEA
Sample size	Sufficient to represent the population of interest	The survey is conducted in 48 companies which cover approximately 4% from 1180 companies with ISO/TS16949 certification in Brazil
Response rate	Greater than 50 per cent of targeted population	48 companies were consulted, the return was obtained in 44 cases, which means a response rate over 90%

Operationally, data collection was conducted in two stages, firstly a personal invitation was made by telephone and then a specific questionnaire was sent. Due to the previous contact, the return rate was over 90%, characterizing sufficient for representation of the units of analysis in the Survey method. Based on these data collection, the criteria were divided into three types, as shown in Table 3.

Table 3 – Criteria rating

Criteria Type	Definition	Example
Single Criteria	When, from the informative response, it was understood that there is only one defined criteria for recommending actions.	"(...) An action is recommended for cases with RPN value > 170 (...)".
Multiple Criteria	When, from the informative response, it was understood that there are more than one defined criteria for recommending actions.	"(...) An action is recommended for cases with RPN value > 170, and also for cases with Severity ≥ 8 (...)".
No Criteria	When, from the informative response, it was understood that there is no defined criteria for recommending actions.	"(...)There is no standard criteria, it may be for several types of analysis (...)".

SURVEY DATA ANALYSIS

Among the 44 responses, there is a balance in the type of criteria used by companies, since 21 companies adopt single criteria, 22 adopt multiple criteria. However, one company reported working without any defined criteria, therefore only 43 responses were considered. A mapping of all the responses is presented in Table 4.

In some cases classified as single criteria, there were a second possibility of taking action, but based on specific situations, such as "Team Meetings"; "When non-compliance occurs"; "Change process"; "Characteristics identified by the Customer"; etc.. For these situations, it was understood that there is not a second criteria defined as an objective rule, it only applies to situations where an assessment of whether or not the recommendation of actions without considering specific values or scores. It was also noted that some generic answers were presented. For the answers just reported that it is done according to the 4th Edition AIAG FMEA Manual (topic "Determining Priority Action"; Chapter IV, p. 103), it was understood that applies the sole criterion for recommendation shares, from values of Severity (S = 9 and S = 10).

In these 21 single criteria, the majority sets the RPN cut value as the rule for recommending actions. Furthermore, it was observed the use of other criteria, such as: Severity; RPN (no cut value); Combination of Severity and Occurrence; Combination of Severity and Detection. Figure 1 shows the distribution of such rules of single criteria cases.

Table 4 – Mapping of responses

#	Criteria Type	Level 1	Level 2	Observation
1	Multiple Criteria	Severity	RPN	No Values
2	Multiple Criteria	Occurrence	RPN	No Values
3	Multiple Criteria	Severity / Detection	Occurrence	Values
4	Multiple Criteria	RPN Cut value	Severity	Values
5	Multiple Criteria	Severity	Occurrence	No Values
6	Multiple Criteria	Severity	RPN	No Values
7	Multiple Criteria	RPN Cut value	Severity / Occurrence	Values
8	Multiple Criteria	Severity	RPN Cut value	Values
9	Multiple Criteria	Severity	RPN Cut value	Values
10	Multiple Criteria	Severity	RPN Cut value	Values
11	Multiple Criteria	Severity	RPN	No Values
12	Multiple Criteria	RPN Cut value	Severity	No Values
13	Multiple Criteria	RPN	Occurrence	No Values
14	Multiple Criteria	Severity	Occurrence / Detection	Values
15	Multiple Criteria	Severity	Severity / Occurrence	Values
16	Multiple Criteria	Severity	Severity / Occurrence	Values
17	Multiple Criteria	RPN Cut value	Severity	Values
18	Multiple Criteria	Severity	RPN	No Values
19	Multiple Criteria	RPN	Severity / Occurrence	No Values
20	Multiple Criteria	Severity	Severity / Occurrence	No Values
21	Multiple Criteria	Severity	RPN	No Values
22	Multiple Criteria	Severity	RPN Cut value	Values
23	Single Criteria	RPN Cut value	None	Values
24	Single Criteria	RPN Cut value	None	Values
25	Single Criteria	Severity / Occurrence	None	No Values

26	Single Criteria	RPN Cut value	None	Values
27	Single Criteria	RPN	None	Top 5
28	Single Criteria	Severity	None	Values
29	Single Criteria	RPN cut	None	Values
30	Single Criteria	RPN cut	None	Values
31	Single Criteria	Severity	None	Values
32	Single Criteria	RPN Cut value	None	Values
33	Single Criteria	Severity	None	Values
34	Single Criteria	RPN Cut value	None	Values
35	Single Criteria	RPN Cut value	None	Values
36	Single Criteria	Severity	None	Values
37	Single Criteria	RPN Cut value	None	Values
38	Single Criteria	RPN	None	Top 5
39	Single Criteria	RPN	None	Top 5
40	Single Criteria	Severity / Detection	None	No Values
41	Single Criteria	RPN	None	Top 5
42	Single Criteria	Severity	None	Values
43	Single Criteria	Severity / Occurrence	None	No Values
44	No Criteria	None	None	No Values

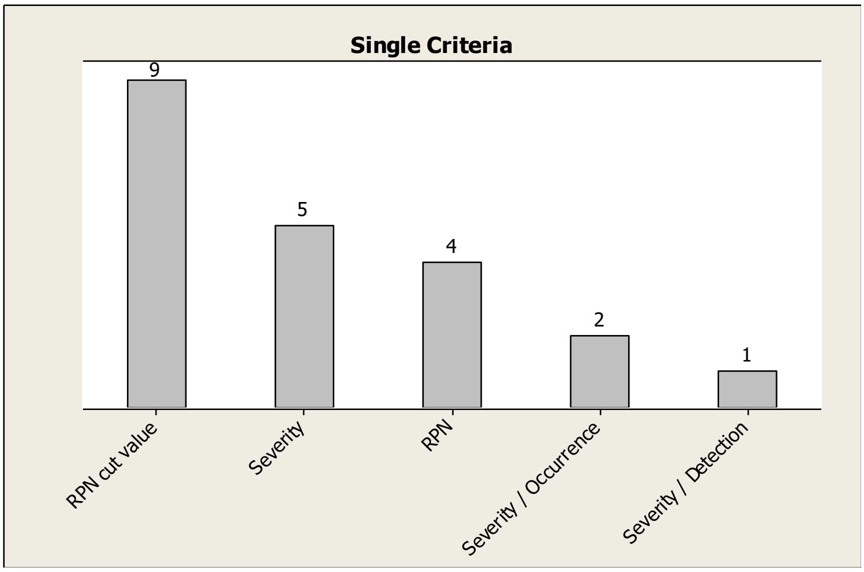

Figure 1 – Rules of single criteria cases

As well as in the case of a second chance-making based on specific situations described about single criteria, there are cases of new action possibility of also recommending actions for cases of multiple criteria. In some of the answers was possible to identify a third level of possibility in taking action, based on situations that do not consider specific values or scores. These situations were not considered as objective criteria for recommending actions.

Among the 22 cases identified as multiple criteria, most present Severity as a first rule (Level 1) for recommending actions. However it was possible to observe other criteria, such as: RPN cut value; RPN (no fixed level of warning); Occurrence; Combination of Severity and Detection. Figure 2 shows the distribution of these rules for cases in Level 1 multiple criteria.

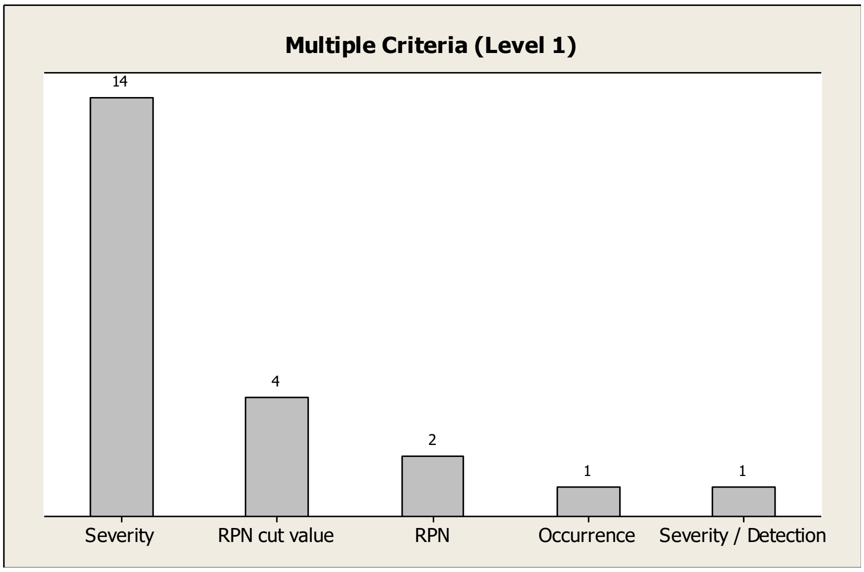

Figure 2 – Level 1 rules for multiple criteria

Still referring to the cases of multiple criteria, there is an unfolding for a second level in each identified situation in Level 1. It is noted where the Severity is the first rule (Level 1) to recommend actions, the majority of cases presents the RPN (with or without cut value) as a second rule (Level 2). Within this split levels, it was also observed the adoption of other Level 2 criteria, such as: Occurrence; severity; Combination of Severity and Occurrence; Combining Occurrence and Detection. Figure 3 shows the distribution of these rules for Level 2 multiple criteria.

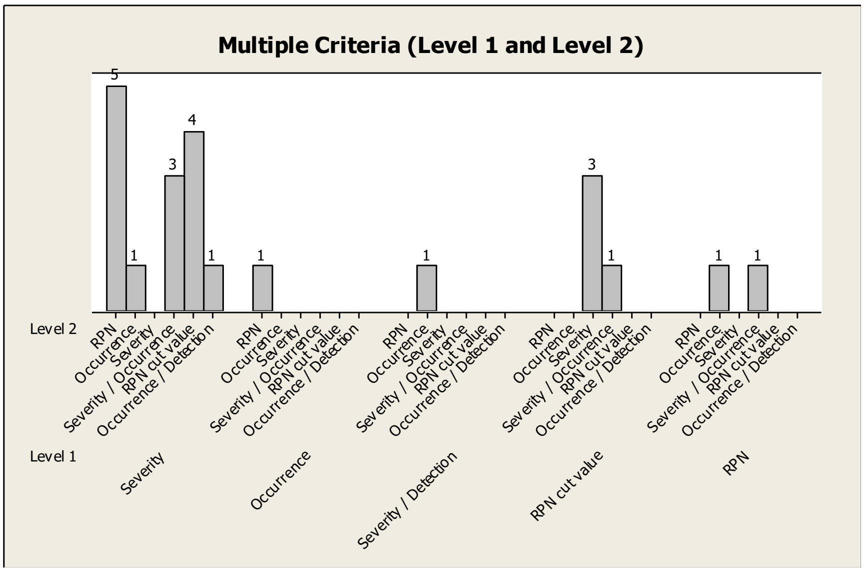

Figure 3 – Rules for Level 2 multiple criteria.

Table 5 - Rules and values for single criteria

#	Rule	Value
23	RPN Cut value	RPN > 100
24	RPN Cut value	RPN > 120
26	RPN Cut value	RPN > 60
28	Severity	S > 8
29	RPN Cut value	RPN > 100
30	RPN Cut value	RPN > 72
31	Severity	S > 8
32	RPN Cut value	RPN > 90
33	Severity	S > 8
34	RPN Cut value	RPN > 150
35	RPN Cut value	RPN > 130
36	Severity	S > 8
37	RPN Cut value	RPN > 130
42	Severity	S > 8

Among the 43 responses considered, 14 companies did not report the values of score (S, O, D or RPN) that comprise the criteria, whether single or multiple. For these 14 cases, it was understood that the criteria have no defined values, which makes it the process more subjective. The other 25 responses were classified as complete, as report the values that determine the need for recommending actions. There were 4 situations that where recommending actions are done for the top 5 RPN values. The rules and the values for single and multiple criteria are presented in Table 5 and 6, respectively.

Table 6 - Rules and values for multiple criteria

#	Level 1 Rule	Level 1 Value	Level 2 Rule	Level 2 Value
3	Severity / Detection	S > 8 e D > 8	Occurrence	O > 4
4	RPN Cut value	RPN > 168	Severity	S > 8
7	RPN Cut value	RPN > 80	Severity / Occurrence	S > 8 e O > 7
8	Severity	S > 7	RPN Cut value	RPN > 200
9	Severity	S > 8	RPN Cut value	RPN > 120
10	Severity	S > 7	RPN Cut value	RPN > 125

14	Severity	S > 6	Occurrence / Detection	O x D > 17
15	Severity	S > 8	Severity / Occurrence	S > 4 e O > 3
16	Severity	S > 8	Severity / Occurrence	S > 4 e O > 3
17	RPN Cut value	RPN > 100	Severity	S > 8
22	Severity	S > 7	RPN Cut value	RPN > 112

CONCLUSION

Performing compilation of research data, it was possible to carry out two interesting comparisons with the criteria used, which if combined, can be presented as the most appropriate solution for the unification of negotiations. The first is the comparison between single and multiple criteria; the other involves the criteria with and without defined values.

Single criteria would not be in discordance with the 4th Edition AIAG FMEA Manual, however it recommends a criteria phased in two specific rules where the first rule is mandatory and the second not. The first rule is specific to situations with severity score greater than 8, with the text: "When the severity is 9 or 10, it is imperative that staff ensure that risk is addressed through current controls or recommended actions (...)"; The second rule is designed for situations Severity score lower than eight, with the text: "For failure modes with severity of 8 or less, the team should consider the causes that have higher ratings of occurrence or detection (...)". Thus, it is understood that the application of a multiple criteria would be a better alternative compared to the single criteria (including 4 situations with recommending actions for the 5 highest values of RPN), which was identified in 22 of 43 responses considered.

Opened criteria, which do not consider the definition of values, would not be in disagreement with the 4th Edition AIAG FMEA Manual, but provide an environment with the decision-making process based on a high level of subjectivity. Therefore, the definition of a rule based on critical analysis, or other based on non-quantitative aspects of evaluation can lead to a false prioritization, which greatly increase the chances of not define additional efforts to risk reduction. Thus, it was understood that the application of a criteria based on values would be the best alternative against no defined values, which was identified in 25 of the 43 responses considered.

Based on these considerations, it was concluded that the most suitable combination for making a decision on the recommendation or not actions would be a multiple criteria based on two rules defined according to Severity score. The first rule is the cut value of the RPN 80 for Severity greater than 8, while the second rule with the cut value RPN 150 to Severity 8 or lower, as shown in Table 7.

Table 7 - Rule for cut value according to Severity score

Recommended Action	Severity	Cut Value
Rule 1	S > 8	RPN > 80
Rule 2	S ≤ 8	RPN > 150

It was also observed that in some responses associated to the criteria of recommending actions to cases of customer complaint. The recommendation for this situation is that the score occurrence is reviewed by the very occurrence of the failure mode, and should also be an analysis score in detection, since the failure mode was not detected. The outcome of this review will generate a new RPN, which should be analyzed within the Rules 1 and 2. As well as for the cases of detections of failure modes by control detection, a critical analysis is recommended in order to identify if score of Occurrence is compatible or not. The outcome of this review will generate a new RPN to be analyzed within the Rules 1 and 2.

It is important to note that Severity as an only criteria for FMEA recommending actions may stagnate the process in terms of continuous improvement. In Process FMEA, where the absolute majority opportunities of reduction RPN Severity score is not changed, the same rule would pass to the next round of recommending actions, creating a redundancy. The recommendation in such cases is to set a limit to how far down the larger RPN for severities, adapting to what is stated in Rule 1.

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Application of Routine Management in the Southern Management Construction Sector in the Dispenser Company of electric energy in the State of Ceará – Brasil

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ABSTRACT

The work shows the importance of the adoption of routine management and the search for continuous improvement in service delivery to the end customer of the distributor company of electric energy in the State of Ceará –Brazil. The service is regulated and supervised by the federal government, which provides the guidelines to be followed for the successful development of services. The objective was to present the results obtained from the adoption of actions aimed at continuous improvement of processes developed by the company. The methodology was applied to action research described by Miguel *et al.*(2012), conceived and developed in close association with the resolution of a collective problem. In conducting research was initially conducted a literature search and then the analysis of data relating to the management system of routine work adopted by the company in the sector studied. The research sought to show the level of adherence to the method of management and its positive impacts. In this management methodology, manage is to set goals and have a plan of action to achieve them, using quality tools and applying the PDCA method with its importance confirmed by Daychoum (2007) and following the steps as described by Fields (2004) , Slack et al. (2002), and very important is standardization, training, identification and treatment of imperfections. The Routine Management and quest for continuous improvement are tools that add a differential with important results for the company adopted since 2010. The construction sector of the Southern Area undertaken changes in order to get better results and adhere to the methodology of management of the company. However, it can be seen that adhesion has occurred gradually, with satisfactory results in the execution of tasks. Was identified as the main problem to be overcome, the pent-up demand of works which suggest futures actions.

Keywords: Quality**,** PDCA Cycle, Routine Management, continuous improvement.

Paper's classification: Case study

INTRODUCTION

In the competitive landscape in which the companies are inserted, the management of routine and quest for continuous improvement is a differential that results in quality products and satisfactory results that guarantee the survival of the company.

The routine management of the day-to-day is a management methodology used for achieving quality through standardization, using the PDCA method and quality tools for continuous improvement in its processes and results.

This study was conducted at Dispenser Company of Electric Energy of the State of Ceará - Brazil. The company stands out among other dispensers operating in Brazil, in terms of quality of services, adopting the use of the tool for the routine management and investing in the dissemination of this methodology and establishing the goal of its aderence. Specifically, the construction sector of the Southern area has displayed prominently in the expansion of service delivery to its customers in its service area, which justifies the search. The focus of this work was to verify whether the management of the routines in the sector has been conducted in order to obtain positive results.

Therefore, the aim of this paper is to describe the adoption of the methodology Management Routine using the PDCA method as a tool in managing the quality management.

The scientific method used in conducting the research was the case study defined by Miguel et al. (2012) as: [...]"an empirical work that investigates a given phenomenon within a real contemporary context through in-depth analysis of one or more objects of analysis (cases)". In this particular case, the object of investigation had direct approach in the day-to-day of the observed sector, allowing the collection of data relating to the results on a day-to-day of the sector.

The research also obtained the bibliographic support for the theoretical context which according to Vergara (2004) serves as a support for the research of case study kind.

According to Gil (2008), the research can also be classified as exploratory because suggest the explanation of the problem and its familiar approach in the case study. To Miguel et al. (2012), the realized research falls under the action-research designed and carried out in close association with the resolution of a collective problem.

In conducting the research, data of the sector were collected for analysis in order to verify if, with the increase in adherence to the management method, positive impacts are observed on business results.

THEORICAL REFERENTIAL

The quality management gained importance in recent years, mainly due to the pursuit of total quality in the processes developed by companies in ensuring competitiveness.

The use of various techniques and tools of quality management has been improved and adopted by organizations, being an evolution of the concepts advocated and developed primarily by Juran, Demin, Ishikawa, Crosby, Feigenbaum and Taguchi.

The expansion of the service sector has made it necessary an attitude toward the quality aimed at satisfying the clients served by companies within the sector as recent work in the area of telecommunications Sousa et al. (2013), hospitals, Morilhas et al. (2013) and gyms Pereira et al. (2013) among other applications aimed at the adoption of measures to improve the quality.

An important method is to use the PDCA cycle as a method of quality control for troubleshooting aimed at continuous improvement through standards set. Campos (2004), Johnston e Slack (2002) agree on the definition of the PDCA cycle when they state: "the continuous improvement literally implies in the endless process, questioning repeatedly and questioning again the work of a detailed operation [...]" (JOHNSTON; SLACK, 2002).

Conceived by Shewhart, but deployed by Deming, therefore also known as the Shewhart cycle or Deming cycle, was released and introduced by Deming in Japan, after the war, as a principle streamline management processes, such as quality management Daychoum (2007). The PDCA Cycle can be understood from Figure 1 that describes it in four distinct phases.

Figure 1: PDCA Cycle

Source: Adaptation from Aguiar, 2012.

The quality tools are used for that be possible the improving of some process, because through them is possible control the results, identify gaps, assess the criticality and impact of problems on the process. When applied correctly are very useful for improving operations (JOHNSTON; SLACK, 2002).

To achieve excellence in management is needed to be well defined the operational and managerial functions and that the manager is a leader of change engaged in goal setting, standardization of processes, monitoring and management of results, working in troubleshooting, also known as anomalies process or outcome. The manager needs to know where to get and how to lead, driving change through dissemination of knowledge, coaching and guiding his team to achieve the goals, adding value to their product and hence the overall quality of the process (CAMPOS, 2004).

The definition of Bouer et al. (2012) for Routine Management is that it is a management system used by the operating areas or business processes, to enable customers will have their expectations met in each activity or process, through continuous improvement of processes.

THE COMPANY OBSERVED

The distribution of electric energy in the State of Ceará is performed from the government concession to the dispenser company in the city of Fortaleza-Ce, Brazil.

The company supplies electricity to a population of 8.4 million inhabitants of which more than 3.4 million are active customers of the company in 184 municipalities of Ceará, and, in relation to volume, is the third largest distributor in the Northeast marketed energy. The company's mission: "People and energy for a better world!" and vision: "Making a difference through our people, our relationships and our performance".

The company currently has 1,250 own employees plus approximately 8,000 outsourced employees (ENDESA, 2013).

The formal organizational structure of the company has reviewed and approved in 2009, presented in Figure 2, featuring one magistracy, eight directions linked to the presidency, fiscal and administrative advice, internal audit and the shareholders' assembly (Id, 2013).

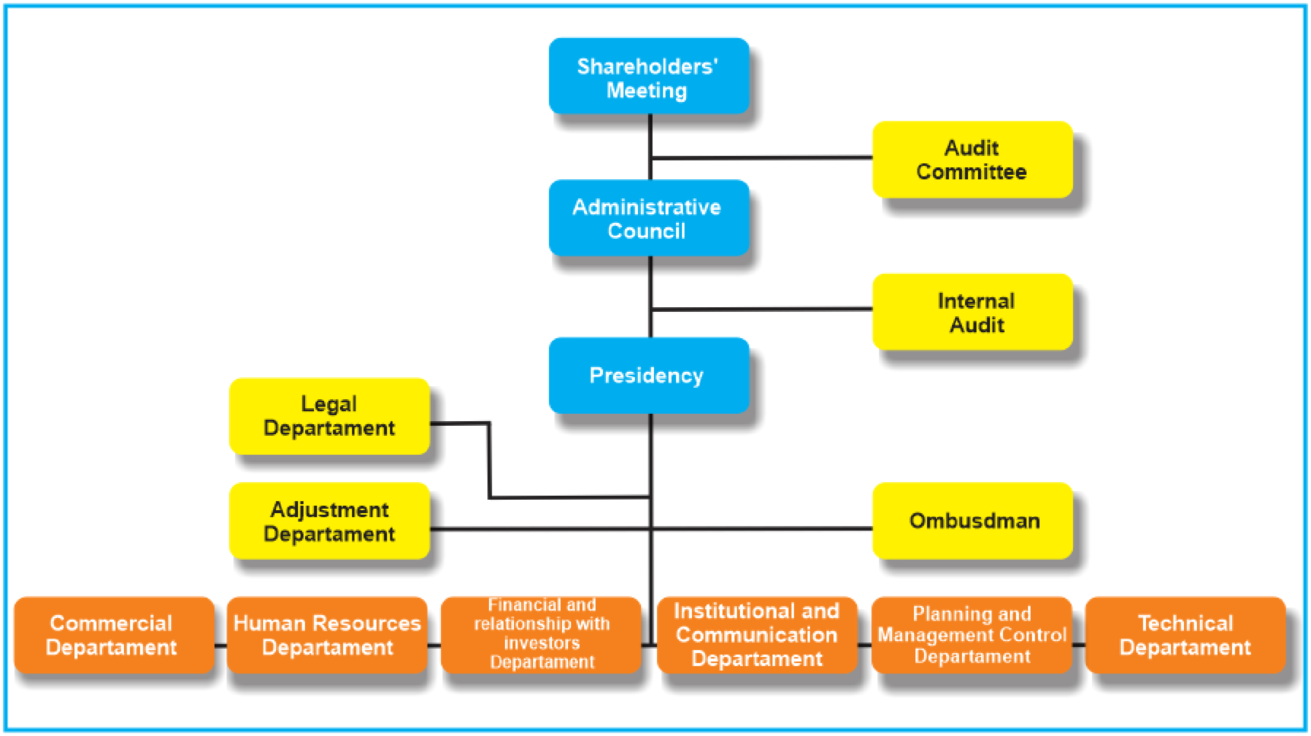

Figure 2: Organizational chart of the Company focus of the study

Source: Adaptation from ENDESA, 2013.

The company has a modern management model focused on its mission and attention to its Shareholders and provision of quality services of Ceará-Brazil population.

THE SECTOR STUDIED

The Southern Management is embedded in the organizational chart in the Technical Direction, responsible for three departments located in the southern state of Ceará, as Figure 3:

- Southern Regional (Cariri): serves 29 counties, with 370,473 active customers currently served by 10 substations;
- Center-South Regional: serves 25 municipalities with 302,523 active customers spread across 13 substations;
- East Regional: serves 21 municipalities with 235,340 active clients served by 11 substations.

The sector serves a total of 908,336 active customers in 75 municipalities in Ceará, where there are currently 34 distribution substations of electricity.

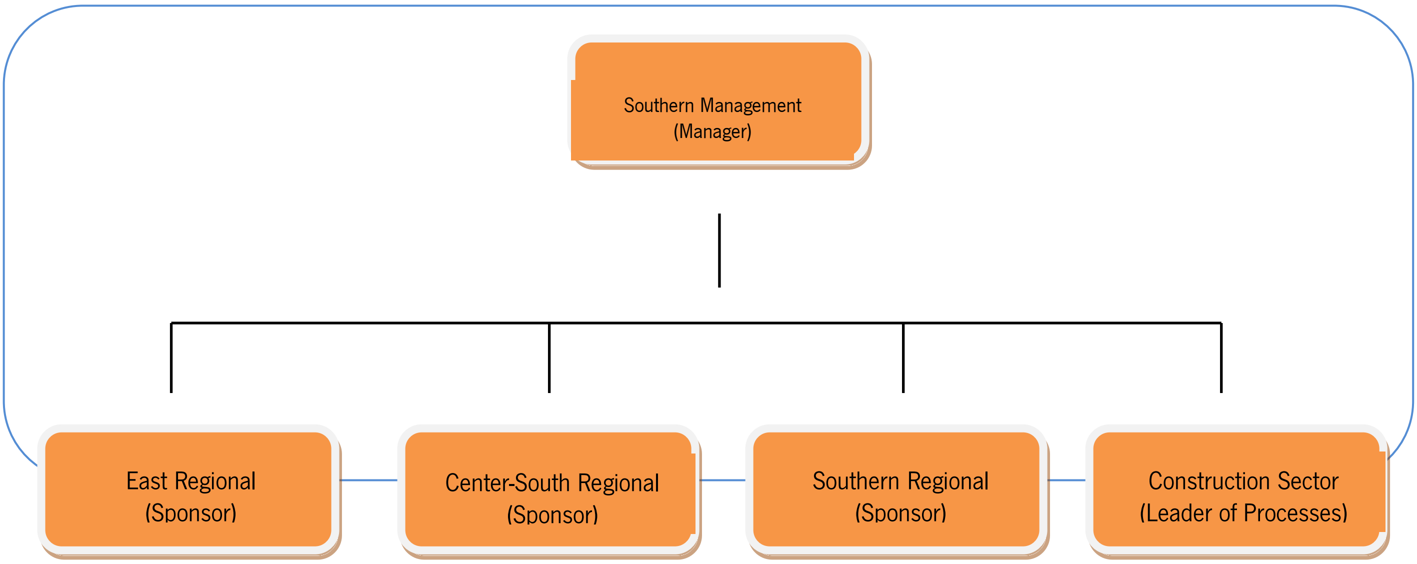

Figure 3: Organization Chart of the Southern Management

Source: The Author.

The Construction Sector has like main product the building of electrical network to serve all the new connection request that requires extension of electric low-voltage (220V/380V) and medium voltage (13.8V). This sector requires most investments in fixed assets of the distribution networks, such as poles, cables (copper and aluminum), transformers, fuses and disconnect switches and other equipment and components of electrical distribution network to serve new customers with Low Voltage - LV and Medium Voltage - MV. Therefore, it is of fundamental importance that resources are applied efficiently, considering the lower cost and better service relationship as required quality standards.

APPLICATION OF ROUTINE MANAGEMENT

The company disseminates since 2010 and trains staff in the implementation of the management system for the routine management in order to standardize processes and allow monitoring of outcomes and measures for correcting faults, enabling the attainment of certain goals.

The application of the management system works in simple manner, as shown in Figure 4. The process is divided into two phases, the management to improve and the management to keep, both applying the stages of PDCA, and enabling continuous improvement of processes.

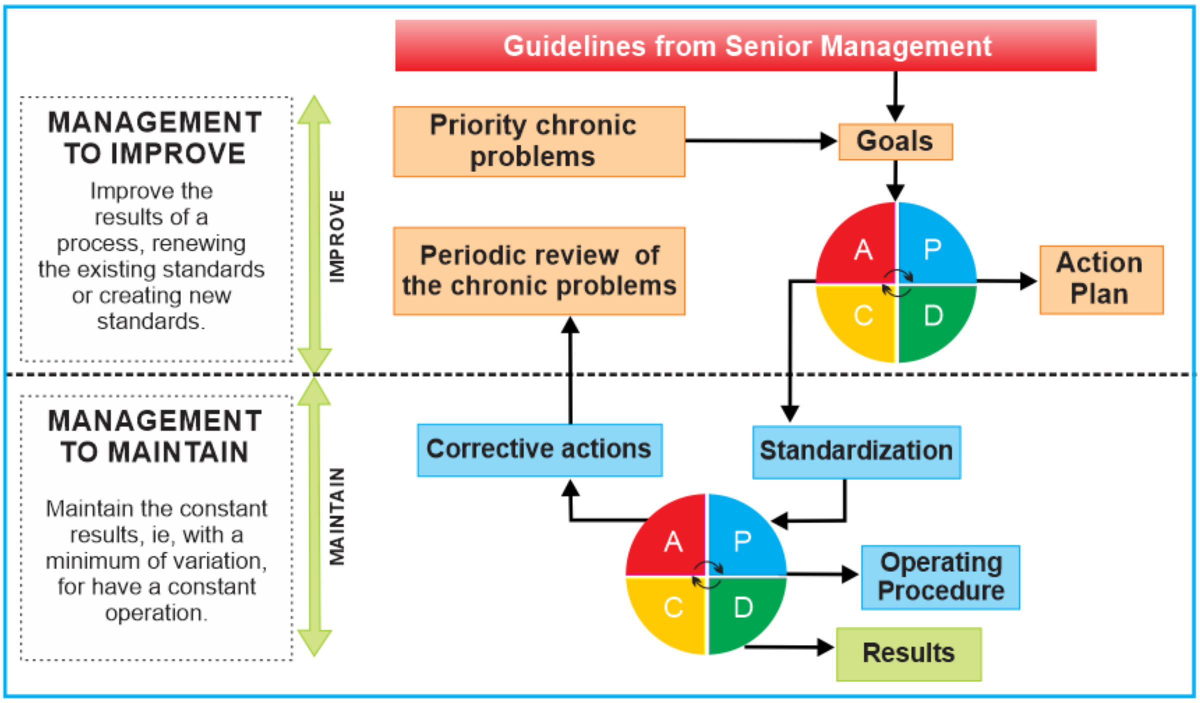

Figure 4: Management to improve and to keep.

Source: Adaptation from Endesa, 2013

The figure 5 shows the results obtained in 2012 by the Construction Sector of the Area.

Goals 2012	Construction Sector of Southern Area	
Indicators 2012	**Goal**	**Result**
STW - Start Time of Work	95%	75,40%
TWP - Time of Writing Projects	98%	92%
Correct RCO emission until 50 days to conclusion	95%	11,99%

Figure 5: Results of the Southern Area and Construction Sector in 2012.

Source: Adaptation from Endesa, 2013

Analyzing the results, it is possible see that these were unsatisfactory. Was applied the routine management to the sector from the PDCA methodology.

For the Planning step, the goals of the Department of Works were initially set in January 2013 by the Southern Area management in the strategic planning meeting with officials, analysts and experts in the field.

The flowcharts that map each step of the processes were created since 2012, following all the standards set by the Quality Management Department of the company, indicating what are the critical activities of each. However, these flowcharts did not represent the reality performed by operational due to unavailability of human resources foreseen in the project implementation, was required the revision flowcharts and redefinition of critical activity, which was only made in June 2013.

Reviewing the flowcharts, it was found that despite the critical points were identified a year ago, there was not a standard procedure to be followed by operating, which increases the possibility of deviations (anomalies) in the process. Considering the importance of standardization to obtain the results, three procedures were drawn up, a procedure for each critical activity identified in the three cases of works.

The procedures, after elaborate, need to be reviewed periodically, with pre-established dates in a schedule of review procedure, or if an abnormality is identified and demonstrate that the procedure is inadequate to achieve the desired result. The South Area has an annual plan review procedures, "On the Job Training" - OJT and Operational Work Diagnostics - OWD, wich deadlines for revisions of the procedures, which will occur in 2014, have already been defined.

The stage of the realization of what was planned had to be made following the procedures set out, so that phase initially consisted in training by the supervisor of the operating process and execution according to the pre-established plan.

Considering that happened delay in delivery of the calendar for implementation of the proposed works, the training of the procedures of works Production Control and Planning (PCP) was performed, however the trainings were conducted in August. While the training procedure of the critical activity of the implementation process was not conducted.

A relevant fact is that after the training procedures of PCP, the execution began to be made by an operator not trained which is not a recommended procedure.

In the verification phase is important to analyze the results, watching periodically whether they are being satisfactory in relation to established goals and procedures are being met as training.

The Operating Technical Diagnostics (OTD) was performed from the realization of trainings. The OTD is the evaluation by the supervisor with the operator of the tasks performed if an abnormality is identified, the operator must be retrained. In the Construction Sector, the process of PCP made the OTD with personnel trained in the procedures, however, the operator that was not trained consequently also did not pass by the OTD, which can be evidenced as an abnormal process that needs to be addressed.

Control and management of anomalies within the process are framed in the Act, phase of the PDCA Cycle, phase of great importance for achieving the desired results and achievement of goals. The analysis corresponds to the month of October 2013, being possible to verify that the CAPEX indicator is unlikely to reach the goal, as presented throughout the year many anomalies and results remained well below target. The indicator of operating efficiency presents evidence reach the goal, but the weight that compose it can be considered questionable, if be deemed that the efficient process meets the deadlines for beginning and execution of works within the period determined by the regulator and by therefore solves the problem of unmet demand using efficient manner also features CAPEX.

RESULTS OBTAINED

The Southern Area Construction Sector monitors the results of its indicators regularly since the beginning of the year through a standard spreadsheet created in Microsoft Excel Software to every company having three distinct colors that signal status indicators: green for satisfactory results, yellow for those who need attention and red for unsatisfactory, in other words, below target.

Equivalent Duration Continuity - EDC represents the average time in hours that customers remain without power during the specified period e the Equivalent Frequency Continuity - EFC represents how many times on average occurs an interruption of supply, ie the Construction EDC is a secondary goal of the South Area, which is how many hours the area customers were without power supply due to construction schedules and FEC and in what frequency occurred. The target set by the area for the Construction Sector limits the consumption of Construction EDC on 5% and the Construction EFC on 2% of the total target area and regional.

The consumption of the target area was 60%, whereas the maximum was consumed in the South Regional equivalent to 77% of the target relative to Construction EDC, while the Construction EFC consumed 49% of the target area. The East Regional got the maximum consumption, 67% of the established target.

The final result of the DEC at the end of the year tends to be positive, with an annual target 0.40 and achieved 0.15, were consumed 37%. However, the attendance of these results must be done carefully, considering that the area is with the annual goal above the intended, which jeopardize the final result, 8.08, having consumed 7.21.

A relevant factor to be considered in Construction EDC and EFC is that indicators are 100% manageable, in which all power outages resulting of construction are planned and scheduled contrary to what occurs in the maintenance.

The Efficiency Indicator in construction is the results obtaned in the most economical way in Construction Sector. Measure the weighted result of the productivity of construction crews (40% weight), assertiveness materials (weight 10%), Start Time of Work - STW of the partnership (30% weighting) and Runtime Work - RW (weight 20%).

The target for this indicator is 80% and the result obtained through the month of September is 96%. Whereas the indicator reflects a weighting, the obtaned result was satisfactory.

It was possible to analyze how the items check behaved, and thus verify if the sector manages these results as directs RM.

For the productivity indicator the results obtained were better than the established target, presenting anomalies result only in February of regional East, in the following months was higher than expected. Importantly, this indicator is directly related to the billing of partner companies and that the stimulus measures and management directly impacted the results.

Analyzing the Time of Construction Start of three regional partners in the area, the target of 95% for the start of construction was not completed within the prescribed period. Important to consider that the anomalies of this indicator, indicate that Start Real Time of the Works has been compromised, which leads to fines for the company and dissatisfaction of its customers and consequently increase in unmet demand. The results presented in RW are also not satisfactory and show that the negative impacts already identified in STW may have been exacerbated. The management of these indicators should be taken with emphasis on blocking these anomalies.

Although the control Efficiency deliver results above the target, the check items that compose it, did not behave in the same way. Except productivity the others showed anomalies that have become chronic, occurring three or more consecutive times.

The Capital expenditure - CAPEX was applied according to minimum target equivalent to 80% and 100% of maximal. The use of these resources, because it is investment results in improvements in product quality in the sector and customer satisfaction.

The Construction Sector has failed to use the available investments, indicating a chronic abnormality results. The treatment of this anomaly should result in its lock, proving inefficient should be treated at managerial level.

CAPEX indicator presents a problem of 16% to goal attainment and needs of actions so that the desired result is achieved. The Construction Sector does not have any plan for this problem.

To complete the analysis of the results regarding the performance of the sector in blocking the presented anomalies, it is noted that despite the sector having weekly meetings and present their results at the monthly meetings, measures to blocking anomalies results are not being effective, being necessary effectively use the tools specified by GR because consequently results in greater gains occur not only in the sector as the Southern Area.

FINAL CONSIDERATIONS

It is concluded that in 2013, there was an increase in adherence to the Model Routine Management - RM through focused meetings on results and establish management practices to achieve goals, targeted for operational training in some cases resulting in gains standardization, greater involvement of staff and reduction in unmet demand for works.

However it is observed that not all the tasks are executed according to the established pattern, there is resistance in some cases despite defined flowchart and critical points, and is therefore important to focus more efforts on training enabling operators to identify hazards and report them to the manager in order to make it possible to lock failures and enable continuous improvements.

The verification of the results even presenting evidence to be taken regularly, there are no records of anomalies properly guidelines that the routine management system pre-sets, thus the actions of improvements and fixes of failures are not managed and efficiency blocking of anomalies has not as be analyzed, recurrence of the same fault can occur without it being controlled or even identified, and appropriate to create a database record low operational anomalies by case in order to give managers capable of working into shares of the blockade with the team.

Becomes evident that the Routine Management was not fully implemented and there visible gaps in your application, the main obstacle to organizational culture resistant to change.

As a suggestion to increase the adhesion of the sector management system commented, we propose management actions that contribute to the continuous improvement of results and achievement of goals as: crafting at the beginning of the year, an annual strategic plan for works to achieve the goals with the involvement of three levels: management, supervision and operation, based on demand from previous years and pent-up demand, predicting within the available budget workmanship and materials in order to identify gaps and develop strategies for problem solving; review procedures for critical activities considering opinions of operational staff involved.

Finally it is concluded that the Routine Management provides significant gains toward goals and consequently credibility in the market by providing quality services as defined industry parameters.

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Understanding Customer Value: Case Application in Call Centers

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ABSTRACT

Purpose. Recently, there has been tremendous growth in call centers around the globe. Business activities such as technical support, sales and marketing, banking transactions, and helpdesk are performed through call centers. Rapid growth in information technology, decreasing cost of data transfer, and globalization has made call centers beneficial and cost effective for business activities that can be performed remotely. Therefore, the quality of call center service and efficient management is a factor of critical importance for most organizations.

Design/methodology/approach. This paper is a combined result of survey findings, review of relevant literature, and case studies used to highlight the major factors of concern to call center quality and management.

Findings. The research results found that a management approach that includes employee empowerment should be practiced to increase the job quality and selecting high performing employees and promoting them within the company after providing necessary education/training can help retain employees and reduce attrition.

Research limitations/implications. The research study was applied only in call centers. Additional analysis should be performed to confirm the results are consistent in other industries.

Originality/value. This research provides a thorough analysis of the key factors for reducing cost and improving employee and customer satisfaction in call centers. A discussion of the various strategies that can contribute to addressing the different quality and management issues found through the survey and in the literature is also provided.

Keywords: Quality Management, Job Quality, Customer Satisfaction, Call Center

Article Classification: Research paper

INTRODUCTION

In today's hypercompetitive and global markets, business operations are spread around the globe. Many companies are entering international markets in addition to their own domestic market, to remain viable. Therefore, the customer base that today's organizations must serve is vast and diverse in nature, language, and culture. As a result, it has become more important than ever for a company to actively understand its customer's needs and to meet their expectations. Businesses in today's global markets also have a need for faster business transactions, operations, and customer services due to the increasing demand for their products and services. Therefore, an organization must perform service functions at a faster pace to provide their customers with product information, sales and marketing activities, and problem solving.

These requirements have led to a rapid development of call centers and call center technologies internationally, particularly in developing countries, due to advancements in telecommunications. According to The Global Call Center Report, the development of the call center sector has been similar in many countries relative to markets, service offerings, organizational structure, and workforce characteristics. However, the main differences lie in the organization of work and human resource practices (Holman et al., 2007).

New technologies and practices continue to be introduced in manufacturing that lead to faster and more efficient business (Garelis, 1996). The emphasis was on mass production by way of assembly-lines and automation, which allowed businesses to manufacture products faster and at a lower cost. However, a low cost focus alone did little to maintain customer loyalty over time. Customers began to demand low cost and high quality products. This led companies to focus on both cost and quality. The work of quality experts such as Deming and Juran showed that high quality and low cost can be achieved simultaneously. This prompted manufacturing industries to shift their management style from the Taylorist approach to the continuous improvement approach. This shift allowed quality initiatives such as Total Quality Management (TQM) to become widely accepted. In addition, a systems engineering approach to faster, better, cheaper philosophy has been shown to promote strong personal commitment, teamwork, communication, and adherence to maintaining customer needs (Meade and Farrington, 2008).

As the numbers of call centers grows, call centers are facing increased competition. Therefore, low cost and high quality services are essential to sustain business as it has been shown in the manufacturing sector. Providing high-quality customer service requires an investment in employees, continuous improvement, and technology. Failure to invest in these activities can significantly affect call centers (Garelis, 1996). For businesses that make these investments, the quality of service will improve followed by improved business performance and increased market share. Call centers should not wait to invest in quality until their customers shift their loyalty. Efficient and quality call center service at the lowest possible cost is a vital aspect of modern day business. As a result, it is important to understand call center operations, identify key performance indicators, optimize processes, and target major areas of concern. This is the new era for call centers, where managers should alter their perspective and embrace quality as a tool to survive and progress.

The purpose of this research is to identify and provide recommendations for reducing cost and improving employee and customer satisfaction. This research will help improve call center performance by focusing on the key issues through quality initiatives.

LITERATURE REVIEW

Cleveland (2006) defined the call center as "a coordinated system of people, processes, technologies, and strategies that provides access to organizational resources through appropriate channels of communication to enable interactions that create value for the customer and organization." The primary reason driving the evolution of call centers is their increased customer demand. The main issues call centers face to address the customer demand is to continually reduce costs and improve customer satisfaction.

Call centers must provide customers with relevant services in real time, while ensuring customer satisfaction. Generating customers and allowing customers to contact a call center representative for a purchase comes under customer acquisition. Call center agents, also known as sales representatives, contact customers on the phone, which requires considerable human resources. Along with the sales of products and services to customers, sales to other business organizations are also involved. Often these activities are carried out by subcontractors which include a team of trained people, as well as a script and response information in order to generate sales, cross sell, and upsell products (www.tech-faq.com, 2008).

Customer care is one of the most important aspects of the call center industry. It is usually the frontline of a business. Customers need information, solutions to their problems, and notifications, among other needs. Customers may contact call center representatives for information on product details, to file complaints about the product, and for a number of similar issues. A company's impression on the customer is often in the hands of the customer care division, which also makes it a vital part of a business (www.tech-faq.com, 2008).

Dwyer et al. (2006) investigated the impact of training, skills, job control, work speed, role demand, and workload on agent performance. The impact was addressed by studying the effect of two categories (job resources and job demand) on performance. Common feedback from call centers on why their employees resign/quit their job is they lack resources to perform the job and are stressed from excessive demands. Job resources most complained about include: control, supervisor support, training, task identity, task significance, skill variety, and feedback. Job demands can be social, physical, psychological, or organizational, which represent aspects of the job that require considerable emotional or cognitive effort of the employee. Dwyer et al. (2006) showed that job resources have a positive impact while job demand has a negative impact on performance.

CALL CENTER BACKGROUND

Call centers can be classified into several categories depending on the markets they cater, type of operation, customer service segmentation service, and call type (Holman et al., 2007). Figure 1 shows the common classifications and Figure 2 provides the percentage of each classification (Holman et al., 2007).

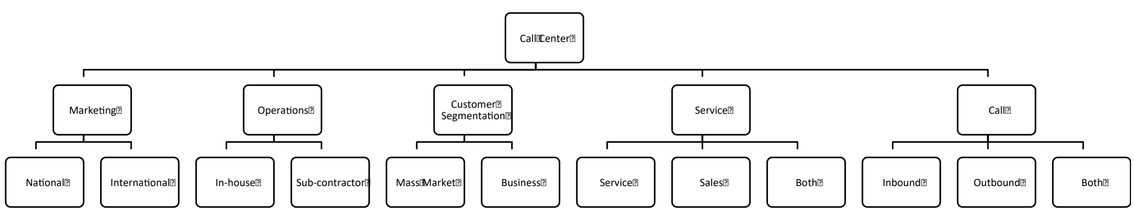

Figure 1 – Call Center Classification

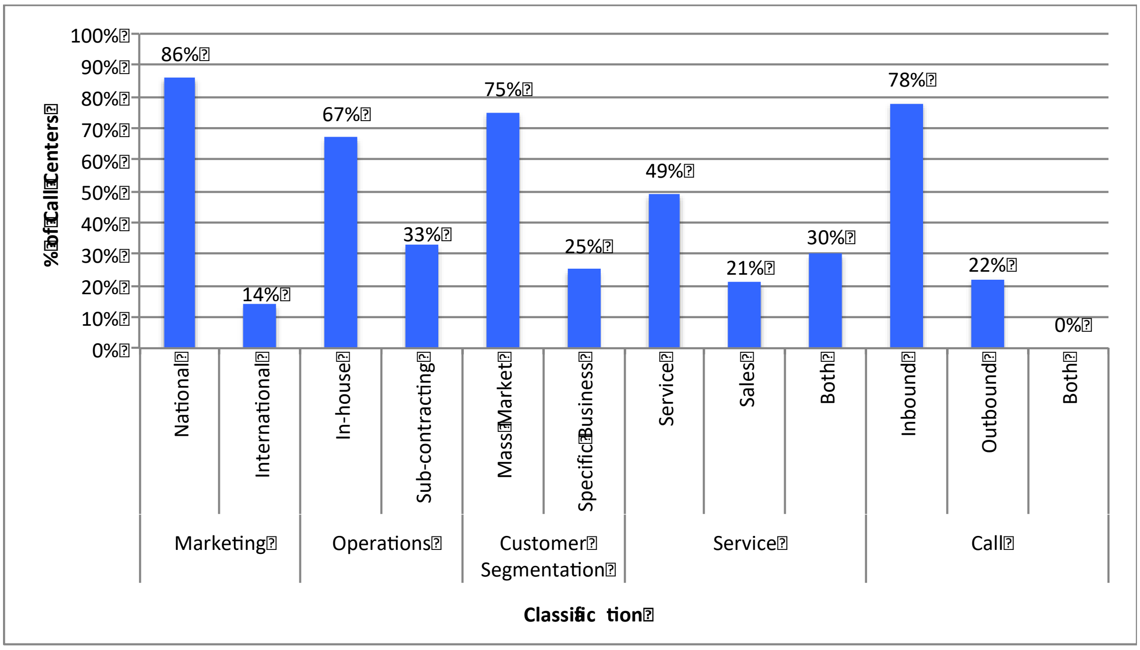

Figure 2 – Classification Distribution

Call centers provide service to a customer and are linked to the profits of the business. Therefore, to remain competitive, a company should track the quality of its products or services as well as their service.

Establishing which quality metrics are important to track is an issue that all companies face. Hallowell and Gack (2008) documented a Six Sigma case study that determined various parameters affecting call center cost and customer satisfaction. The case study discussed the Six Sigma phases of Define, Measure, Analyze, Improve, and Control (DMAIC). Recommendations from this case study were implemented in a pilot program that realized cost savings. Galvin (2007) explained the importance of first call resolution as a metric, rather than the traditional call handling rate. The drawbacks of using a call handling rate as a metric to measure service quality were discussed. In addition, improving first call resolution was presented as the right goal for a call center.

CASE APPLICATION: SURVEY OF CALL CENTER EMPLOYEES AND CUSTOMERS

A survey was developed for call center employees to identify the problems faced during their daily activities and to develop solutions to these problems. The survey was deployed internationally to call center employees at all levels of the organization. The survey's design included multiple choice questions, yes/no questions, ranking questions, and open comment questions. The results of the survey came from 38 responses with diverse respondent profiles. For example, the work experience of the respondents ranged from six months to more than 10 years, and the job positions spanned the company from top to bottom with positions ranging from agents, managers, consultants, and CEOs. The survey also provided global information due to the diverse country of work of the respondents. The list of countries of work included Australia, Canada, India, Pakistan, Philippines, Switzerland, and USA.

To help draw out the voice of the customer, a second survey was conducted to investigate the differences between the customers' and call center employees' point of view towards the factors impacting customer satisfaction of call center service. In both surveys, the respondents were requested to rank the same list from most important to least important. The ranked responses of both the surveys were analyzed using the Kruskal-Wallis Test using Minitab®.

RESULTS AND DISCUSSION

After reviewing the literature and the survey responses, three main areas of opportunity for improvement in call centers were identified including (1) customer satisfaction, (2) ways to reduce cost, and (3) employee satisfaction. This section presents the survey results and provides recommendations for ways call centers can improve.

Call center customers can be located anywhere in the world where there is a phone or internet connection. These customers speak different languages, have different cultures, and most importantly, have different criteria of customer satisfaction. Ironically due to globalization, the products and services available are almost the same. Therefore, customer satisfaction for the call center industry is difficult to manage. The most important mantra of any business today is that performance is directly linked to customer's loyalty towards the product or service.

The various factors that impact customer satisfaction (Cleveland, 2008; Hallowell, 2008) are listed in Table 1. Table 1 also shows the difference between the factors that customers rank as important and the factors that call center employees rank as important. These results show that there is a disconnect between what customers rank as important for them and what call center employees think is important to customers.

Table 1 – Difference Between Customers and Employees on Customer Satisfaction (1 being most important)

Factors that Impact Customer Satisfaction	Customers' Rank	Employees' Rank
Quick follow-up on unresolved issue with appropriate solutions	1	7
Effective communication skills or ability to understand customer problems	2	4
Quick solution to customer problems	3	1
Doing the job right the first time	4	3
Initially making clear what the customer should expect from the call	5	16
No or minimal call transfers	6	13
No or short wait time	7	6
Consistency in call handling	8	15
Responsiveness of the agent to the needs of the customer	9	8
Meeting commitments and keeping promises made to the customers	10	2
Courtesy and politeness of agent	11	5
To the point approach instead of asking information and customer details	12	11
Clarity of automatic response	13	14
Promptly doing what the customer asks for, without argument	14	9
No or short hold time	15	10
Ethical and socially responsible nature	16	12

The methods of measuring customer satisfaction vary greatly across call centers, which was evident from the survey responses shown in Table 1. Survey responses on the methods of customer satisfaction measurement are summarized in Figure 3.

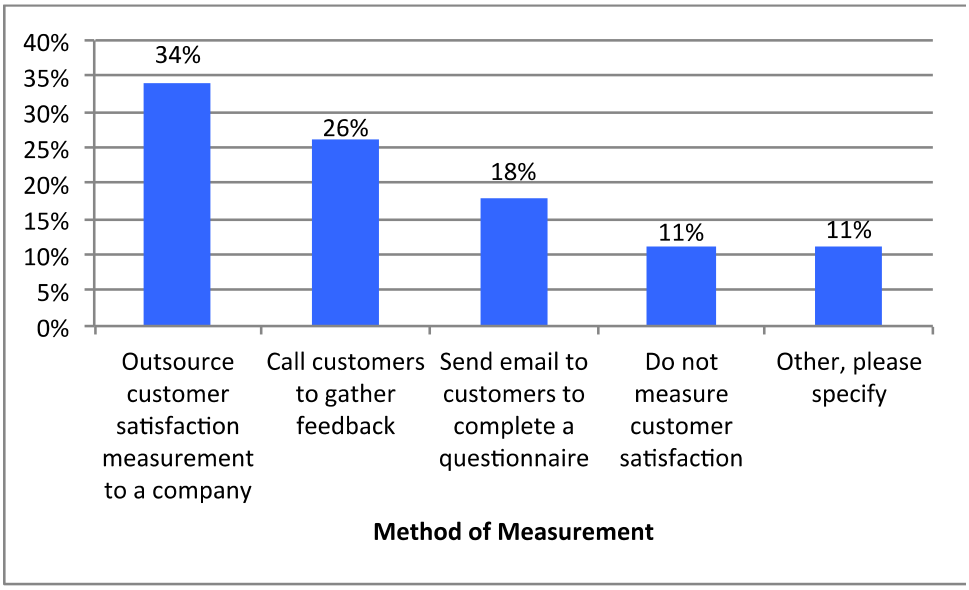

Figure 3 – Customer Satisfaction Measurement

For companies that use measurement methods not listed, they selected other and were asked to comment on their company's measurement method. Responses included 'Peer group statistical comparison of relevant facts' and 'interactive voice response (IVR) survey application'. For example, one respondent working in North America said that they do not put much credence in the results of any customer satisfaction measurement method. In addition, 11% of the respondents said that their company does not measure customer satisfaction.

Customer satisfaction ratings for call centers are calculated based on the feedback of customers measured by one of the methods provided in Figure 3. However, none of the methods account for abandoned calls, which also impacts customer satisfaction. Calls in which the customer hangs up due to large queues and long waits are referred to as abandoned calls. Abandoned calls are lost business and increase the call volume as customers must call back which affects customer satisfaction.

The cost considered as an opportunity for improvement is the operating cost of the call center. There are a number of factors that affect cost and may also impact customer satisfaction. Figure 4 (Hallowell, 2008) is a cause and effect diagram that summarizes the relationships between cost and these factors.

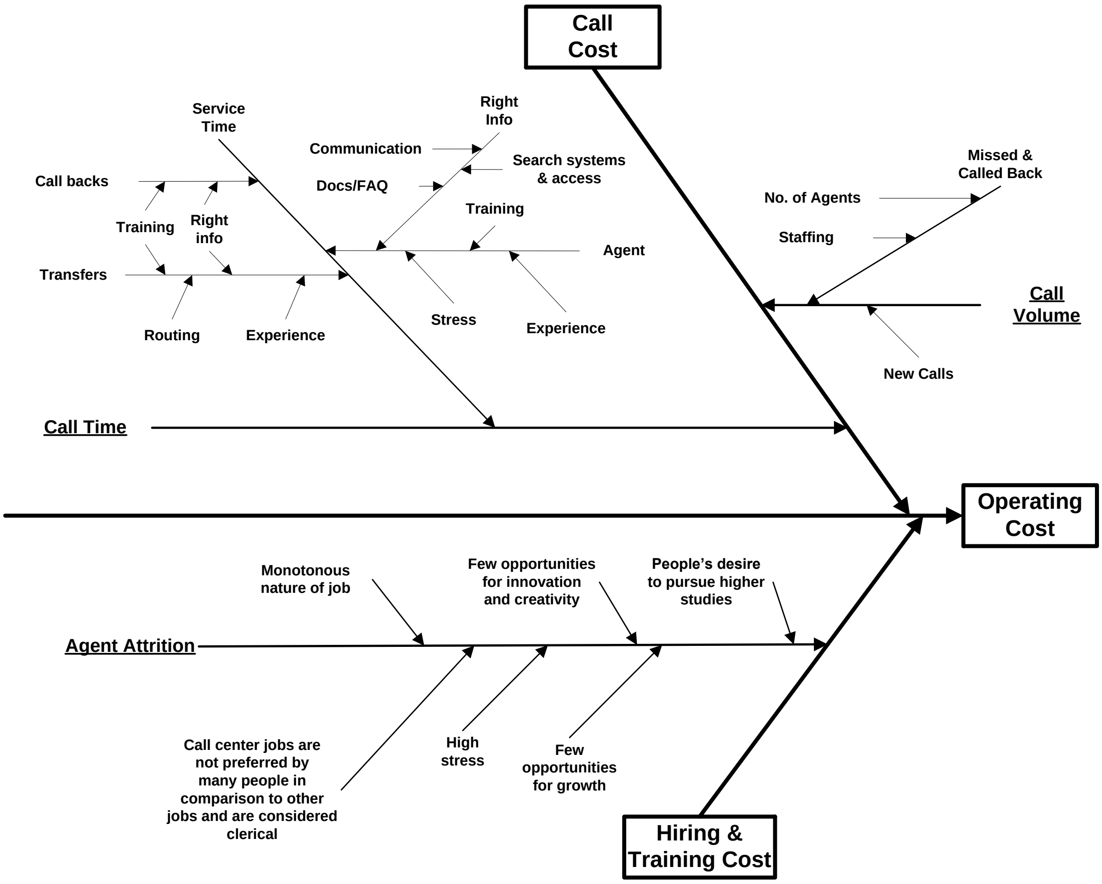

Figure 4 – Factors Impacting Cost

For example, consider a single stream flow relationship between various parameters as shown in Figure 4. First start with the effect, operating cost. Operating cost is caused or influenced by the call cost. Call cost is related to call time that, in turn, is related to service time. The service time is further related to the agent. The agent is related to the availability of accurate information and the availability of accurate information is related to communication. This approach highlights the root causes where the focus of improvements should concentrate. There are many more relationships that can be drawn from this cause and effect diagram, which permit the user to understand the opportunities for improvement relative to operating cost.

The identified wastes in call centers from the survey are listed in Table 2, starting with the most important to the least as ranked by survey respondents. Calling back is analogous to rework and is undesirable. As illustrated in Figure 4, calling back is mostly due to the lack of accurate information, improper training, or experience. Lack of information depends on communication, documentation, and search system effectiveness. Call wait time, which is the time waiting in cue before being serviced, may be due to either high call volume or poor staffing levels. Call transfers are caused by improper routing and lack of information or training. Asking for details is often a mandatory requirement; however, unnecessary cross checking and verification can be identified and removed to reduce the time with each agent during a series of transfers. Call hold time, which is comprised of searching databases, asking for details, and the number of call transfers, can depend on the agent knowledge, skills, and information. Researching information also leads to call hold time and depends on communication, documentation, and the search system. All of these factors increase the call time that, in turn, increases the call cost and causes customer dissatisfaction due to the length of call resolution time.

Table 2 – Survey Results

Wastes in Call Centers	Factors that Contribute to Job Satisfaction	Factors that Contribute to Agent Attrition	Factors that Contribute to Increasing Efficiency in a Call Center	Barriers to Six Sigma/Lean Projects
[1] Having to call back to solve unresolved issues (not resolved first time), [2] Call wait time, [3] Number of call transfers, [4] Asking for customer details and verifying with a database, [5] Call hold time, and [6] Doing research or referring to databases to provide solutions for the customer's issues.	[1] Salary and incentives, [2] Awards and recognition for good work, [3] Career growth, [4] Work environment, [5] Worker empowerment, [6] Agents' input in decision making that influence the total call center, [7] Flexibility in shift schedules, [8] Rapport with supervisor/ boss, [9] Variety in tasks, [10] Less performance monitoring, and [11] Less stress.	[1] Monotonous nature of job, [2] Few opportunities for growth, [3] High stress, [4] People's desire to pursue higher studies, [5] Call center jobs are not preferred by many people in comparison to other jobs and are considered clerical, and [6] Few opportunities for innovation and creativity.	[1] Providing up-to-date information about the policies and standard operating procedures to agents/employees to avoid confusion and reduce hold times. [2] Ensuring agents have the proper knowledge of resources for call transfer to avoid inappropriate transfers. [3] Recording solutions to reduce the need for calling back to follow up or call holding during the next call of the same type of issue. [4] Standardizing processes or following a specific protocol. [5] Reducing the word count of pre-recorded tapes that are played during calls. [6] Using email instead of calling back for follow up. Email should contain the solution to the customer problem.	[1] Lack of employee awareness about what can be achieved through Lean/Six Sigma, [2] Employee belief that Lean/Six Sigma and improving the call center operations process is the job of management and not of employees, [3] Lack of support from upper management for Lean/Six Sigma projects, [4] Too few employees to handle Lean/Six Sigma projects, [5] Improper training on Lean/Six Sigma philosophy and tools, [6] No time to monitor or work on Lean/Six Sigma projects, [7] Lack of employee interest in Lean/Six Sigma, [8] No or few funds allotted for Lean/Six Sigma projects, [9] Lack of commitment from team members, and [10] No incentive provided by management for undertaking Lean/Six Sigma projects.

The factors that contribute to job satisfaction from the survey are listed in Table 2, starting with the most important to the least as ranked by the survey respondents. Based on the survey responses, it is evident that employee stress is an important aspect that impacts attrition and customer satisfaction. The number of sick days that employees take per year is an indicator of employee stress (Holman et al., 2007), which results in lost productivity. Agent stress is reflected in the efficiency of an agent and the quality of service to the customer. Loss in efficiency increases the cost as well as impacts customer satisfaction. Hence, agent stress management is a key aspect for call center improvement.

Handling agent stress is vital as it leads to agent dissatisfaction and affects service quality. Among the total survey respondents, 84% stated employee counseling at regular intervals could help reduce work stress. In addition, 97% state team spirit, camaraderie among employees, social activities, and a good work environment reduce stress and frustration and increase motivation in their daily work. According to one of the respondents, apart from relieving stress "counselling helps in finding the main facts which contribute to employee dissatisfaction and attrition, reducing the work stress is solely in the hand of employer to improve the work conditions based on the new findings". Another respondent stated that eliminating the walls between cubicles so that agents can see one another and using a reader board showing the team's service level is a good practice. It can help keep an agent motivated, which reduces stress and increases the bonding among agents. Therefore, building a good team and work environment is important.

In addition, 79% responded that the introduction of short breaks during work for meditation, yoga, or other stress relieving exercises help reduce work stress. Some employers also encourage employees to follow their interests during their break; for example playing a guitar.

Training impacts agent productivity as well as customer satisfaction. Proper training and knowledge management is essential to keep agents updated with the latest technology, products, policies, and soft skills. This will reduce call time, which reduces cost and increases customer satisfaction. Experience and skills also contribute to cost reduction and customer satisfaction.

The most important contributor to agent attrition from the survey is the 'monotonous nature of job', which is a factor of agent job quality. The global call center report (Holman et al., 2007) measures job quality by the amount of discretion at work and the extent of performance monitoring found in the workplace. Job quality is a major factor shaping attrition in call centers. Per the global call center report, only 32% of call centers have high to very high job quality. High job quality is defined as employees having high discretion to make decisions and low job monitoring of employee performance. Therefore, empowering employees to make decisions and self-monitor increases job quality. However, only 12% of agents work in these jobs while the remaining have low (with low discretion and high monitoring) quality jobs (Holman et al., 2007).

RECOMMENDATIONS

Customer satisfaction ratings should not be the only metric to rate the quality of service and can sometimes be misleading (Minnucci, 2008). As discussed earlier, customer dissatisfaction due to abandoned calls should also be taken into account while determining customer satisfaction.

As previously illustrated in Figure 4, providing up-to-date information reduces call hold time and the need for customers to call back. Proper call transfer protocol reduces the number of call transfers. Recording solutions helps reduce the need for customers to call back and the average call hold time. Standardizing the process reduces call hold time and call transfers.

Technology, such as interactive voice response (IVR), can help in implementing a standard protocol (Bushey et al., 2006). IVR is a technology in which a computer detects voice and touch-tones using a normal phone call. IVR systems can respond with pre-recorded or dynamically generated audiotapes to further direct callers on how to proceed with the call (Bushey et al., 2006). Using skill based routing of calls can help reduce the number of call transfers and call hold time and often reduces staffing requirements. All of these factors contribute to improving efficiency and customer satisfaction (Brown, 2000).

Abandoned calls also impact customer satisfaction. Proper staffing can reduce the percentage of abandoned calls. This was shown in a Six Sigma Project where a ten percent reduction in call wait time was achieved (Gack, 2008). Forecasting the demand of calls from past trends can be used to staff accordingly and can reduce the percentage of abandoned calls. This will, in turn, reduce the call volume. In a case study on IT call centers, Gack (2008) found that deploying more staff on weekdays, which have higher call volumes, and less on the weekdays, when the volume is low, helped reduce the call wait time and the percent of abandoned calls. Also, setting up a staffing model can help reduce the percentage of abandoned calls and call wait time.

Hiring the right agents is the first initiative in agent-focused improvement; therefore, the agent selection process is important. Assessing agent skills before hiring is vital as one's ability to perform a job is not the same as their interest in performing that role. The selection process should evaluate the agent for aptitude, attitude towards call center work, communication skills, and future career goals.

Simulation is a useful tool for agent selection. Situational interviews can be used to assess an applicant's behavioural tendencies and behaviors required for successful performance (Maurer, 2006). A typical call center simulation allows an applicant to field a few calls from a computer workstation and provides explanations to the user on-screen taking them through data entry, looking up information, and handling callers in a variety of emotional states. The simulation measures keyboarding skills and the prospective agent's ability to multi-task. According to Joe LaTorre of Employment Technologies Corporation (Sheff, 2007), "one of the greatest advantages of the simulation is it gives the applicant the opportunity to experience what the position is like, so it builds more realistic expectations about what it's like to do that job". It also provides an opportunity to self-judge out if they do not feel the work is suitable for them. In addition, it measures whether they have the baseline skills in order to be trained and be successful on the job (Sheff, 2007).

Attitude is also an important quality. The prospective agent should have the proper attitude and behavior towards the call center work. Behavioral surveys can be used to access the applicant's attitude and interest towards call center work. Their future career goals should be in alignment with the organizational goals or else the applicant will not stay in the call center environment.

Per the survey, 90% respondents stated that, in the case of call centers run by a large global parent company, choosing performing managers/agents and promoting them within the company after providing necessary education/training can help retain employees and reduce attrition. One respondent quoted their example as "I can be considered as a good example. I joined a company in 2003 as an entry level sales representative and am still working with this company after 5 years." Therefore, creating growth opportunities within the organization is important in retaining agents and employees. Large companies with in-house call centers can make it mandatory for entry level employees to serve as an agent for a specified period of time to know the customer, market, and products better before going to technical or other fields. Along with call center workforce and staffing this can also increase the knowledge pool of the employees working in other departments in a call center.

Employee empowerment, which is practiced in other industries, has been shown to improve the job quality of the employees. Based on the survey results, 92% of the survey respondents stated that a management approach including employee empowerment (authority and responsibility for work, team work, agent input in decision making) should be practiced to increase the job quality.

To address the monotonous nature of activities the concept of call blending can be used. Call blending means using outbound agents to handle inbound calls, or using inbound agents to handle outbound calls (Shusmul, 2008). For example, if the agents receiving calls remain idle for a particular amount of time, they can be reassigned temporarily to outbound calls. Agents can also switch between different channels other than calls such as chat support or email support. Integrating inbound, outbound, and other services, helps call centers in maximizing their agent's productivity, skills, and time. Most importantly, this practice improves job quality by introducing variety in daily tasks (Bhulai and Koole, 2003).

The concept of home agents and virtual call centers (Beal, 2008) is another solution to the problems faced by call centers. Problems of attrition, staffing, stress, and productivity can be addressed by using home agents. In this concept, employees with Internet connectivity, a computer, and a headphone can handle calls whether sitting at home or in an Internet café. Call centers can benefit from this technology by using part time agents as home agents. This solves the issues of attrition as employees with different career goals can also work.

Organizations that allow agents to work from home generally can get more qualified agents and have lower employee attrition. Additionally, agents have been shown to perform better when they work from home (www.five9.com, 2008). There is greater flexibility in incorporating split shifts and call center expansion (www.five9.com, 2008). Companies can also get employees from a wider geography when hiring. According to Beal (2008), "There are also cost savings. A virtual contact center saves on facility costs and the pay scale is generally 5% to 15% lower than in-house agents, according to a recent report from Cambridge, Mass.-based Forrester Research Inc.". From the survey results, 46% of the respondents stated the concept of work from home or virtual call centers can be used to reduce employee stress and attrition and increase performance and quality of service. On the other hand, 33% responded that it is not practically feasible while 21% say that this concept is neither practical nor can it solve these problems.

These recommendations can be implemented through quality improvement initiatives such as Six Sigma or Lean. However, these initiatives have certain barriers. The important barriers to Six Sigma/Lean projects in order of importance as ranked by the survey respondents are listed in Table 2. Improvement techniques are not as well established in call centers as in other industries. Therefore, change management is vital to change the attitude of call centers towards quality.

CONCLUSIONS

Call centers are the frontline of many business organizations. Therefore, call centers must continue to provide quality service to customers and focus on continuous improvement. Call centers should also focus on cost, staff, and technology in order to increase customer satisfaction and competitiveness by reducing process waste. Organizations should consider call center staff as an important asset and consider their inputs in decision-making and focus on the collective knowledge management of the call center. Call center managers should acknowledge quality initiatives to drive down cost simultaneously with customer satisfaction improvement by empowering employees. The recommendations provided can be implemented using quality initiatives such as Six Sigma, Lean, and Total Quality Management (TQM). Encouraging teams and individuals to undertake Six Sigma, Lean, and TQM projects in reducing wait time, abandoned calls, hold time, and attrition can help achieve higher customer satisfaction and gain competitive position.

Call centers are an integral part of the present global market. In order to operate a call center efficiently, management must focus on the four aspects of call centers including service quality, cost, people, and technology. It is necessary to improve job quality in call centers by making it less stressful and more interesting for agents to allow them to pursue long term career goals in this industry.

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A standard proposal for biological resources centres

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ABSTRACT

Purpose. Culture Collections play a vital role by expertly preserving biological material (BM) in ex-situ repositories and making it promptly available to several users such as industry, R&D in biotechnology and teaching. The rise in the scientific and biotechnological importance of BM along with an increased awareness of governments on the necessity of preserve the microbiological diversity has resulted in a global understanding of the need to assure stable and well managed operations inside culture collections. Organisation for Economic Cooperation and Development (OECD) recommended culture collections to work under certificated or accredited schemes thus reaching the status of Biological Resource Centre (BRC). However, no relevant international normative document, covering all the activities of BRCs, exists. The purpose of this article is to establish the launch pad for the OECD purpose on the establishment of a Global Biological Resource Centre Network composed by certified or accredited BRCs.

Methodology. Relevant standards that could apply to BRC are compared with the OECD recommendation for BRCs. A new standard is proposed and the mechanism to its development is presented as well as the main structure and sub-clauses.

Findings. No relevant international document exists covering fundamental issues for BRC operation. Based on existing normative documents it is possible to develop a consistent, credible and compatible standard that fits BRC purposes without overlap existing normative documents.

Practical implications. The developed standard will enable the culture collections accreditation by providing the necessary requirements for the quality and competence management system implemented, being though a fundamental step for the establishment of the Global BRC Network (GBRCN).

Originality/value: Original paper

Keywords: Culture Collection, BRC, standard, standardization, management system, quality, competence, certification, accreditation, standard-setting.

Article Classification: Research paper

INTRODUCTION

The invention of the microscope in the XVII century opened a window to a new and fascinating universe that has boosted the development of life sciences: the world of microbes. If making microbes visible was a huge achievement, to preserve them with their unique characteristics for the long-term, is an even greater challenge which culture collections (CC) had first embraced 120 years ago [Santos e Lima 2001].

The existing 661 service CC in 70 countries and regions (http://www.wfcc.info/ccinfo/, access in 12.05.2014) plays a vital role by expertly preserving biological material (BM) in *ex-situ* repositories and making it promptly available to several users such as industry and services, R&D in biotechnology and teaching [Lima 2007]. They have the responsibility to maintain BM that fulfils characteristics claimed in their catalogues (1) in order to assure reliable results of research based on supplied samples and reproducibility on industrial processes, as well as (2) to preserve biodiversity that is being rapidly destroyed [Boundy-Mills 2012].

Culture Collections were formerly considered as individual research initiatives hosted by Universities and Research Institutes. However, the rise in the scientific and biotechnological importance of BM along with an increased awareness by governments of the necessity of protection of the microbial BM origin and the implementation of mechanisms to assure biosecurity, has resulted in a global understanding of the need to create stable and well managed operations inside CC, assuring that accession, maintenance and provision of authenticated microbial strains of known origin are in operation.

In the coming years, biodiversity and genomics will be the source of a “tremendous amount of biological material” and data [OECD 2001] both crucial to the development of R&D in life sciences and biotechnology, making the role of CC even more critical.

OECD recommended the creation of a CC network, the Global BRC Network (GBRCN, www.gbrcn.com, access in 21.05.2014). Each BRC member should work under certification or accreditation schemes based on scientifically acceptable international criteria, supported by national governments [OECD 2001] with an audit programme established to evaluate the BRCs compliance with requirements [OECD 2004].

A normative document providing requirements for the BRC management system, auditable, enabling the BRC certification or accreditation must therefore be put in place.

BACKGROUND

For at least three decades CC have been managing its processes under the recommendations of the World Federation of Culture Collections Guidelines (http://www.wfcc.info/guidelines/, access in 21.05.2014) [WFCC 2010]. More recently OECD published the OECD Best Practice Guidelines (OECD BPG) [OECD 2007] and subsequently promoted the CC self-evaluation publishing a set of three documents containing checklists based on those guidelines [OECD 2009 A, B and C]. The provided OECD recommendations and WFCC Guidelines are not auditable documents.

At the moment, only France and Brazil have respectively developed standards for BRC certification and accreditation.

The French standard “NF S 96-900 - Qualité des Centres de Ressources Biologiques (CRB)” [AFNOR 2007] was based on OECD BPG and ISO 9001 standard [ISO 2008] provisions. Thirty one French BRCs are certified under the NF S 96-900 standard [personal communication from Dominique Clermont]. The Brazilian standard NIT-DICLA-061 [ABNT 2012] based in the recommendations of OECD BPG and, the provisions of the norm ISO/EC 17025 standard [ISO 2005 B] and the ISO Guide 34 [ISO 2009] to our best knowledge is not implemented in any CC.

Some ISO standards, providing requirements for management systems, apply to BRC and have been implemented in some CC. ISO 9001 was implemented in twenty four CC while ISO/IEC 17025 was partially implemented in two. ISO Guide 34 is also considered for CC producing reference BM [Betsu et al. 2008, Smith and Ryan 2012].

ISO 9001standard is seen as an appropriate standard for organisations with scope on biological resources as it provides a framework for de organizations identify and document its processes, to undertake continual improvement in those processes, to reassure owners of deposited BM of the BRC competence to manage their resources, to assure clients of the supplied BM about BRC’s commitment to consistency and quality [Davis et al. 2012]. The process documentation helps to preserve, control and effectively change the know-how as well as facilitates the staff training especially for the newcomers [Pascal et al 2001]. It is mainly focused on (1) product and service requirements, (2) in monitoring and evaluating processes and, (3) in the continuous improvement of the management systems.

According to ISO standard 17025, the conformity of the management system with the requirements of ISO 9001 does not prove, by itself, the competence of the BRC to produce technically valid data and results. This means that ISO 9001 certified BRC could not have enough technical competence to assess conformity of BM, as this standard is mainly concerned with what to do to achieve customer satisfaction [Barradas and Sampaio 2011].

If a BRC is certified according to ISO standard 9001 there is a guarantee that operations are conducted in accordance with established procedures and standard provisions. While ISO standard 17025 demands the execution of technical work according to such established procedures it goes beyond this in that it requires confirmation of the technical competence of those involved in that work.

Despite their contribution in supporting quality (ISO 9001) and competence (ISO/IEC 17025) management systems, neither of the above mentioned standards cover all BRC’s operations and ISO/IEC 17025 standard in some other aspects is considered to go too far demanding independent accreditation for each process and each preservation technique and authentication method [Smith and Ryan 2012].

METHOD

Evaluating the need for a standard-setting. To evaluate the need for a new standard development, avoiding standard duplication, current ISO standards and BRC standards implemented in CC were examined.

Existing gaps were identified comparing its provisions (subjects covered, mandatory records and mandatory documented procedures) with the recommendations of the OECD BPG. The provisions of the standard NIT-DICLA-061 were not compared because the standard doesn’t have the validation that comes from the implementation in a BRC.

Relevant international guidelines for standard-setting were examined in order to establish:

- The type of standard to develop and the characteristics it shall obey
- The structure of the standard and contents
- The standard development activities

Method for the development of the structure and content. Firstly the objectives of the standard were established to build the foundation for the standard and related principles.

Looking for consistency and alignment with ISO management system standards (MSS) with overlapping scope, the high level structure, identical sub-clause titles, identical text and common terms and core definitions of the Annex SL [ISO/IEC 2014] were adopted. Additional sub-clauses were added in order to achieve a logic framework. Hanging paragraphs were avoided.

Use of terminology, in order to ensure consistency, is based on (1) the "Terms and Definitions" clause presented in each of the reference documents, (2) the ISO 9000 Standard [ISO 2005 A], (3) the ISO/IEC Guide 2:2004 [ISO/IEC 2004], (4) the ISO Guide 73 [ISO 2009 B] and the (4) "OECD Glossary of Key Terms in Evaluation and Results Based Management" [OECD 2010]. Conflicting terminology was decided according to the nature of the term: for quality management terms the ISO documents were followed, for technical terms, the OECD BPG was followed.

The standard was expressed in terms of process, management and performance requirements/criteria giving space for innovation and flexibility. Examples and explanations were added in order to facilitate transposition of pure performance requirements/criteria into practical solutions.

The requirements/criteria stated within the standard were established in order to be clear, objective and verifiable. To facilitate the link between the requirement/criteria and the appropriate principle, an intention declaration was made defining the objective of the principle. So it was assured that (1) a clear link exists between what is required in practice and the objective that is intended to achieve, (2) all requirements clearly contribute to the attainment of the standard goals and only criteria that are relevant to meet these outcomes are included, (3) all requirements/criteria are included to address all of the defined goals.

Standard content was based in OECD Good Practice Guidelines and relevant international normative documents, namely

- ISO 9001:2008
- ISO 15189 [ISO 2012]
- ISO Guide 34 [ISO 2009 A]
- ISO/IEC 17025 [ISO/IEC 2005]
- NIT DICLA 61 [INMETRO 2012],
- ISO 11133:2009 [ISO 2014]
- NP EN 12128: 2000 [IPQ 2000]
- ISO 15190:2007 [2003]
- NP EN 1619 [IPQ 1999]

Appropriate and relevant requirements/criteria from the standards and almost all recommendations of OECD BPG were assembled into this new ISO-consistent standard. The original text of ISO 9001 was widely adopted as background.

The standard incorporates requirements, recommendations and other statements which are distinguished by using the following words [ISO Directive Part 2]:

- Requirements : shall / shall not
- Recommendations : should / should not
- Permission : may / need not
- Possibility and capability : can / cannot

Supplemental information providing guidance, examples and explanations is included as footnotes to the text.

Writing is done using plain language, looking for short sentences, having one idea per sentence, using the active voice and using lists whenever possible.

Requirements are classified into three different compliance levels: baseline, medium and high level compliance. The BRC would apply for a conformity assessment within a defined level.

Method for the standard development activities - involving interested parties. The standard development was planned by adhering to international procedures that constitute credible practices for setting standards, namely the:

- ISO/IEC Directives, Part 1 and Consolidated ISO Supplement [ISO/IEC 2014]
- ISO/IEC Directives, Part 2 [ISO/IEC 2011]
- CEN/CENELEC Guide 17 [CEN/CENELEC 2010]
- ISO/IEC DIR IEC SUP [ISO/IEC 2012]
- ISO Guide 82 [ISO 2014]
- ISO Guide 59 [ISO/IEC 1994]
- WTO Agreement on Technical Barriers to Trade [WTO 2005]

The figure 1, presents the process for the standard development activities to permit participation by interested parties, providing appropriate opportunities for contribution and achieving transparency.

RESULTS

Despite the availability of important guidelines, no relevant international normative document, covering all the activities of BRCs, exists. Although the ISO 9001 standard could apply to BRC and even several CC are certificated under its provisions the standard fails in addressing (1) key operational processes like shipping, handling and authentication of the biological material, (2) validation of methods and procedures, (3) preparation and production of culture media, (4) microbial BRC competence for the MB supply and preservation, (5) specific needs for the management of documented information, (6) biosecurity mechanisms and (7) CC long term sustainability.

ISO 17025 is focused on competence, but as with ISO 9001 it fails to address some of the key operational processes, and specific management needs of BRCs. Some of these are handling and shipping of BM, the use and preparation of reagents, media and other supplies, a strategic plan for BRC future sustainability, in order to avoid the loss of BM, and biosecurity. In some other aspects is considered to go too far demanding independent accreditation for each process, each preservation technique and authentication method [Smith D., Ryan M. 2012].

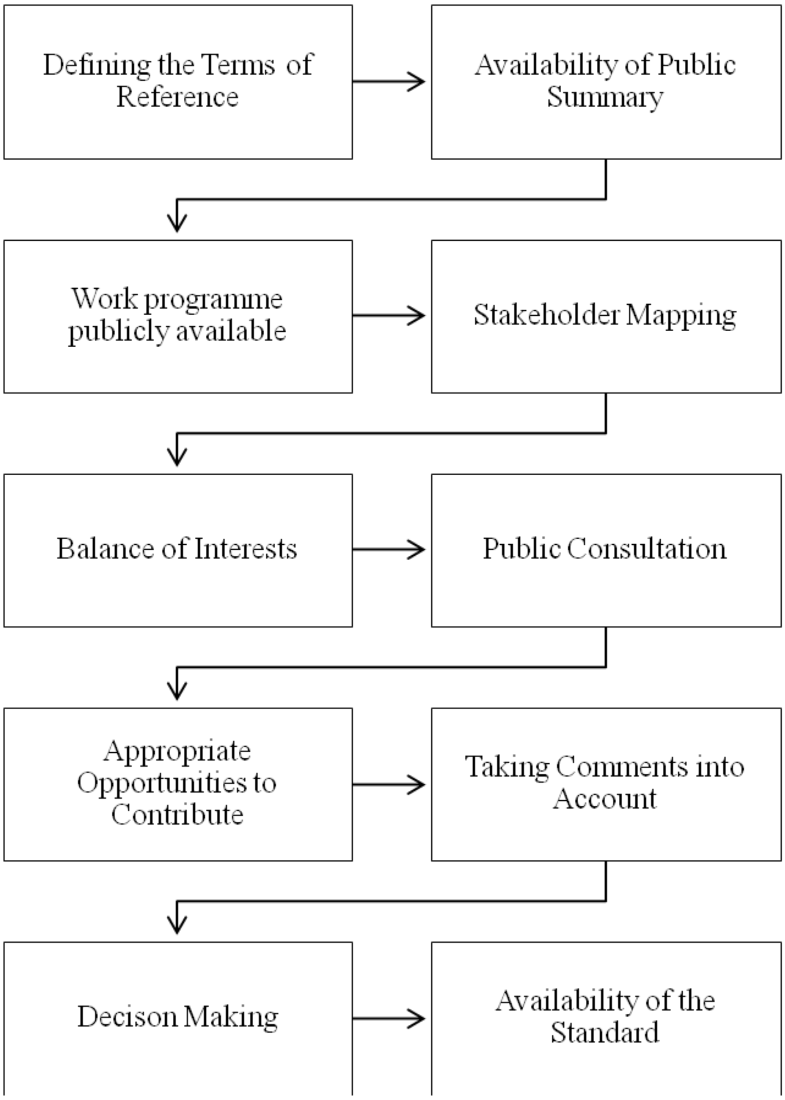

Figure 2 - Main steps for the BRC standard development

The French norm NF S 96-900 fails in addressing biosecurity mechanisms, long term sustainability and some process key aspects such as quarantine regulations, BM supply, validation of methods and procedures.

ISO Guide 34 applies to reference BM which have to be submitted to extensive characterization pointing to the importance of the BM certificate condensing all the information about provided BM.

Results of the comparison between relevant standards. Aiming to avoid duplication, the ISO 9001 standard (among the ISO standards the most sought by CC) and the NF S 96-900 standard (specifically designed for the certifications of BRCs managing biological resources from human or microorganism origins) were examined.

Existing gaps were identified comparing the scope, mandatory records, mandatory documented procedures and subjects covered against the recommendations of the OECD Good Practice Guidelines. Tables 1, 2, 3 and 4 present the most relevant findings of the comparison main documents. The Best

Practice Guidelines on Biosecurity for BRC were not compared with the mentioned standards since neither of them addresses this subject.

Table 1 - *Clauses of OECD GPG applied to all BRC that have no correspondence on NF S 96-900 and ISO 9001.*

	NF S 96-900		ISO 9001
4	Organisational requirements		
4.1	Long term sustainability	4.1	Long term sustainability
5	Premises		
		5.1	Biological resource centre operations
5.2	Construction and operation	5.2	Construction and operation
		5.3	Access
7.1	Compliance with internal documentation	7.1	Compliance with internal documentation
		8	Data and informatics
		8.1	Data management
		8.2	Data processing
		9	Preparation of media and reagents
		10	Accession of deposit to the BRC
		10.1	Receipt and handling of biological materials
10.2	Accession	10.2	Accession
		10.3	Quality checks on the biological material
		11	Preservation and maintenance
11.1	Methodology (of preservation)	11.1	Methodology (of preservation)
11.2	Stock control of the preserved biological materials	11.2	Stock control of the preserved biological materials
11.3	Storage of preserved biological materials	11.3	Storage of preserved biological materials
11.4	Validation of methods and procedures	11.4	Validation of methods and procedures
12	Supply of material	12	Supply of material
		12.1	Order placement
12.2	Availability of the biological material ordered	12.2	Availability of the biological material ordered
12.3	Information provided with the biological material supplied	12.3	Information provided with the biological material supplied
		12.4	Packaging
12.5	Invoicing for supply charges	12.5	Invoicing for supply charges
12.6	Traceability of biological materials supplied	12.6	Traceability of biological materials supplied
12.7	Handling complaints and anomalies		
12.8	Refunds	12.8	Refunds
		12.9	Confidentiality
13.1	Purpose		
13.2	Responsibility		

Table 2 - Clauses of OECD GPG applied to the Microbial Domain that have no correspondence on NF S 96-900 and ISO 9001.

	NF S 96-900		ISO 9001
10.1	Long-term preservation	10.1	Long-term preservation
11.2	User validation	11.2	User validation
11.5	Traceability of hazardous biological materials	11.5	Traceability of hazardous biological materials
12	Micro-organism BRCs compliance with national and international law	12	Micro-organism BRCs compliance with national and international law
12.1	Classification of micro-organisms according to the risk groups	12.1	Classification of micro-organisms according to the risk groups
12.2	Quarantine regulations	12.2	Quarantine regulations
12.3	Intellectual Property Rights	12.3	Intellectual Property Rights
12.4	Safety information provided to the recipient of micro-organisms	12.4	Safety information provided to the recipient of micro-organisms
12.5	Control of distribution of hazardous micro-organisms	12.5	Control of distribution of hazardous micro-organisms

Table 3 - *Mandatory records in OECD Best Practice Guidelines and NFS 96 900*

Clause	Holding recommendations	OECD BPG for all BRC	NFS 96 900	Holding recommendations	Clause
4.3		Training records for specialist equipment use	Training courses ought to be record (including internal training)		7.1.2
5.5	“held on file”	Copies of purchase orders	Records of the results of suppliers evaluation		8.1
5.5	five years	Records of suppliers			
6	Held in the BRC EMCLog books	Records from service management (equipment management procedures) and key documents	Records of maintenance and cleaning of premises		7.2.2
			Inventory of laboratory material		7.3.1 b)
			Records from laboratory material and equipment maintenance		7.3.1 c)
			Records from equipment maintenance		7.3.1 d)
7.1		SM permission and justification for departures from documented procedures			
7.1		Deviation report (AC) – when a procedure is not followed			
			Traceability of data changes and updates		9.9.4
8.1		Evidence to assure the validity of data (given by depositors)			
8.1		Minimum data set/Recommended Data set/ Full data set, for biological material (in accordance with domain specific criteria).			
8.2		Records of a loss strain must be either printed and stored on file or copied to a digital archive			
8.3		Data (made available to users) describing the biological material and its origin	Record the received biological material		9.4
10.3	“Should be retained”	Quality testes on the received biological material			
11.		Key parameters of “preservation and maintenance” process	Records ought to be maintained for (1) monitoring and recording freezers	7.3.2	

		temperatures, (2) control of nitrogen levels, (3) thresholds exceed alert, (4) a storage equipment failure		
11.1	Batch date or number and the accession number (on the biological material label).			
11.1	Where possible the expire date must be record for user knowledge			
11.3	Details of inventory control, lead times and re-stocking practices should be documented.			
11.4	The results of preservation methods and procedures validation must be recorded			
12.6	Records of all requests for biological materials, including those refused			
12.6	Records of biological material sent	Records of biological material sent		9.8
12.6	Records of shipment receipt			
12.7	All user queries			
12.7	All user complaints			
12.7	Records of responses/solutions should be stored			
13.3	Enquiry			
13.3	Database			
13.3	Results of audit reviews and record reviews			
13.3	Results of third party audit reviews and record reviews			
13.3	Results of the annual review			
		Results of quality control of biological material in all processes		9.2
		Demands of stakeholders of scientific projects	Must be kept	4.2 f)
		Quality Manual		4.2.2 a)
		Control of documents		4.2.3
		Control of records		4.2.4
		Management review		5.7.1
		Internal audits reports		6.1.3
		Records of NC and CA		6.2

Table 4 – Mandatory records for OECD BPG on Microbial Domain and NF S 96 900

Clause	Holding time	OECD BPG on Microbiological Domain	NF S 96 900	Holding time	Clause
8.		Media [and reagents] should be labelled with batch number and expire date			
10.2		Results of quality checks on preserved material			
		Individual records of all requests for hazardous biological materials, including those refused			
11.5		Individual records of hazardous biological material sent			
12.3		Terms and conditions for further distribution of deposited micro-organisms			

Standard structure and contents. The structure and sub-clauses of the standard are presented in table 5. Main structure is based in Annex SL High Level Structure. Additional sub-clauses, based on

ISO/DIS 9001 [ISO 2014 C] and OECD BPG, essential for the construction of a logic structure, were added.

Table 5 – Structure and sub-clauses of the BRC Competence and Quality Management System Standard

Clause / sub-clause				Title
1				**Scope**
2				**Normative references**
3				**Terms and definitions**
4				**Context of the organization**
	4.1			Understanding the organization and its context
	4.2			Understanding the needs and expectations of interested parties
	4.3			Determining the scope of the C&Q management system
	4.4			C&Q management system and its processes
5				**Leadership**
	5.1			Leadership and commitment
	5.2			C&Q Policy
	5.3			Biological material accession Policy
	5.4			Biological material supply Policy
	5.5			Organizational roles, responsibilities and authorities
6				**Planning for the C&Q management system**
	6.1			Actions to address risks and opportunities
	6.2			Biosafety planning
	6.3			Biosecurity planning
	6.4			C&Q objectives and planning to achieve them
	6.5			Planning of changes
7				**Support**
	7.1			Resources
		7.1.1		General
		7.1.2		People
		7.1.3		Infrastructure
		7.1.4		Environment for the operation of processes
		7.1.5		Monitoring and measuring resources
		7.1.6		Organizational knowledge
	7.2			Competence
	7.3			Awareness
	7.4			Communication
		7.4.1		General
		7.4.2		Network communication
	7.5			Documented information
		7.5.1		General
		7.5.2		Creating and updating
		7.5.3		Control of documented information
		7.5.4		Information systems

8				**Operation**
	8.1			Operational planning and control
	8.2			Selection, verification and validation of technical procedures
	8.3			Determination of requirements for products and services
		8.3.1		Customer communication
		8.3.2		Determination of requirements related to products and services
		8.3.3		Review of requirements related to products and services
	8.4			Control of externally provided products and services
		8.4.1		General
		8.4.2		Type and extent of control of external provision
		8.4.3		Information for external providers
	8.5			Production and service provision
		8.5.1		Control of production and service provision
			8.5.1.1	General
			8.5.1.2	Deposit and supply accession
			8.5.1.3	Material reception
			8.5.1.4	Material preservation
			8.5.1.5	Control of preserved material
			8.5.1.6	Material supply
			8.5.1.7	Material authentication
			8.5.1.8	Certificate and declaration contents
			8.5.1.9	Media and reagent preparation
		8.5.2		Identification and traceability
		8.5.3		Property belonging to customer or external providers
		8.5.4		Post –delivery activities
		8.5.5		Control of changes
	8.6			Release of products and services
		8.6.1		General
		8.6.2		Material authentication
	8.7			Control of nonconforming process outputs, products and services
9				**Performance Evaluation**
	9.1			Monitoring, measurement, analysis and evaluation
		9.1.1		General
		9.1.2		Customer satisfaction
		9.1.3		Analysis and evaluation
	9.2			Internal audit
	9.3			Management review
10				**Improvement**
	10.1			General
	10.2			Nonconformity and corrective action
	10.3			Continual improvement

In a second stage of the standard-setting, requirements will be classified in three different levels of achievement: Baseline, Medium and High Level. Baseline level requirements are the minimum compliance that quality and competence management systems need to meet to be considered a BRC after integrating the GBRCN. Microbiogical Resource Centres (mBRCs) at this level have to make a commitment to comply with the Medium level within two to three years, developing an improvement programme. The same steps are taken for mBRC at the Medium level to reach the High level compliance.

Relevance / contribution. OECD recommended the creation of a Global BRC Network with each element operating under certification or accreditation schemes. The large majority of the certified CC, on the microbiological domain, had opted for certification by ISO 9001 standard. Two CC embarked in accreditation by ISO/IEC 17025 and in France a standard was specifically developed for the BRC management activities. Brazil had also developed its one reference document. However none of these standards cover fundamental issues for BRC thus having a major impact on the long term sustainability of BRC, the efficient preservation of authenticated biological material, biosecurity assurance and biodiversity preservation.

This standard, based on relevant international standards is being developed within a transparent process guided by the provisions of credible international standard developers. The expectations and wishes of interested parties are being taken into account as well as the state of the art in order to create a standard that fits BRC purposes.

CONCLUSION

BRCs need the implementation of a management system that assures both (1) technical competence to perform BM testing and (2) compliance of its services according to interested parties' requirements without creating unnecessary requirements.

The standard which is being presented, and which is still a work in progress is specifically to fill the void which exists in current available standards for quality and competence management of the BRC. It is being developed by selecting relevant requirements for BRC operation from several international standards, considering ISO and CEN guides and directives issued for standard development.

The final standard will consist of a combination of baseline, medium and high level requirements fostering continual improvement of BRC's quality and competence management system.

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An exploratory study of the correlation between ISO 9001 certification and corporate performance of Italian companies

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ABSTRACT

Purpose. The paper aims at verifying a possible relationship between Quality Management System certification according to ISO 9001 standard and risk of failure of Italian companies.

Design/methodology/approach. A synthetic index which summarize the most crucial economic/financial aspects of the studied companies is assumed as the response variable of a statistical model for studying the effects of three specific factors: certification, company size and regional development. The analysis is conducted on a sample of Italian companies belonging to different manufacturing sectors. The used data are obtained from the database Aida® by Bureau van Dijk and from the database of the Italian accreditation body Accredia. The study is based on ANOVA (Analysis of Variance) and Contingency Tables.

Findings. Preliminary results of ANOVA show that only company size and regional development can be considered fully significant. However, the major conclusion from the analysis of Contingency Tables is that ISO 9001 certification is connected to the risk of failure of a company. Hence, the scenario is quite variegated and a significant positive interaction between certification and corporate performance is not always confirmed.

Research limitations/implications. Although the research shows some interesting results, it is liable to extensions and improvements. In particular, at the current exploratory level, it is limited to a specific period of time and considers only the Italian sector, but it could be extended to a wider number of years and to European and international level.

Practical implications. The study opens a way for a number of important questions about the meaning, usefulness and effectiveness of ISO 9001 certification. In particular, it may be time to ask whether the paradigm of certification actually needs a radical rethink.

Originality/value. This work represents a first exploratory attempt to correlate the risk of failure with the achievement of ISO 9001 certification. There are several similar works in literature which, however, focus mainly on sectorial aspects of the corporate background.

Keywords: ISO 9001, ISO 9000 standards, quality certification, corporate performance, risk of failure.

Article Classification: Research paper.

INTRODUCTION

The evolution of the concept of "quality" in company management systems has encouraged the development of several models that focus on the various aspects of the organizational process with different levels of involvement (Wither et al., 1997). Quality certification has become a common practice, in particular ISO 9000 standards are one of the most diffused models in the world for the design, implementation, maintaining and certification of Quality Management Systems (Franceschini et al., 2006; Marimon et al., 2009; Sampaio et al., 2009; Marimon et al., 2010; Sampaio et al., 2011.a; ISO, 2013). Promoted by International Organization for Standardization, ISO 9000 series are a set of policies, rules and activities necessary for quality assurance of products and services provided by an organization, and may be applied to any kind of small, medium or large organizations either in the manufacturing or service (private or public) field. (ISO 9000:2005; ISO 9001:2008; ISO 9004:2009; ISO 19011:2011).

Organizations that operates according to ISO 9000 standards may obtain a "certification", that is a formal acknowledgement that their Quality Management System (QMS) satisfies standards' requirements.

Since the introduction of quality standards, many researchers and scholars have tried to find a link between certification and business performance, obtaining conflicting results. The question has been largely discussed in the scientific literature, an interesting cross-section of the situation referring to the old and new release of the standards has been depicted in the last surveys proposed by Dick et al. (2008), Sampaio et al. (2009), Karapetrovic et al. (2010), Rusjan and Alic (2010) and Kim et al. (2011).

The present work takes its origin from the need of verifying the existence of a possible relationship between the Quality Management System certification according to ISO 9001 standard and the risk of failure (bankruptcy, liquidation, arrangement) of Italian companies in the period 2008/2010, marked by the beginning of a severe economic crisis.

The research is based on a statistical approach. A set of economic/financial indexes extracted from the balance sheet of the studied companies is used in order to give an aggregate expression of the performance profile of a company. Five macro-aspects of a company are analyzed: liquidity, profitability, leverage, solvency and activity.

Assuming as the response variable of the statistical model a synthetic index which summarize all these aspects, the effects of a specific set of multiple factors is studied. Certification, company size and regional development are used as possible causes (factors) which contribute systematically to the variability of this response variable.

The analysis is conducted on a sample of Italian companies belonging to the manufacturing sector. The used data are obtained from the database Aida® by Bureau van Dijk (www.bvdinfo.com/) and from the database available on the website of the Italian accreditation body Accredia (www.accredia.it/). The process of analysis is developed in two phases: Analysis of Variance (ANOVA) and analysis of connection between qualitative variables through the use of Contingency Tables (Everitt and Dunn, 2010).

The paper is organized as follows: Section 2 presents a literature review and the main findings of the most recent studies of the filed; Section 3 describes the proposed methodology, with particular attention to the explanation of the econometric model and the statistical tools used for the analysis;

Section 4 is dedicated to the presentation and discussion of the obtained results; Conclusion and future work are reported in Section 5.

LITERATURE REVIEW

Data published on "The ISO Survey of Management System Standard Certifications - 2012" show that, up to the end of December 2012, at least 1.101.272 certificates had been issued all over the world (ISO, 2013). The 2012 total represents an increase of 2 % (+21 625) over 2011. Even if the global situation is close to reach a saturation level, for many countries the diffusion trend is still increasing. In particular, Italy, Spain, Eastern-European and Asian countries (these latters introduced quality certification only in the recent years) are among the ones in continuous rising for number of certificates. The top three countries for the total number of certificates issued up to the end of 2012 were China, Italy and Spain, while the top three for growth in the number of certificates from 2011 to 2012 were Spain, China and Romania.

Considering this wide diffusion of certification, which involves 184 countries in the world and every kind of organization, it does not surprise that a considerable number of researches is focused on the study of the causes and effects related to these standards. An accurate review of the current scientific literature has confirmed that many studies and researches have been conducted with reference to ISO 9000 standards.

By analyzing the most recent scientific publications concerning ISO 9000 standards and certification, it has been noticed that the most investigated topics are (Dick et al., 2008; Sampaio et al., 2009; Karapetrovic et al., 2010; Rusjan and Alic, 2010; Srivastav, 2010; Kim et al. 2011; Bell and Omachonu, 2011; Wu and Chen, 2012; de Vries et al., 2012):

- the current diffusion of quality certification and its future trend;
- the reasons that drive an organization towards the acquisition of a certificate;
- the benefits and the obstacles/drawbacks;
- the impact of the certification on the economic/financial performance and on the organizational process.

The research studies, focused on these topics, have been supported by different specific approaches, such as surveys, questionnaires, statistical analyses, financial and economic analyses, case studies, bibliographical reviews, etc..

Concerning the aim of the present work, particular attention has been dedicated to those researches related to the impact of quality certification on the performance of corporate companies.

The effectiveness of ISO 9001 certification in terms of improvement of organizational performance is still highly debated. Many researchers have tried to individuate with different empirical approaches the possible relationship between these two aspects. Some analyses demonstrated, by comparing the results obtained by certified and not-certified companies, that the formers succeed in reducing defectiveness, reworking and guarantee costs, as well as showing high levels of customer satisfaction, profitability and productivity. Specifically, Yahya and Goh (2001) reported that certified companies take profits higher than not-certified ones and a major awareness about quality and improvement of measuring systems. More recently, Koc (2007), studying a sample of certified and not-certified companies, observed significant differences on the results obtained in some of the phases of the production process (product design, production planning, control, use of machinery and instrumentation, working and waiting times, lot sizing, row materials inventory) and on some competition advantages (delivery results, volume flexibility, product variety and quality).

Texeira Quirós and do Rosário Fernandes Justino (2013) in their comparative analysis of a sample of certified and not-certified Portuguese companies showed that the sole significant differences between the two sets of companies are played by variables such as, customers relations, human resource management, strategic quality planning, and even quality costs.

Conflicting conclusion have been obtained by an exiguous fringe of researchers: in particular Terziovski et al. (2003) reported that ISO 9001 certification is not positively correlated with customer satisfaction, while Rahman (2001) has not observed any different results between certified and not-certified companies, in terms of organizational and financial variables.

If, according to the majority of the studies, a positive relationship between the implementation of quality management practices and organizational performance improvement may be proven, the conclusions reached about the effect of quality certification over business performance are still contradictory (Sampaio et al., 2009).

A first study about this question was proposed by Hendricks and Singhal (1996), that empirically investigates the impact of winning a quality award on the market value of firms. The approach was based on the estimation of the mean abnormal change in the stock prices of a sample of firms on the date when information about winning a quality award was publicly announced. They noted that the abnormal returns generated by the quality award winning announcements provide a lower bound for the impact of implementing an effective quality award improvement program and their results showed that the stock market reacts positively to quality award announcements.

The studies that compare the economical/financial results of certified and not-certified companies present very different and contradictory results. For example, Heras et al. (2002) demonstrated that the companies certified according to ISO 9001 standard obtain better results in comparison to not-certified ones. On the contrary, Lima et al. (2000), in a comparative study of the two typology of companies, did not individuate any significant difference according to most of the analysed financial/economic indicators.

An interesting conclusion is proposed by the work of Dick et al. (2008), according to which, although there is some evidence to indicate that Quality Management System certification has some causal influence on business performance, there is also evidence for the existence of a substantial mechanism whereby better performing firms self-select to adopt certification. This has profound implications for interpreting business performance achievements associated with quality certification because the benefits found may well be inflated by the presence of this self-select mechanism.

Feng et al. (2008), even if demonstrated a positive and significant relationship between certification practices and operational performance in Australia and New Zealand-based manufacturing and service companies, did not find any significant relationship between these practices and business performance. Basing on the analysis of a public database of Portuguese companies' financial information, Sampaio et al. (2011.b) observed that companies with higher financial performance present a greater propensity to implement and certify their Quality Management Systems. However, for some financial indicators, not certified companies present, on average, higher performance than those that are certified.

Similar results about business performance have been obtained by Martínez-Costa et al. (2008, 2009) concerning Spanish companies. On the contrary, Marín and Ruiz-Olalla (2011), by analysing a sample of Spanish companies from the furniture sector, and using a different approach considering not only financial indicators but also the results of other activities that may eventually help the managers in improving the financial results of their companies, demonstrated the existence of a positive relationship between ISO 9000 quality certification and both quality results and operative results.

Downstream of this literature review, it can be affirmed that up to now the research about relationship between ISO 9001 certification and economic/financial performance has not lead to definitive results. The various methods used for conceptualizing and measuring the involved variables are one of the major causes that obstruct the univocality of the conclusions. The contradiction may also be due to the difficulty to establish a clear relationship between the certification effects and business results, because of the presence of other intermediate factors, such as for example productivity, image, customer satisfaction, etc., that in turn are affected by many variables and may influence the direct relationship between quality and financial results (Hardie, 1998).

In their survey, Sampaio et al. (2009) concluded that there are a multitude of variables that could influence a company's business financial performance, and thus it is very important to define a group of variables which must reflect the impact of Quality Management System implementation over a company financial performance. Other important factors that may mislead the conclusions concerning the real impact of quality certification over financial results are activity sectors, size, geographical location, etc..

The goal of this work rises from the requirement of defining a role, in terms of economic/financial benefits, of ISO 9001 certification in the three-year period 2008/2010, that, haw demonstrated by national databases, has been negatively marked by a very high percentage of "mortality" of Italian companies (www.infocamere.it).

Excluding from this study the analysis of the relationship cause/effect between certification and corporate success, the question to which the research tries to give an answer is: in what way did the companies that in the examined three-year period hold a certified Quality Management System differentiate themselves from not-certified ones?

THE METHODOLOGY

In order to produce an objective response to the risen questions a statistical approach has been implemented. The Altman indicator Z-Score (Altman and Hotchkiss, 2005) has been used to give an aggregate expression of the economic/financial profile of a company. This index summarizes, through a single numerical value, five macro-aspects of a company: liquidity, profitability, leverage, solvency and activity. High values of Z-Score indicate that the company is in a situation of stability and economic security, conversely, low values of Z-Score signal that the company is at risk of failure.

Assuming as response variable of the statistical model the *risk of failure* associated to the Z-Score, the effects of a specific set of multiple factors (*certification*, *company size* and *regional development*) have been studied.

The Z-Score as response variable of the statistical analysis. Z-Score index is generally used for representing the economic/financial "health" of a company on the basis of a set of specific independent variables ("financial ratios"). This index represents a simple but powerful instrument for predicting the probability of success or failure of a company in the following two years after its computation (Altman and Hotchkiss, 2005).

A first version of the previsional model Z-Score have been developed in 1968 by E.I. Altman using an approach based on MDA (Multiple Discriminant Analysis) (Lebart et al., 1984). According to this method, a linear discriminant function, which transforms the individual variables into a single discriminant score (specifically, the Z-Score), can be defined and used to classify companies.

Altman set and analyzed the economic/financial characteristics of two groups, respectively constituted by bankrupt and active companies. He individuated five independent variables that were significant for the model and classified them into five standard categories: liquidity, profitability, leverage, solvency and activity.

The discriminant function obtained by Altman in the first edition of his model was (Altman, 1968; Altman and Hotchkiss, 2005):

$$Z = 0.012X_1 + 0.014X_2 + 0.033X_3 + 0.006X_4 + 0.999X_5 \qquad (1)$$

where:

X_1 = working capital/total assets,

X_2 = retained earnings/total assets,

X_3 = earnings before interest and taxes/total assets,

X_4 = market value equity/book value of total liabilities,

X_5 = sales/total assets,

Z = overall index (Z-Score).

Variables X_1 through X_4 are expressed as absolute percentage values, while variable X_5 is expressed in a relative manner (Altman, 1968; Altman and Hotchkiss, 2005).

Since the original model was only applicable to publicly traded entities, in 1993 Altman revised his model and substituted in X_4 the "market value of equity" with the "book value of equity" (Altman et al., 1993; Altman and Hotchkiss, 2005). As a consequence of this correction, all the coefficients resulted to be changed. The obtained discriminant function was:

$$Z' = 0.717X_1 + 0.847X_2 + 3.107X_3 + 0.420X'_4 + 0.998X_5 \qquad (2)$$

where:

X'_4 = book value equity/book value of total liabilities.

Further revisions of Z-Score have been introduced during the years by Altman, but they are not considered in the present study since they do not fit the characteristics of the analyzed corporate sector (Altman et al., 1977; Altman et al., 1995; Altman and Hotchkiss, 2005).

In general, according to the Z-Score model, it is possible to classify a company on three different zones of risk: *bankrupt zone*, *zone of ignorance* (*gray zone*) and *non-bankrupt zone*. Furthermore, in the *gray zone*, a cutoff score between the two groups of companies (bankrupt and active companies) may be identified. Tables 1 reports the different zones obtained with Z-Score and Z'-Score.

Table 1 – Representation of the classification zones according to Z-Score and Z'-Score, and corresponding values of cutoff (Altman et al., 2013)

	Bankrupt zone	Grey zone	Non-bankrupt zone

Z-Score (for publicly traded entities)	$Z \leq 1,81$	$1,81 < Z < 2,99$ $(\text{cutoff} = 2,67)$	$Z \geq 2,99$
Z'-Score (for firms in the private sector)	$Z' \leq 1,23$	$1,23 < Z' < 2,90$ $(\text{cutoff} = 2,67)$	$Z' \geq 2,90$

It is important to highlight that, even if the first introduction of the Z-Score dates back to 1968, many successive studies have demonstrated the robustness and effectiveness of the model so that it is still widely applied in many context for the analysis of a company risk of bankruptcy (Altman and Hotchkiss, 2005). Recent studies have demonstrated good predictive effectiveness of Z'-Score when applied to Italian market, though Italian peculiarities could require the development of ad hoc parameters (Altman et al., 2013). In the statistical approach implemented in the present work, the analysis is specifically focused on the Italian manufacturing sector. Owing to that, for this exploratory study, the Z'-Score is used, which is most representative for this commodity sector and represents an appropriate variable for the statistical analysis.

In order to better interpret the Z'-Score meaning and to avoid heteroscedasticity effects due to the significant non-linearity of this variable, the obtained values have been transformed in the corresponding values of *risk of failure*. The transformation has been obtained by applying a binomial logistic regression between Z'-Score and the legal status (active, not active) of the analyzed companies (Hosmer and Lemeshow, 2000; Minitab®, 2014).

Factors considered for the statistical analysis. The goal of the analysis presented in this paper is to verify if the ISO 9001 *certification* may be considered one of the possible factors that systematically influence the *risk of failure* of a company. As well as *certification*, *company size* and *regional development* have been investigated as two other possible factors that may affect company economic/financial performance. Hereafter there is a description of these three factors and the definition of the corresponding levels of variation.

Certification

With *certification* it is intended that a company is in possession of a valid (i.e. not expired) ISO 9000 quality certificate. Three levels are defined for this factor:

- *not certified*: companies that have never obtained a quality certification or that had it in the past, but it expired and has not been renewed in the triennium 2008/2010,
- *certified for less than three years*: companies that obtained the certification for the first time in 2008, 2009 or 2010,
- *certified for more than three years*: companies that obtained certification before 2008 and that in the triennium 2008/2010 had a still valid certificate.

This classification aims at distinguish between *certified* and *not certified* companies in the considered triennium, making a further distinction for long run (i.e. for more than three years) and short run certified companies.

Company size

With factor *company size* it is intended the dimension of the company in terms of headcount and annual turnover (or annual balance sheet total). Four levels are defined for this factor:

- micro,
- small,
- medium-sized,
- large.

The classification for the first three levels (see Table 2) has been defined in accordance with the European Commission recommendation number 1422 of 6 May 2003 (2003/361/EC). The two classification criteria are cumulative, that means that both of them must be satisfied. It is assumed that a *large* company is a company which does not fulfill any of the reported criteria.

Table 2 – Criteria for SME (Small-Medium Enterprises) definition (European Commission, 2003)

Company size	**Headcount: Annual Work Unit (AWU)**		**Annual turnover (€ million)**		**Annual balance sheet total (€ million)**
micro	<10	and	<2	or	<2
small	<50	and	<10	or	<10
medium-sized	<250	and	<50	or	<43

Regional development

Company classification according to the *regional development* is obtained on the bases of QUARS (Qualità Regionale dello Sviluppo) indicator, which is a composite indicator specifically constructed for measuring the level of development of Italian regions (Gnesi et al., 2010).

The variables concurring to the definition of QUARS are 41 and are grouped in 7 dimensions: environment, economy and work, health, education and culture, rights and citizenship, equality of opportunity, and involvement. According to these dimensions, 7 macro-indicators are defined, obtained by synthesizing the 41 original variables. QUARS is a single indicator obtained through a further synthesis of the 7 macro-indicators and is used for region comparison. It is periodically calculated and compared with other indicators (such as Human Development Index, Gender Equity Index, Basic Capabilities Index, Footprint Index, etc.) produced by UN (United Nations), ISTAT (Istituto Nazionale di Statistica), World Bank and Banca d'Italia (Gnesi et al., 2010).

Referring to the scores reported in QUARS report 2010, and considering that positive values represent a score higher than the regional mean, while the negative ones corresponds to a lower score, in the present analysis the *regional development* factor has been defined according to two levels (Gnesi et al., 2010):

- *positive*: values higher than the mean,
- *negative*: values lower than the mean.

Data collection. Data collection for the statistical analysis presented in this work has been conducted in two different phases: as a first step a sample of Italian companies has been extracted considering general corporate information (register, economic, financial), in a second step for each company of the sample the presence of a ISO 9001:2008 certification has been verified.

Data have been acquired from two sources: the database Aida® by Bureau van Dijk (www.bvdinfo.com) for general corporate information and the database of the Italian accreditation body Accredia (www.accredia.it) for certification information.

In the first phase of data collection, in order to select an appropriate and representative set of companies, the two following filters have been fixed (www.infocamere.it):

- type of company: *corporation* (Srl, Srl unipersonale, Spa),
- commodity sector: *manufacturing* (according to ATECO 2007 codification).

The option of focalizing this first exploratory work on a single commodity sector (i.e. *manufacturing*) has been motivated by the fact that this sector has the widest presence of factories in Italy. Hence it represents a significant area to be investigated. Future research will be extended also to other sectors.

The data extracted from Aida® are:

- legal status (active, not active),
- sub-sector (according to ATECO 2007 codification, 23 sub-sectors have been defined),
- register data (name of the company and legal address),
- complete balance sheet according to the scheme defined by the Fourth European Directive (European Council, 1978) and related financial indexes,
- headcount.

Aida® database includes all the companies with a minimum turnover of € 250,000, hence, according to this constraint, companies with an annual turnover lower than this threshold have not been considered in the present analysis.

According to these constraints (*turnover > € 250,000*, *balance sheet registered in 2010*, *corporations* and *manufacturing sector*), the considered sample was formed by 63,400 Italian companies.

In the second phase, the goal was to individuate, among all the companies in the sample, those having a valid quality certification according to ISO 9001:2008 standard. In order to obtain this information, data have been extracted from Accredia database fixing the following filters:

- standard: ISO9001:2008,
- date of issue of the certificate: till the end of year 2010,
- commodity sector: manufacturing,
- registered office: Italy.

The obtained sub-sample was composed by 12,082 certified companies. Data have then been matched with the information included in the sample extracted from Aida® database, obtaining the complete set of input data for the statistical analysis.

RESULTS OF THE ANALYSIS AND DISCUSSION

From a first rough descriptive analysis of the obtained data, it is possible to see that among the 63,400 companies with registered offices in Italy, that have been detected and analysed, 19.06% of these are certified and, in particular, 5.27% attained a quality certification in the period from 2008 to 2010, while the remaining 13.79% got it before 2008.

In order to give a synoptic cross-section of the considered sector, a preliminary statistical analysis, based on frequency tables, has been performed considering data shared among the 23 sub-sectors of ATECO 2007 classification for *manufacturing* sector (see Table 3). This preliminary analysis has shown that these sub-sectors present many differences in terms of certification and risk of bankruptcy.

Table 3 – Manufacturing sub-sectors according to ATECO 2007 classification

Sub-sector	**Code**
Manufacture of food products and Manufacture of beverages	C10/C11
Manufacture of tobacco products	C12
Manufacture of textiles	C13
Manufacture of wearing apparel	C14
Manufacture of leather and related products	C15
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	C16
Manufacture of paper and paper products	C17
Printing and reproduction of recorded media	C18
Manufacture of coke and refined petroleum products	C19
Manufacture of chemicals and chemical products	C20
Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21
Manufacture of rubber and plastic products	C22
Manufacture of other non-metallic mineral products	C23
Manufacture of basic metals	C24
Manufacture of fabricated metal products, except machinery and equipment	C25
Manufacture of computer, electronic and optical products	C26
Manufacture of electrical equipment	C27
Manufacture of machinery and equipment n.e.c.	C28
Manufacture of motor vehicles, trailers and semi-trailers	C29
Manufacture of other transport equipment	C30
Manufacture of furniture	C31
Other manufacturing	C32
Repair and installation of machinery and equipment	C33

Table 4 reports the sub-sectors ordered according to the percentage of certified companies in 2010. For each sub-sector, this percentage is given by the ratio of certified companies over the total of companies included in the sub-sector. From Table 3 it is possible to say that C24, C20 and C26 were the most certified sub-sectors in 2010.

Deepening the analysis, Table 4 also reports, for each sub-sector, the percentages of companies resulting certified in year 2010 that in year 2007 were respectively *not certified*, *certified for less than three years* and *certified for more than three years*, while Table 5 reports the increase of the percentage of certified companies during the period of analysis.

Table 4 – Italian *manufacturing* sub-sectors ordered according to the percentage of certified companies in year 2010 and their state of certification in 2007

		State of certification in 2007		
Sub-sector (code)	*Certified* (in 2010)	*Not certified*	*Certified* (*< 3 years*)	*Certified* (*> 3 years*)
C24	31.69 %	6.53%	25.16%	68.31%
C20	31.31%	6.31%	25.00%	68.69%
C26	29.71%	7.45%	22.22%	70.33%
C22	27.48%	7.21%	20.21%	72.58%
C27	26.99%	5.87%	21.13%	73.00%
C29	26.28%	6.89%	19.39%	73.72%
C25	22.06%	6.55%	15.45%	78.00%
C23	19.99%	6.94%	13.02%	80.04%
C28	19.21%	5.43%	13.78%	80.79%
C10/C11	18.77%	5.50%	13.27%	81.23%
C33	17.38%	5.90%	11.49%	82.61%
C17	17.14%	4.52%	12.63%	82.85%
C19	15.69%	3.92%	11.76%	84.32%
C30	15.55%	5.30%	10.25%	84.45%
C21	14.36%	2.27%	12.09%	85.64%
C16	14.16%	5.22%	8.84%	85.94%
C31	12.58%	3.65%	8.90%	87.45%
C32	10.77%	3.36%	7.41%	89.23%
C18	10.30%	2.63%	7.67%	89.70%
C13	8.33%	2.00%	6.33%	91.67%
C12	5.56%	5.56%	0%	94.44%
C15	5.00%	0.84%	4.16%	95.00%
C14	3.13%	1.20%	1.93%	96.87%

From Tables 4 and 5 some important differences emerge. For example, looking to the comparison in Table 5, the sub-sectors showing an increase of certifications in comparison to the past are C12, C23, C16, C33, C30, C25, C32, C14, C10/C11, C31 and C28. The result obtained for C12 is conditioned to the very low number of companies in this sub-sector. While the sectors showing the greatest number of new certificates in the investigated period are C26 (6.71%), C22 (6.49%) and C23 (6.25%).

Table 5 – Increase of the percentage of certified Italian companies in *manufacturing* sub-sectors in 2010

Sub-sector (code)	*Certified (> 3 years)*	*Certified (< 3 years)*	Net increase of certificates
C12	0.00%	5.01%	5.01%
C23	4.46%	6.25%	1.79%
C16	3.03%	4.70%	1.67%
C33	3.93%	5.31%	1.38%
C30	3.51%	4.77%	1.26%
C25	5.29%	5.90%	0.61%
C32	2.54%	3.03%	0.49%
C14	0.66%	1.08%	0.42%
C10/C11	4.54%	4.95%	0.41%
C31	3.05%	3.29%	0.24%
C28	4.72%	4.89%	0.17%
C17	4.32%	4.07%	-0.25%
C18	2.63%	2.37%	-0.26%
C13	2.17%	1.80%	-0.37%
C22	6.92%	6.49%	-0.43%
C29	6.64%	6.20%	-0.43%
C19	4.03%	3.53%	-0.50%
C15	1.42%	0.76%	-0.67%
C26	7.61%	6.71%	-0.90%
C27	7.23%	5.29%	-1.95%
C21	4.14%	2.04%	-2.10%
C24	8.61%	5.88%	-2.73%
C20	8.56%	5.68%	-2.88%

Table 6 reports the Italian *manufacturing* sub-sectors ordered according to the percentage of companies included in the *bankrupt zone*, according to Z'-Score values, on the total number of companies in the sub-sector.

Table 6 – Italian manufacturing sub-sectors ordered according percentage of companies included in the *bankrupt zone* in 2010

Sub-sector (code)	Companies in *bankrupt zone*
C23	6.53%
C16	5.41%
C30	5.38%
C31	5.00%
C12	4.81%
C18	4.79%
C13	4.72%
C17	4.63%
C29	4.59%
C25	4.52%
C10/C11	4.36%
C22	4.27%
C24	4.21%
C14	4.11%
C28	4.04%
C19	3.98%
C32	3.86%
C26	3.79%
C27	3.68%
C21	3.66%
C20	3.58%
C33	3.27%
C15	2.79%

Analysis of influence factors. After the early exploratory analysis, a three factors ANOVA has been performed. The large amount of available information and the unbalanced distribution of the acquired data over the levels of the three considered factors have suggested to adopt the General Linear Model (GLM), which is an extension of the balanced ANOVA and serves to perform univariate ANOVA with unbalanced as well as balanced designs. In such a model some fundamental assumptions, namely the linearity of the dependency model, normality and homoscedasticity of the observations are less restrictive (Everitt and Dunn, 2010; Minitab®, 2014).

ANOVA allows to analyze, in a comprehensive manner and according to a rigorous scheme, the information contained in the sample of examined companies. The goal is to study the effects of one or more of the three factors (*certification*, *company size* and *regional development*) or their interactions on the response variable *risk of failure*.

The analysis has been performed using statistical software Minitab® 17 (Minitab®, 2014). Table 7 reports the obtained results.

Table 7 – ANOVA result table as in Minitab® 17 output (A = *certification*, B = *company size*, C = *regional development*) (Minitab®, 2014)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
A	2	0.011079	0.002775	0.001387	2.69	0.068
B	3	0.067701	0.011061	0.003687	7.15	0.000
C	1	0.179035	0.011729	0.011729	22.75	0.000
A*B	6	0.007419	0.006955	0.001159	2.25	0.036
A*C	2	0.000474	0.000488	0.000244	0.47	0.623
B*C	3	0.004134	0.001133	0.000378	0.73	0.533
A*B*C	6	0.001592	0.001592	0.000265	0.51	0.798
Error	63,377	32.680011	32.680011	0.000516		
Total	63,400	32.951445				

Company size and *regional development* have a P-value equal to zero, so they can be fully considered significant. On the contrary, certification can be considered significant only if a level of significance equal or lower than 73.2% is accepted (P-value equal to 6.8%). From the practical point of view, it is not possible to say that *certification* is fully connected to the *risk of failure* without the shadow of doubt.

The Main Effects Plots display individually the influence of each factor on the response when it is changed from one level to another. The Main Effects Plot of Figure 1 shows that *not certified* companies are related to the higher *risk of failure*, while the *certified* ones are associated to lower levels of *risks*, especially if they have obtained certification for more than three years. This was the expected result, even if conditioned by a low level of significance (lower than 95%, which is typically accepted).

Furthermore, according to Figure 2, it may be also noted that the *risk of failure* is maximal for *micro* and *medium-sized* companies, while it is minimal for *small* and *large* companies. This is largely justified by the particular corporate structure of the Italian market, especially during the analyzed period (www.infocamere.it).

Figure 3 shows the *risk of failure* related to *regional development* when it varies from *negative* to *positive*. The observed difference in favor of the developed regions was rather predictable on the bases of the used criterion.

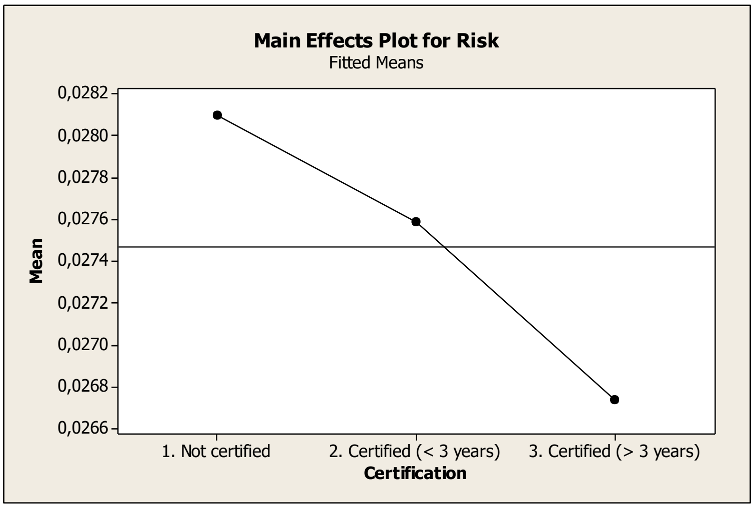

Figure 1 – Main Effects Plot for *certification*

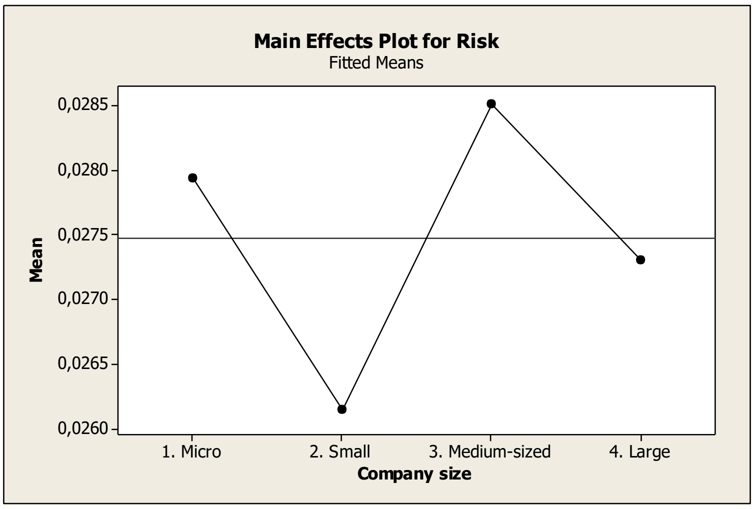

Figure 2 – Main Effects Plot for *company size*

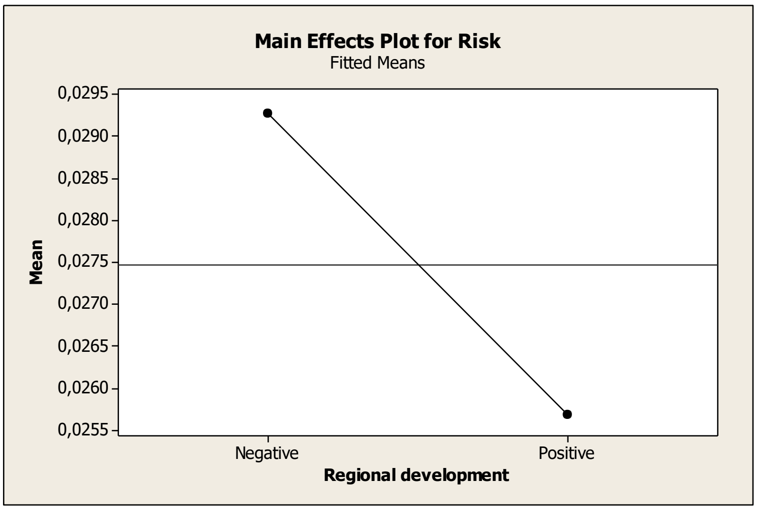

Figure 3 – Main Effects Plot for *regional development*

The only highly significant interaction revealed in Table 7 (P-value equal to 3.6%) is among the factors *certification* and *company size*. The effects of these two factors on the response are not additive and independent, but show a combined action. Interaction Plot in Figure 4 clarifies the situation: it can be observed that the effect of *certification* is different at different levels of *company size*, especially if comparing *micro* and *small* companies with *medium-sized* and *large ones*.

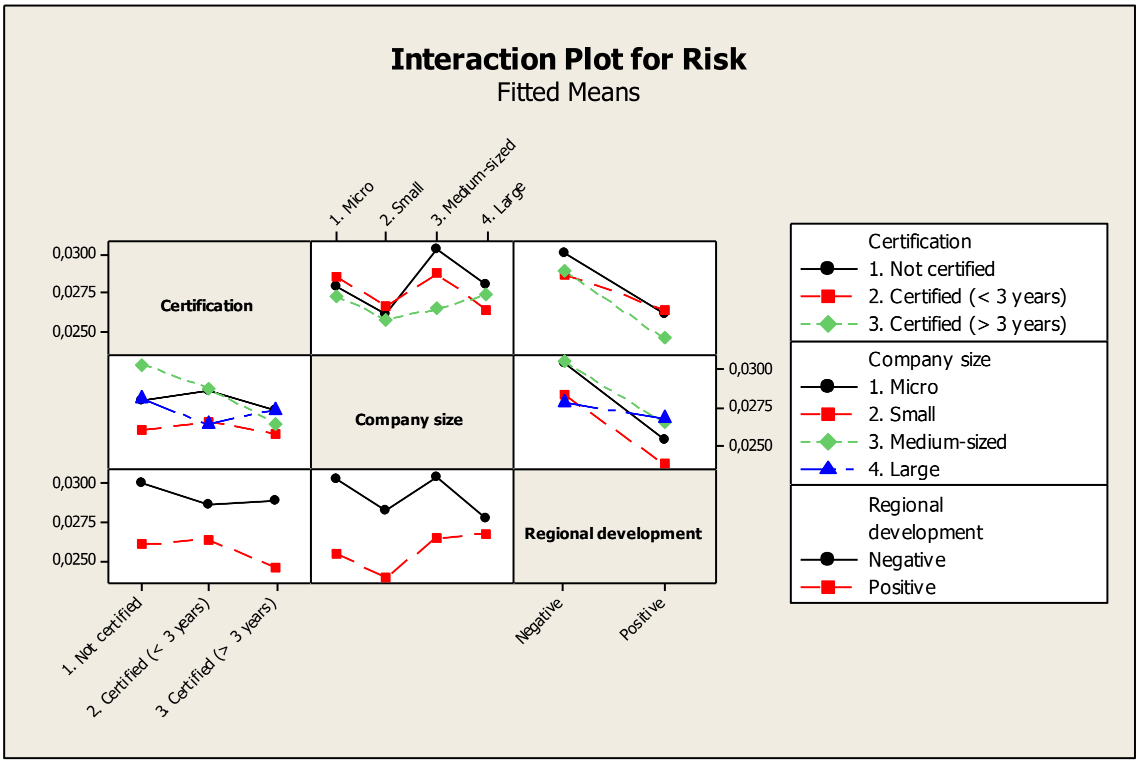

Figure 4 – Interaction Plot

In order to achieve a less generalized result and highlight possible similar behaviors for rational subgroups of the population, the above ANOVA has been split in three different analysis referring respectively to the three zones of risk of bankruptcy according to Z'-Score. The obtained P-values for the three different ANOVAs are reported in Table 8.

Table 8 – P-values according to ANOVA results for companies appertaining to the three zone of risk of bankruptcy (A = *certification*, B = *company size*, C = *regional development*)

Source	*bankrupt zone*	*grey zone*	*non-bankrupt zone*
A	0.000	0.000	0.001
B	0.022	0.011	0.556
C	0.720	0.000	0.682
A*B	0.561	0.243	0.487
A*C	0.650	0.042	0.124
B*C	0.905	0.063	0.397
A*B*C	0.989	0.381	0.289

For all the three analysis *certification* is significant (P-value lower than 1%), *regional development* is significant only for companies appertaining to *grey zone*, while company size is significant for companies appertaining to *bankrupt* and *grey zones*, no interaction is significant with a significance higher than 97.5%. This result is unsurprising and can be justified by the fact that companies appertaining to *non-bankrupt zone* are so robust that do not suffer any other external effect, companies appertaining to *grey zone* are very variegated in terms of *size* because they operate in a very spread market, and many companies appertaining to *bankrupt zone* are mostly affected by their fragile structure (also related to their *size*) than by the *regional development*.

The study has been further detailed by splitting the ANOVA according to the different commodity sub-sectors. The results confirm the general analysis. *Certification* factor results statistically significant for many of them. Although *certification* has different effects for each sub-sector, it is confirmed that, for most of the sub-sectors characterized by a high level of *risk of failure*, *not certified* companies reach the maximum levels of *risk* while companies *certified for more than three years* stand on the lower level. A separate application of ANOVA for *micro*, *small* and *medium-sized* companies, produced an acceptable level of significance (higher than 95%) for *certification* only for *medium-sized* companies.

Connection between qualitative variables. In order to further investigate a possible connection between *legal status* (*active*, *not active*) of a company and ISO 9000:2008 *certification* (*certified*, *not certified*), a connection analysis between these two qualitative variables has been conducted. This analysis is based on the use of two ways Contingency Tables and Chi-square (or Pearson) Contingency Test for qualitative variables (Everitt and Dunn, 2010).

As well as on the overall sample of companies, the analysis has been conducted according to two types of segmentations: the first one takes into account the four levels of *company size* (*micro*, *small*, *medium-sized* and *large*) associated to the three zones of *risk of bankruptcy* (*bankrupt zone*, *grey zone*, *non-bankrupt zone*), while the second one considers the 23 commodity *sub-sectors*. This classification has been decided in order to highlight any different behavior between *company size*, *risk of bankruptcy* and commodity *sub-sector*. Furthermore it should be noted that, although the sample size is important for the validity of the Chi-square test, on the other hand when using very large samples it is very easy to obtain factor significance even when the connection is very low, because the test tends to reject the hypothesis of independence (Everitt and Dunn, 2010).

The analysis of Contingency Tables and the Chi-square test have been conducted using the statistical software Minitab® 17. The main results are briefly summarized hereinafter.

As a first result, the analysis conducted on the whole set of companies has shown that *certification* and *legal status* are not independent (P-value of the Chi-square test is equal to zero), with a percentage of *not active not certified* companies which is three times bigger than the percentage of *not active certified* ones.

Regarding the *company size*, for all the considered typologies (*micro*, *small*, *medium-sized* and *large*), the same behavior has been observed: if companies appertain to *bankrupt zone* or *gray zone*, *certification* and *legal status* are not independent (P-value of the Chi-square test are equal to zero), if they appertain to *non-bankrupt zone*, the hypothesis of independence cannot be rejected with a level of significance lower than 97.5%.

As for the *sub-sectors*, three groups can be distinguished based on the value of the P-values of the Chi-square test. The first group is formed by C10/C11, C20, C22, C23, C24, C25, C26, C27, C28, C29 and C31. These sub-sectors are characterized by a strong dependence between *certification* and *legal status* (P-value lower than 1%). The second group, constituted by C16, C18, C21 and C33, includes those activities in which the dependence between the two qualitative variables is weak (P-value higher than 1% and lower than 10%), finally, the last group does not show any relationship between the variables (P-value higher than 10%). It is composed by C13, C14, C15, C17, C30 and C32. C12 and C19 cannot be analyzed because of the low number of companies for each category. This distribution is mainly related to the particular nature of Italian corporate sector, direct connections need to be further investigated in the future work (www.infocamere.it).

CONCLUSION

This study aimed at investigating whether there is a relationship between ISO 9001 quality certification and the risk of failure of Italian companies in the period 2008/2010, characterized by the beginning of a serious economic crisis. In this regard, a statistical analysis was performed on a sample of 63,400 Italian companies in the manufacturing sector. The first step was to identify an indicator able to express concisely the economic/financial profile of a company. The choice fell on Altman Z'-Score, which summarizes, through a single numerical value, five macro-aspects of a business: liquidity, profitability, leverage, solvency and activity. High values of Z'-score indicates that the company is in a situation of stability and economic security, conversely low values of Z'-Score signal that the company is at risk of failure.

Assumed the *risk of failure* associated to Z'-Score as a response variable of the statistical model, the second step was to study the effects of the following factors: *certification*, *company size* and *regional development*. ANOVA showed that the three factors are statistically significant. However, since *certification* presents a low level of significance, it is not possible to affirm with any certainty that quality *certification* has a direct connection with the *risk of failure*.

In particular, it has been shown that *not certified* companies present the higher *risk of failure*, while companies *certified for more than three years* seem to have the lower level of *risk*, companies *certified for less than three years* are positioned between these two extreme levels.

ANOVA has then been performed on three groups of companies obtained according to the three zone of risk defined by the Z'-Score model (*non-bankrupt zone*, *grey zone* and *bankrupt zone*), revealing no substantial differences in comparison to the global analysis.

A further ANOVA was conducted by considering each single *manufacturing* sub-sector, it emerged that for many of 23 sub-sectors *certification* is statistically significant. However, even if the certification has shown to be statistically significant on effecting the *risk of failure* of a company, it is necessary to highlight that different sectors presented a very variegated range of different behaviors. Moreover, ANOVA, performed separately for *micro*, *small* and *medium-sized* companies, showed that *certification* is significant only for medium-large companies.

In a third step the connection between the qualitative variable *certification* (according to levels *certified/not certified*) and the qualitative variable *legal status* (according to levels *active/not active*) was analyzed. Contingency Tables and Chi-square test have been used as statistical tool for this analysis. As well as for the overall set of companies, the analysis has been conducted according to two types of segmentations: the first one considering the *company size* associated with the *risk of bankruptcy*, the second one considers the 23 manufacturing *sub-sectors*. Regarding the first segmentation, the analysis showed that, for all typologies of companies appertain to *bankrupt zone* or *gray zone*, *certification* and *legal status* are connected. As for the results obtained for the second segmentation, three groups had distinguished: sub-sectors showing a strong connection between the two variables, sub-sectors showing a weak connection, and sub-sectors where there is no evidence connection. Apparently, no explanation can be found about this different behavior of the analyzed sub-sectors, in the future work specific investigations involving the analysis of Z'-Score time variation can better explain these results.

Since this analysis cannot drive to the certain conclusion that ISO 9001 certification has a positive connection with the corporate profile of a company, the study opens a way for a number of important questions about the meaning, usefulness and effectiveness of ISO 9001 certification. In particular, it may be time to ask whether the paradigm of certification actually needs a radical rethink.

In addition to that, it must be said that the present work represents a preliminary study for a more extensive survey involving an all-round analysis of the Italian corporate sector and updated to current years. Z'-Score has been used for tracing the economic/financial profile of companies, but due to the fact that it takes its origin from the USA market it may not fit exactly the Italian situation. Currently the analysis is being reviewed by introducing a more advanced econometric model more suitable for Italian sector, and updating company profiles to a more recent period of time. Furthermore, a deeper analysis of the effect of certification will be investigated by extending the analysis to a wider interval of time and comparing the company values of the used econometric index before and after the acquisition of the certification.

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Process performance management: The impact of Performance indicators on the organizational profitability

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ABSTRACT

Purpose. This study is conducted in order to affirm the applicability of the steps involved in PPMS, to identify and prioritize the facilitators and inhibitors behind the implementation decision of PPMS and the effect of performance indicators on the profitability of the firms.

Design/methodology/approach. The data was collected from the top level management of the 200 manufacturing companies in Pakistan through a structured questionnaire out of which a stratified sample of 100 companies who have implemented the PPMS is used. SPSS 17 was used in order to check the impact of performance indicators on the overall business performance index.

Findings. This paper found that the manufacturing organizations in Pakistan are following almost all the steps involved in PPMS. The results of AHP analysis show that the "Supportive Culture" and "PPMS facilitate the competitive advantage" are the major facilitators for those organizations who have implemented the PPMS, whereas the organizations who have not implemented PPMS have major inhibitors as " Non supportive culture" and "Have another Performance System". And the Measuring financial performance, Quality performance, Delivery reliability performance, customer satisfaction performance and employees satisfaction lead to increase in the organizational Profitability.

Research limitations/implications. The target population of the study is the manufacturing sector of Pakistan, as the study is conducted on the basis of the data collected from the top management of the manufacturing organizations from Pakistan. We couldn't generalize the results of this study for overall world manufacturing market.

Practical implications. This study will be helpful to the top management of the organizations from manufacturing sector regarding the implementing decision of the PPMS. The organization can choose the best indicators used by firms in order to achieve the overall excellence.

Originality/value. This paper has put together all important performance indicators used by firms in a single list which was not previously done.

Keywords: Process Performance Management System, Key Indicators, Profitability, AHP, Critical factors.

Article Classification: Research paper

INTRODUCTION

Since the beginning of the 1990s, performance measurement has become a vital issue for academics and practitioners. The proficient literature has suggested that managers should design new performance measurement systems that include financial and non-financial measures (Gosselin, 2005). Usually firms use the performance management in order to keep an eye on their operations and objectives. A performance management system serves four purposes i,e. to measure, monitor, compare and manage the performance. There are many systems in practice by the firms for performance management. The traditional and modern systems are different in terms of the performance indicators and the point of focus. The traditional systems actually used the financial measures and focus the organizational performance in broader sense, whereas the modern systems use both types of performance indicators (financial and non-financial) as suggested by the researchers and they measure the organizational performance narrowly. The process performance management system (PPMS) is one of the modern systems for performance management. The PPMS uses both types of performance indicators and focus on process performance for managing the overall organizational performance.

The main purpose of this study is to affirm the steps involved in PPMS suggested by Oakland (2010) in the manufacturing sector in Pakistan. The other purpose of the study is to investigate either the profitability of the firms which are using the PPMS for performance management, is significantly different from the others firms which are not using the PPMS. The last purpose of the study is to know that what are most important inhibitors and facilitators regarding the implementation of PPMS. This study is the descriptive research, which has used the survey research method and some statistical techniques in order to find the purpose of the study. The section 2 discusses the literature review and section 3 deals with the research methodology. Sections 4 and 5 describe data analysis and conclusion respectively.

LITERATURE REVIEW

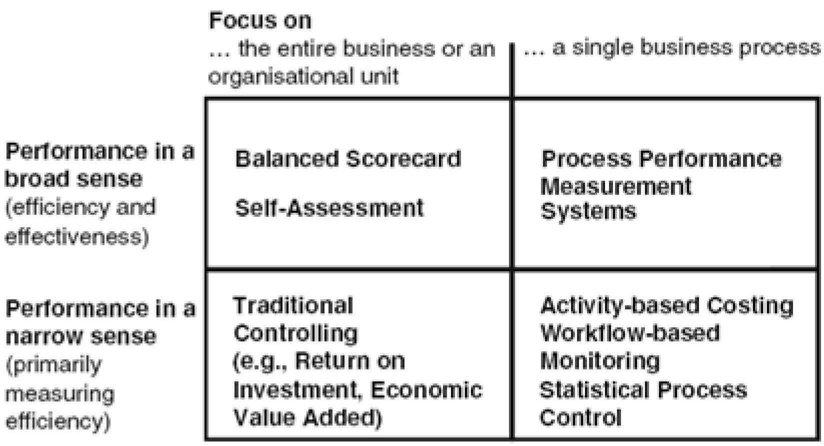
The phenomenon performance measurement is used by the organizations in order to ensure that they are going on right direction, or achieving targets in terms of organizational goals and objectives. The performance measures are used to evaluate and control the overall business operations. They are also used to measure and compare the performance of different organizations in the industry, plants, departments, teams and individuals (Ghalayini and Noble, 1996; Neely et al, 2000; 2005). The business performance measurement is not an untapped topic. A large number of researches have been conducted by the researchers on this topic. According to Neely (2000), almost 3,615 researches on business performance measurement were published in three years 1994 to 1996, which means that for every five working hour one article on the issue was published. The overall organizational performance could be measured by using financial indicators, operational indicators or by using both. The financial indicators may include the sales growth, profitability and Earning per share, which are organization specific and if we consider the market then the market to book and stock market returns and its variants are taken as the financial indicators of the organization's overall financial performance. The second types of indicators are operational indicators which are also called the non-financial indicators of the organization's performance. They include the market share, new product introduction, quality of the products, marketing effectiveness, manufacturing value-added and other measures of technological efficiency (Venkatraman and Ramanujam 1986,De Toni and Tonchia 2001 and Browne et al 1997).

Performance management systems. Heckl and Moormann (2010) have identified the following systems for measurement of performance of the organizations.

- Balanced scorecard
- Self-assessment,
- Traditional controlling,
- Activity based costing
- Process performance measurement system.
- Work flow based monitoring and
- Statistical control system.

All above mentioned systems have different set of objectives and characteristics but also have some common set of elements with each other. Heckl and Moormann (2010) have differentiated these approaches on the basis of two dimensions; the first one is the focus and the second is scope as shown in figure 1.

Figure 1- Positioning of performance management systems.



Balance scorecard

Kaplan and Norton (1992) have developed the balanced scorecard instrument to clarify and operationalize the organization vision with respect to four perspectives (financial, customer, internal process & learning and growth perspective). This system is developed in order to describe the overall business performance in terms of financial and non-financial indicators on continuous basis. This framework is based upon four important aspects which include the financial, customer, internal process & learning and growth. This system can be used for three main purposes which are the reporting of strategic performance, linking the strategy with performance measures and to describe different perspectives in numerical terms. This system is very important as it focuses on strategic business units of the organizations. It focuses on the business process as far they are critical for achieving the business mission and goals (Kueng and Krahn 1999, Aitken and Brinkworth 2010).

Self Assessment:

The origin of self -assessment system is found in Japan. In 1951 the Japan has introduced an award system for Quality driven organization. Following the Japan the USA also has introduced the award system named as Malcolm Baldridge National Quality Award (MBNQA) in 1988 in order to appreciate the Quality driven organizations. Afterward the organizations start to focus on self-assessment system in order to improve their product quality. Focus was the overall performance of the organizations but not the processes (Kueng and Krahn 1999). The managers of the organizations can measure the performance of the overall business on the basis of predefined criteria of the performance evaluation and framework. This system is called self-assessment system for performance measurement of the business organizations (Hakes 1996). This system is developed and recommended by the quality management associations (e.g. European foundation of Quality Management, EFQM). By this system the organizations can measure and manage their overall performance on the regular basis to keep check either they are going to the right direction. This system provides number of benefits to organizations, like monitoring the organization's performance by keeping the checking on the strengths and weaknesses of the organizations. But this system measures the overall performance of the organizations but not the process or activity independently (Rolstadas 1998 and Heckl and Moormann 2010).

Traditional controlling

The traditional controlling also focuses on the whole business to control and manage the performance (Kueng 2000). Key indicators to assess the profitability, growth and risk factors are determined and then the senior management continuously observes these indicators. By this process the senior management becomes able to assess any problem in the business and takess any corrective measures (Heckl and moormann 2010).

Activity based costing

The activity based costing (ABC) was firstly introduced in mid-1980's by the computer aided manufacturing international with the framework of the cost management systems programs. This system came into the existence during the considerations of the modern manufacturing, logistics and IT changes and the process and cost structures of the organizations. These days the organizations don't consider the indirect cost and value added activities costs but they only used to consider the direct costs. The activity based costing system of performance management developed the concept of considering the all other indirect costs as well. The ABC system focuses on the very small unit of the business in order to measure the performance. But its major consideration is cost indicator (Kueng and Krahn 1999).

Process performance measurement system

This system focuses on the performance of the each and every single process of the business in order to assess, control and manage the performance of the overall business. Actually this system takes the process as the foundation of the overall business. So performance of the process is easily assessed and controlled as compare to overall business. In this approach with respect of vision and mission statement of the overall business the objectives of the single process are defined and then indicators for the process performance are determined in order to make complete grip over the process performance (Neely 2000).

Work flow based monitoring

The work flow based monitoring facilitates the top management by automatic and semi-automatic assessment of the process variations, coordination of the different process activities and communication between the workers of the processes. The different IT systems used automatically record the information of the different activities which may be very useful for the future planning and decision making (Heckl and Moormann 2010). The data gathered automatically provide many useful insights into the activity based costing, time related to completions of process and different workload on process workers. The traditional performance system focus on entire performance level of the organizations but the workflow system focuses on the process based performance (zur Muhlen 2004). The limitations of the work flow based monitoring may include the qualitative performance and performance data about activity or processes which are conducted manually and are very difficult to monitor and achieve. It is very difficult to assess this kind of data. The work flow monitoring system monitor the performance of the process during its execution so the chance of mistake is minimized (Kueng and Krahn 1999).

Statistical control system:

The statistical control system uses different statistical techniques in order to find any variations in the process (Juran and Gyrna, 1993). The main target of these techniques is to find maximum variation accurately as they can (Kueng and Krahn 1999). And then this data provided by the statistical control system is used to control the variation found in the processes. The main objective of this system is to achieve the stable processes, because the more stable process may lead toward more accurate prediction of the behaviour of the process, which at the end gives reliable predictions about the quality of the products (Heckl and Moormann 2010).

As a summary the balanced scorecard and self- assessment systems are related to same category, because of their common focuses on the performance of the whole organization, although they have different approaches. Statistical process control, activity based costing and workflow based monitoring are usually used for the measuring the performance of a single process and focuses only on efficiency aspect. Traditional controlling also considers the organization as a whole and focuses on the efficiency, whereas the process performance measurement system focuses on an individual business process, rather on the performance of the whole organization or an organizational unit.

The process performance management.

What is a process?

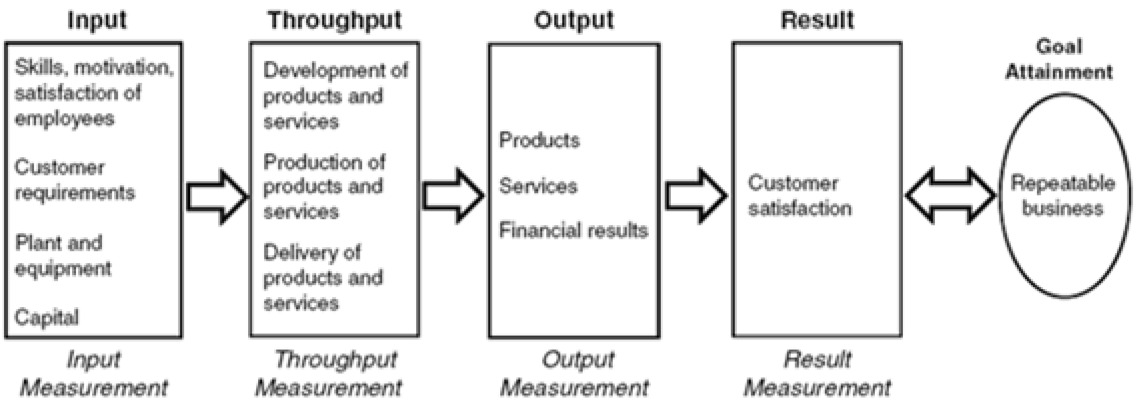
According to Zairi (1997) the process is an approach for converting inputs into outputs. It is the way in which all the resources of an organization are used in a reliable, repeatable and consistent way to achieve its goals (Palmberg 2009). Aitken and Stephen (2010) have defined the process as "A sequence of tasks undertaken by actors within a single community" Essentially; there are four key features to any process. A process has to have:

- Predictable and definable inputs;
- A linear, logical sequence or flow;
- A set of clearly definable tasks or activities;
- A predictable and desired outcome or result.

Framework for measuring process performance:

The business process performance is not any-thing absolute due to the large number of available performance indicators, figures and measures. The performance of a same process can be different on the basis of performance measured by different measures and performance indicators. An organization's objectives and vision is used to provide the basis for determinations of measures of process performance. The performance measures should be aligned with the wishes and objectives of the organization as the entire organization should be aligned with the wishes and requirements of its stakeholders and clients. Moreover the process performance is a multi-dimensional concept and should not be measured on the single dimension like profitability. A very valuable frame work is given in the literature which gives a stronger process perspective. This distinguishes between the input, throughput and output and it advises the researchers to determine the performance indicators according to this classification. The input of the process may include the labor, machinery or plant, and other sources of capital (Scheer 2010). We can make decision about the customer's satisfaction by the quality and quantity of the input. During the throughput phase the operations are done on input to convert it into valuable output. An output may include some valuable goods and services. The organizations can measure their performance at any stage like at input level, throughput level, or results or output level. (Figure 2) (Heckl and Moormann 2010).

Figure 2-Stages of performance measurement in the process



As previously stated that the organizations can judge their performance at any stage of the process (e.g. input, output, throughput), so the performance indicators could be like input related, output related or throughput related.

Steps for PPMS:

In his book the total organizational excellence the Oakland (2010) has identified the following steps in measuring and managing a organization performance which can be applied for business process performance management.

Defining the organization vision, mission, and goals and strategies:

In the first step of the PPMS the organization's vision, mission, goals and strategies to achieve these goals are defined. Almost over a thousand of the books and articles about defining the organization's vision have appeared in the press but the technically vision is yet hypothetical phenomenon. The vision is something which could not be directly observable and apparently carries meanings beyond any single and simple description (Larwood 1995; Hui and Chuan 2002). The organization vision, mission, goals and strategies are very important to define because they set the direction for the organization (Oakland and Gadd, 2002). The first step in the PPMS is to define the organization's vision, mission, goals and strategies. The vision and missions are broad terms which carry the futuristic desires of the organization's top management (Zairi and Sinclair 1995). But the organizational goals are rather short-term objectives of the organizations which are derived directly from the mission statement of the organization and are stated in terms of physical values. And this mission rather than the organization's objectives drives the organization's strategy (Leong and Ward, 1990; Kaplan 2001 and Kellen 2003).

Business process documentation:

This is the second step in the PPMS in which the organizations points out all the processes involved in the overall business of the organization and then draw diagrams of these processes on the paper (Zairi and Sinclair 1995). First of all the management define their processes and the boundaries of the processes and then they document all the processes. Without the proper documentation of the process there are often conflicting views about the process that what the process exactly is? The main benefit of the process documentation is that it includes the systematic descriptions of the process which brings agreement among all team members and managers that what constitute a process (Elzinga et al, 1995).

Defining the Critical Success Factors (CSFs):

The third step of the PPMS is defining the critical success factors (CSFs). These CSFs are defined on the basis of organization's vision, mission, goals and strategy. The CSFs can be defined as the important factors which organization must accomplish in order to achieve the mission of the organization (Oakland 2001). Basic rule behind choosing the CSFs is that they should be necessary and sufficient to achieve the overall organization mission (Zairi and Sinclair 1995; Oakland 2001).

Defining the core processes:

In this fourth step of PPMS the organizations define their core processes on the basis of their critical success factors. Actually the core processes of the organizations are the most important processes to achieve the mission of the organizations. The core processes and the CSFs of the organization should be linked together (Zairi 1997; Oakland 2001).

Defining the Key performance Indicators (KPIs):

The most important step of the PPMS is the defining of the key performance indicators of the organization. There are two categories of performance indicators; the qualitative and quantitative. We can divide the performance indicators as the internal and external performance indicators also. The Costs / financial, Quality, Time, Delivery reliability, Flexibility are largely accepted indicators of organizational performance (White 1996 and Koufteros and Doll, 1998, Cyrus et al 2013). But several authors have defined other indicators as well on the basis of their case study researches. Sinclair and Zairi (1995) have found the customer satisfaction, quality, delivery, employee factors, productivity, financial performance, safety and environment / social performance as the indicators of business performance used by many organizations. Parmenter (2009) has identified the customer's satisfaction, employees' satisfaction, environment/community, financial, internal process performance and learning and growth as the performance measurement perspectives. The performance indicators must be based upon the competitive strategy of the organization (Sinclair and Zairi 1995).

Benchmarking:

The improvements can only be done if the benchmarking is done for performance of any process, activity, task or overall organization (Parmenter 2009). If the improvements have been made then these improved results could be the new standards for that particular process, activity, task or overall organization. The benchmarks could be the previous performance the company or performance of the competitors company (Sinclair and Zairi 1995).

Process Analysis:

This is the overall seventh step of the PPMS but it is the start of second phase of PPMS. The evaluation of the performance starts from this step. In this step the organizations evaluate the performance of the each and every process and compare it with standards or benchmarks (Oakland 2002; Heckl and Moormann 2010 and Skrinjar et al, 2010).

Identifying the skill needed:

This is the very next step after the process evaluation stage. During this stage the skill needed to improve the overall performance of the organizations are identified. This step is not always done but when there are some technological changes occurred in the market or when company has adopted these changes then this step become important to perform. During identifying the skill needed to performance various task the HR department of the organizations come into action in order to identify the proper skills needed provide to the employees of the organization (Oakland 2001; 2010).

Providing the skill needed:

After identifying the list of skill needed the HR department of the organizations provide the necessary skills to respective employees, who lack these necessary skills. In this process a necessary training and education about the overall organizational mission, vision, goals and strategies are provided to employees (Oakland 2001; Neely 2005).

Managing the Process:

On the basis of the processes performance data the process managers try to manage the performance of their processes. The process managers firstly clearly understand the results of the process performance data and then make positive and effective decisions about the improvements in the process performance (R. Skrinjar 2010). At first the performance of the processes is measured and compared with the benchmarks or standards and any improvements are suggested for the processes. By this the performance of the processes can be increased which contributes towards the overall performance of the organization (Oakland 2001).

Process improvements:

This is the important step of the second phase of the PPMS in which the organizations start improvements in the processes by rearranging the process activities. The flow charts are drawn in this stage and different performance indicators are redefined by the managers. The improvement programs are started and the skills and knowledge of the employees is fully utilized. A proposed framework of continuous improvements by Oakland (2001) is that the managers should start by defining the problem, review the information, investigate the problem, verify the solutions, and execute the change (Oakland 2002).

Feedback generation:

Feedback is the primary source of continuous improvement and the employees remain motivated and work with full commitment from this feedback. Managers try to provide the feedback of the performance against organizational goals, new opportunities, performance against internal standards and external standards to their subordinates (Oakland 2001).

Assigning the responsible person:

When there is not any responsible person for any activity then who will take the responsibility of that particular activity. In this step the responsibility of process performance is delivered to any manager, who keeps the check on the outcome of his assigned process (Scheer 2010 and R. Skrinjar 2010). The management then asks for any undesirable outcome of the process directly to the responsible person. The responsible person is then has an authority to make any decision regarding the process. The other benefit of the assigning the responsible person is that the rewards and incentives could be delivered to right person (Oakland 2002).

Upgrading the strategies and organizational goals:

This is the last step of PPMS where the whole cycle is complete. In this step the feedback is used to update the organizational strategies, objectives and goals by the budgetary control team within the organization. The whole process is revised on continuous basis in order to manage the overall organizational performance. This is also an important step and if this step is not performed then the whole process is useless. The feedback should be used to update the benchmarks and strategic planning (Oakland 2001).

THE METHODOLOGY AND MODEL

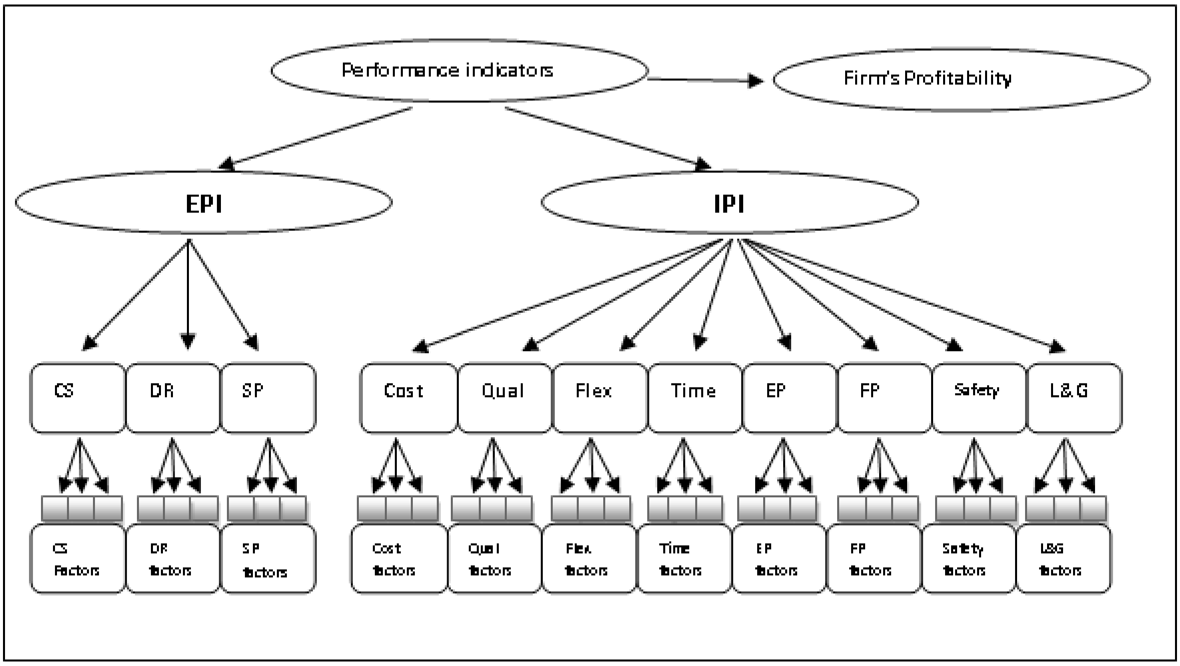
This study explores the dimensions of organizational performance in terms of performance indicators; defines indices of overall performance indicators and its dimensions; establishment of the relationship of performance indicators to Pakistani manufacturing sector's companies from four different industries which have applied the PPMS. The research questions identified for this study are stated as:

1. Whether the organizations in Pakistan are following these steps as suggested in literature?
2. Is there any difference between the firms who have applied the PPMS and who have not applied PPMS in terms of profitability?
3. What are facilitators and inhibitors behind the implementation decision of PPMS?
4. What is the effect of each performance indicator on the profitability of the firms?

This study is descriptive which involves the practices and different performance indicators from the organizations using the PPMS in order to manage their performance in a better way. This will help the other organizations in the same industry to follow the best practices organizations or set them as benchmark. The selection of the variables and indicators is the result of in-depth survey of the literature.

Research model. This study is about process performance management and the most of its part is related to key performance indicators selection process and the effect of performance indicators on the profitability of the organizations. The numbers of items in each performance indicator are developed in the qualitative part of the study where as the ultimate number of performance indicators are the result of factor analysis. The overall study has followed the framework presented in (figure 3).

Figure 3-The framework of the study



Sample and population. The target population of this study is the manufacturing sector of the Pakistan. In order to have a full extent of the whole population, we have selected four most important sub sectors from the Manufacturing sector (automobiles, electronics, sports and textiles). The data is collected from the top level management of the 200 manufacturing companies in Pakistan through a structured questionnaire out of which a stratified sample of 100 companies implemented the PPMS.

Data collection tools and techniques. This study is based upon the primary and secondary data. For this purpose the primary data is gathered through a structured questionnaire to be filled by top management of the selected manufacturing organizations of Pakistan. And In order to get the secondary data regarding the profitability of the organizations the annual reports of the organizations are analysed. The sources of the secondary data are the websites of the organizations, databases of the organizations and the website of the KSE. For the purpose of data analysis the statistical package SPSS 17 (statistical package for social science) and MS-Excel are used. We applied statistical techniques like, descriptive Statistics, Factors Analysis, AHP and Multivariate Regression Analysis

THE FINDINGS

Descriptive statistics. We have used steps of process performance management suggested by Oakland (2001). In order to conduct our analysis to check whether the manufacturing organizations in Pakistan are also using these steps for performance management. So for this purpose we include a question that whether the organizations are applying these steps for performance management. In our research instrument there were five options available in front of each step. The options include the 1= Never(0%), 2= Occasionally (1-30%), 3=Frequently(31-60%), 4=Most Times(61-99%), 5=Always(100%). From total 200 organizations visited, there were only 100 organizations from different industries of manufacturing sectors which are using the PPMS for their performance management. The descriptive statistics of the responses of the respondents is given in table (1).

Table 1- The descriptive statistic for the PPMS steps

No	PPMS	S.D	Mean
A)	Strategic process planning		
1	Define the organization vision, mission, and goals and strategies.	0.810	4.71
	Business process documentation		
2		0.832	4.61
3	The critical success factors are defined based on the organization's vision, mission, goals and strategies.	0.685	4.61
4	The core processes are defined on the basis of critical success factors.	0.836	4.57
	The Key performance indicators (KPI) are defined for the processes.		
5	Develop or identify the benchmarks and standard for the process performance.	0.962	4.54
6	Process evaluation	0.460	4.71
B)	Process Analysis and Compare the performance with the benchmarks or standards.		
1		0.826	4.64
	Skills needed to perform the tasks in the major processes are defined.		
2	Skills training for tasks required to design and manage major processes are provided.	1.056	4.68
3	Process managers use performance data to manage their processes.	0.826	4.64
4	Process improvement programs are in place to identify and improve problems and defects.	0.772	4.82
5	Feedback is generated and given it to employees.	1.071	4.54
	The responsible person is assigned for the performance of the particular process.		
6		1.654	4.07
7	Feedback is used to improve and develop the strategies to achieve the organization goals.	1.654	4.07
8		0.819	4.68

The results related to the questions for defining the vision, mission and goals and documentation of the business processes show that the most of the organizations using PPMS always follow these steps (mean=4.71, mean=4.61 respectively). The third step is related to "the critical success factors are defined based on the organization's vision, mission, goals and strategies". The results related to this question show that the most of the organizations using PPMS always follow this step (mean=4.61). Then in the next step of PPMS the organizations defined their core processes on the basis of previously defined CSFs. The most of the respondents from organizations which are using the PPMS are in point of view that they always follow this step (mean = 4.57). The step 5 of the PPMS is about defining the Key performance indicators (KPIs), which is very important step in the whole process. In this step the organizations define their key performance indicators on the basis of their competitive strategy and core processes. Each and every core process has different performance indicators. The respondent's responses show that the most of the organizations using PPMS are following this step (mean = 4.54). Then in the next step the organizations identify the benchmarks and standard for the process performance. These benchmarks can be processes within the organization and can be processes of competitors' organizations. The descriptive statistics according to this step shows that most of the organizations always follow this step (mean = 4.71). The first six steps of the PPMS are related to Strategic process planning phase. And the next eight steps are all related to second phase of PPMS which is Process Evaluation phase. The next step which is the first step of second phase of PPMS is about process analysis and comparing the performance with standard and benchmarks. The results related to this step (mean = 4.64) show that the most of the organizations always follow this step. The second step of process evaluation is about the identification of skill needed to perform tasks in the major process. The mean value of the responses related to this process is 4.68, which reveals that the most of the organizations using PPMS always follow this step. The next and third step of the second phase of PPMS is to provide the skill training to employees needed to perform the tasks related to design and manage the major processes. The results about this step reveals that the most of the organizations in Pakistan which are using the PPMS to manage their performance are following this step (mean = 4.64). The other steps involved in the second phase are; process managers use the performance data to manage their performance (mean = 4.82), process improvement programs are in place to identify and improve problems and defects (mean = 4.54), feedback is generated and given it to employees (mean = 4.07), the responsible person is assigned for the performance of the particular process (mean = 4.07) and feedback is used to improve and develop the strategies to achieve the organization goals(mean = 4.68). The results show that the organizations in Pakistan, which are using the PPMS, are following these steps "always" or "most of times".

Analysis of variance (ANOVA). Analysis of variance is conducted on the profitability variables to see difference between the firms which are using the PPMS and others which are not using the PPMS. This is also the second objective of the study. The results of the ANOVA are given in table 2.

Table 2- ANOVA for the profitability of the firms

		Sum of Squares	df	Mean Square	F	Sig.
Sales Growth	Between groups	214.436	1	214.436	.424	.517
	Within groups	41517.477	198	506.311		
	Total	41731.913	199			
Income Growth	Between groups	476.210	1	476.210	.440	.509
	Within groups	88750.957	198	1082.329		
	Total	89227.167	199			

ROA	Between groups	.034	1	.034	1.972	.164
	Within groups	1.433	198	.017		
	Total	1.467	199			
ROE	Between groups	4.416	1	4.416	2.730	.102
	Within groups	132.680	198	1.618		
	Total	137.096	199			

The results in the table 2 show that there is no significant difference between the firms who are implementing PPMS and those who are not applying PPMS with respect to profitability. The reason behind the same profitability is that the firms who have not applied the PPMS are using another performance management system for the management of their performance. The other reason behind the same profitability is that the firms selected for this study are the best performers in their respective industries; therefore they have not any significant differences with respect to profitability. Again the ANOVA is conducted on the Indices of performance Indicators to see difference between the choices of firms of manufacturing sector which are using the PPMS and which are not using the PPMS. The results of the ANOVA are given in (Zahid, 2012). The results of ANOVA on the basis of PPMS implementation show that there is significant difference between firms' choice of performance indicators. Both the firms which have applied the PPMS and which have not have significant differences with respect to financial, time, flexibility, delivery reliability, safety and employees satisfaction indicators of the performance.

AHP (Analytical hierarchy process). In order to achieve the third purpose of the study that which are the important inhibitors and facilitators behind the implementation of PPMS, we have applied the AHP (analytical hierarchy process). AHP is a multi-criteria decision making (MCDM) method. MCDM is a well-known class of decision making that was firstly come into to action by the Wind and Saaty (1980). The AHP actually converts respondents' preferences into ratio-scale weights that are pooled into linear additive weights for the alternatives. These resultant weights are used to rank the alternatives and thus assist the decision maker in making a strategic decision (Forman and Gass 2001). The major distinction of AHP is that it structures any complex and multi-dimensional problem hierarchically. By applying the AHP a matrix of pair-wise comparison of the elements can be constructed where the entries indicate the strength with which one element dominates another with respect to a given criteria. This scaling formulation is translated into largest Eigen-value problem which results in a unique vector of weights for each level of the hierarchy (always with respect to the criteria in the next level) which in turn results in a single composite vector of weights for the entire hierarchy. This vector measures the relative priority of all entities at the lowest level that enables the accomplishment of the highest objective of the hierarchy. These relative priority weights can provide guidelines for the allocation of resources among the entities at the lower levels of the hierarchy. These defined hierarchy levels can be helpful for the determining the number of key strategic decisions of the organizations (Wind and Saaty 1980). A detailed analysis of the data was conducted in order to prioritize the possible reasons behind the organizational decision about implementing the PPMS. The global weights are listed in Table 3. The factors of facilitator are divided into three Tiers based on the global weights. The first Tier is composed of critical factors. "The supportive culture" and "PPMS facilitate the competitive advantage" lie in this tier I. The business organization who intends to implement PPMS is required to make the ground for the supportive culture and ambition for getting the competitive advantage. There are four factors which belong to tier II (Supporting factors). These factors are "Want to involve people in measurement" "Top management commitment" "PPMS is an efficient system" "Clear understanding of the process". The management should enhance these factors to support the critical factors. Whereas in Tier-III items are "stakeholders' pressure" and "have only single option available".

Table 3-Global priority weight for facilitators

No	Facilitators	Weights
1	Supportive culture	0.22226
2	PPMS facilitate the competitive advantage	0.18456
3	Want to involve people in measurement	0.14062
4	Top management commitment	0.13857
5	PPMS is an efficient system	0.13069
6	Clear understanding of the process	0.1239
7	Stakeholder's pressure	0.04348
8	Have only single option available	0.01592

In this study there were 200 organizations visited, out of these 200, there were 100 such organizations which are not using the PPMM for managing their performance. So for the sake of the analysis there was a question of possible reasons behind not implementing the PPMM for organizational performance management. A detailed analysis of the data is conducted in order to prioritize the possible reasons behind the organizational decision about not implementing the PPMS. According to the global priority weights obtained through the AHP (Table 4), we observe that two factors namely "Have another performance system" and "not supportive culture" lie in Tier-I. This result indicates that the management of an organization not implementing PPMS should analyse the benefit of PPMS along with the existing system, and make the effort to make the supportive culture for PPMS and the least important reason is the performance measurement is the waste of time (weight=0.015).

Table 4-Global priority weights for Inhibitors

No	**Inhibitors**	**Weights**
1	Have another performance management system	0.2591
2	Not supportive culture	0.2179
3	Time / resource constraints	0.1342
4	Existence of inherited system("inertia")	0.1134
5	Lack of Top Management commitment	0.0913
6	Lack of process understanding	0.0790
7	Lack of clear mission / vision	0.0661
8	Performance measurement is waste of time	0.0387

Regression analysis. The calculation of the performance indicators indices is given in the (Zahid, 2012). The multivariate regression analysis is performed in order to check the impact of performance indicators indices on the profitability of the firms. The results of the multivariate regression are given in the table 5. The results indicate that the Financial Index has a positive significant impact over the organizations ROE (p value = 0.08). The Quality has a positive significant impact over the ROE (p value = 0.026) followed by the ROA (p value = 0.029) and sales growth (p value = 0.057). The Delivery Reliability has also a significant impact over the ROE (p value = 0.056). The Customer Satisfaction has a significant impact over the ROE (p value = 0.040). The employees' satisfaction has a significant impact on the ROE (p value = 0.056) and lastly the learning and growth index has a significant impact over the ROE (p value = 0.045). Measuring the financial performance, Quality performance, Delivery reliability performance, customer satisfaction performance and employees satisfaction lead to increase in the organizational return on equity (ROE), and the measuring the quality performance leads toward the improvements in the sales growth and Return on Assets (ROA) of the organizations.

Table 5-Regression coefficients for performance Indicators

Source	Dependent Variables	df	Mean Square	F	Sig.
Cost	Sales Growth	1	64.246	.128	.722
	Income Growth	1	755.176	.761	.386
	ROA	1	.001	.092	.763
	ROE	1	3.453	2.422	.124
Financial	Sales Growth	1	5.244	.010	.919
	Income Growth	1	911.255	.918	.341
	ROA	1	.001	.155	.695
	ROE	1	4.361	3.059	.085
Quality	Sales Growth	1	1887.949	3.753	.057
	Income Growth	1	517.646	.522	.473
	ROA	1	.047	4.951	.029
	ROE	1	7.362	5.164	.026
Time	Sales Growth	1	137.944	.274	.602
	Income Growth	1	728.303	.734	.395
	ROA	1	.006	.604	.440
	ROE	1	2.079	1.458	.231
Flexibility	Sales Growth	1	53.512	.106	.745
	Income Growth	1	8.512	.009	.926
	ROA	1	.001	.083	.774
	ROE	1	.827	.580	.449
Delivery Reliability	Sales Growth	1	291.168	.579	.449
	Income Growth	1	63.783	.064	.801
	ROA	1	.001	.146	.704
	ROE	1	5.371	3.767	.056

Safety	Sales Growth	1	98.778	.196	.659
	Income Growth	1	469.843	.473	.494
	ROA	1	.005	.554	.459
	ROE	1	1.935	1.357	.248
Customer Satisfaction	Sales Growth	1	606.422	1.205	.276
	Income Growth	1	676.445	.681	.412
	ROA	1	.022	2.366	.128
	ROE	1	6.237	4.375	.040
Employees Satisfaction	Sales Growth	1	305.118	.607	.439
	Income Growth	1	169.624	.171	.681
	ROA	1	.001	.117	.734
	ROE	1	5.363	3.762	.056
Social	Sales Growth	1	91.392	.182	.671
	Income Growth	1	5.092	.005	.943
	ROA	1	.015	1.548	.218
	ROE	1	.456	.320	.574
Learning & Growth	Sales Growth	1	41.010	.082	.776
	Income Growth	1	.120	.000	.991
	ROA	1	.005	.537	.466
	ROE	1	5.915	4.149	.045

SUMMARY AND CONCLUSIONS

The phenomenon performance measurement is used by the organizations in order to ensure that they are going on right direction and achieving their preset targets in terms of organizational goals and objectives. For this purpose the performance measures are used to evaluate and control the overall business operations. They are also used to measure and compare the performance of different organizations both within the organization and outside of the organization. The performance can be compared within the departments, sub departments, teams and individual processes (Ghalayini and Noble 1996). This study is an attempt to know that whether the manufacturing organizations of Pakistan are following all steps for PPMS as suggested by Oakland (2001). What are the potential inhibitors and facilitators regarding the implementing and not implementing the PPMS and what is impact of each performance indicator on the profitability of the organizations.

On the basis of the results and data analysis we can conclude that the manufacturing organizations in Pakistan are following all steps involved in process performance management system as suggested by the researchers. The most important facilitators behind implementing the PPMS are supportive culture and the "PPMS facilitate the competitive advantage" and the least important facilitator is stakeholder's pressure on the firms to implement the PPMS, which means that the there is no pressure from any stakeholder on the company to implement the PPMS. The most important inhibitors behind not implementing the PPMS are that the firms have another performance management system and not supportive culture in the organization. And least important inhibitor is "performance management is the wastage of time", which means that organizations which have not applied the PPMS, do not consider that the "performance management as wastage of time" is the important inhibitor behind not implementing the PPMS. And the companies which have not applied the PPMS have another performance management system or they do not have supportive culture for implementing the PPMS.

The results of regression show that the Measuring the financial performance, Quality performance, Delivery reliability performance, customer satisfaction performance and employees satisfaction lead to increase in the organizational return on equity (ROE), and measuring the quality performance also leads toward the improvements in the sales growth and Return on Assets (ROA) of the organizations. In order to simplify our results we can say that by measuring the overall organizational performance has a significant impact over the profitability of the organizations significantly. The results of ANOVA show that the companies who have applied the PPMS and who have not applied the PPMS have the same profitability. There is not any significant difference between the selected industries regarding the using of performance indicators except the textile and automobiles regarding the use of learning & growth performance indicator.

From these results we conclude that KPI performance measurement importance could also be expressed by next statement: KPI tells you where performance has been in the past, where it is now, and perhaps more useful, where performance is likely to be in the future " (Smith, 2001).

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Integrated Management Systems in the Food Sector: Insights from a Dairy Plant

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ABSTRACT

Purpose. This research focuses on the integrated adoption of the quality, environmental and food safety management systems standards in a dairy plant aiming to explore the benefits and constraints of integration with regard to sector and size.

Design/methodology/approach. A single case is studied in depth based on the literature findings in order to understand the integration of management systems in a food manufacturing setting by exploring why and how the integration evolves.

Findings. This case shows that sector-specific characteristics have a significant impact on the integration process. Motivated by the perceived integration benefits the case company is planning to further integrate the environmental dimension on the existing platform.

Research limitations/Implications. The analysis of more food companies of different sizes would reflect a wider sector-specific perspective of integration. Conclusions drawn intend to motivate food industry managers to streamline the quality, environmental and food safety management processes following an integrated approach. It is also shown how sector-oriented research brings to light the opportunities for sustained business that come from the integrated management systems adoption.

Originality/value. To the best of the authors' knowledge, this is the first in-depth study on the adoption of an integrated quality and food safety management system by a single food manufacturing unit. The case of the dairy plant visualises the contribution of an integration approach to the effective management of the critical food safety and quality operations and the significant environmental aspects.

Keywords: integrated management system, food safety, environment, quality, management standards, sector, dairy

Article Classification: Research Paper

INTRODUCTION

Food sector is thriving even in the current challenging era. However, high market competition leads food producers to a quest for the most efficient managerial practices. According to the latest ISO survey (ISO, 2013) the number of ISO 22000 certified organisations shows a significant "jump" (up 20 % on 2011), with Greece being in the third place world-wide with 1097 certified companies. Moreover, a shift is noted from the former prevailing products' standards to the standards of processes (Vladimirov, 2011). Trienekens and Zuurbier (2008) suggest that proliferation of standards in the food industry can be addressed by a "modular system" encompassing all kinds of standards and norms, which reflects the integrated management system (IMS) concept.

The ISO 22000:2005 standard integrates the requirements defined by the ISO 9001:2000 standard and the methodology used for the hazard analysis and critical control points (HACCP) based on the systems approach (Teixeira and Sampaio, 2013). Moreover, ISO 22000:2005 introduces a supply chain approach to communication both upstream and downstream across the food chain, whereas ISO 9001 refers to the communication of the focal company with the immediate suppliers and customers. It is stressed that the food safety management system (FSMS) will be more effective "if established, operated and updated within the framework of a structured management system and if integrated in the overall organisation management activities" (Teixeira and Sampaio, 2013).

In this case study, a key food safety concept, traceability, is seen as a process that connects all production steps both within the company and throughout the agri-food chain in order to track and trace possible risks in food safety and quality issues, while incorporating social and environmental aspects at the same time (Augustin et al., 2013; Bosona and Gebresenbet, 2013). Furthermore, this case aims to highlight the potential of integration in addressing interrelated requirements of generic and sector-specific standards by focusing on the challenges and the anticipated benefits from the incorporation of the environmental management dimension.

Within the outlined context, a literature review is conducted in the next section to identify possible relationships between food safety, quality, environmental and occupational health and safety management in the respective standards' adoption. The case research method is presented in the third section. In the fourth section, the case is analysed in line with the literature review findings. Next, the results are discussed and finally conclusions are drawn.

LITERATURE REVIEW

A literature snapshot follows whereby the IMS features are firstly described in general and a focus to the food sector is given later on. The integration strategy being one of the main IMS features refers to the scope of standardization and the management systems (MSs) implementation sequence. In general, four options of implementation sequence are identified: first the quality management system (QMS), then other MSs; first the environmental management system (EMS), then other MSs; QMS and EMS simultaneously, then other MSs; and a common IMS core, then IMS modules (Karapetrovic, 2002).

The proliferation of MSSs and the lack of an IMS international guideline have shifted the research interest towards developing generic approaches for the integration of multiple MSs (see, e.g., Karapetrovic, 2003; Zeng et al., 2007). However, the vast majority of organizations integrate by using widely known tools, such as process mapping and the analysis of MSSs common elements (Bernardo et al., 2011).

To assess the degree of integration a three levels scale is commonly used (Asif et al., 2010a**;** Bernardo et al., 2009); no integration (keeping the systems separate), partial integration (some components of the MSs being integrated), and full integration (all components of the MSs being integrated). Sampaio et al. (2012) proposed four evolution levels towards complete integration: documentation integration, management tools integration, common policies and goals, and a common organizational structure.

According to Khanna et al. (2010) some of the factors that motivate companies to integrate are the customers' pressure, the need for competitiveness and image improvement, the continuous improvement culture, the costs and redundancies reduction, the sharing of documentation, the quest for synergies and the employees' awareness enhancement.

The integration is proven beneficial to the internal cohesion, the use and performance of the systems, the corporate culture, the image and strategy, and the stakeholders' implication (Khanna, 2010; Simon et al., 2012). Furthermore, the level and the benefits of integration are found to have a positive effect on innovation and competitive advantage (Simon and Petnji Yaya, 2012; Wagner, 2009).

Impediments to implementing integration are the lack of integration guidelines, the differences in the models for implemented standards the lack of management commitment, the demand for training and cultural change, the lack of skilled auditors and consultants, the lack of employees motivation and human resources (Simon et al., 2012).

The internal and external audits can be evaluated as fully, partially or not integrated by assessing the integration level of the respective auditing elements, i.e. plan, team, guideline, method, simultaneity, frequency, and report (Bernardo et al., 2010).

Integration of management systems in the food sector. Evidence shows that about 80% of the food companies in Spain implemented first a QMS, which facilitated the introduction of the FSMS (Escanciano et al., 2014). In the same survey 32% of the firms were ISO14001 certified with almost 95% of them having their MSs integrated either totally (73.2%) or partially (21.2%). De Oliveira Matias et al. (2013) contend that the integrated adoption of the food safety and occupational health and safety (OHS) standards enhances both the food safety and the prevention of occupational risks in a complementary manner, since the measures taken for food hazards mitigation coincide with the occupational hazards preventive actions. Likewise, several researchers highlight the increased compatibility of the occupational health and safety with the environmental management norm (Kraus and Grosskopf, 2008; Salomone, 2008; Sampaio et al., 2011).

Due to their prior experience and the compatibility of quality and food safety standards, ISO 9001 adopters are expected to be the first to integrate food safety within their quality system (Chountalas et al., 2008). This is confirmed by a survey where out of 97 Greek food companies that were ISO 9001 certified, 83 were found to have implemented the HACCP methodology, nine were ISO 14001 certified and two have adopted the European Foundation for Quality Management (EFQM) Excellence Model (Fotopoulos et al., 2010).

In the extant body of literature there is a limited number of cases on the integration of food safety with other management systems. Fresner and Eisenhardt (2004) study a brewery IMS and refer to the assignment of hygienic tasks to the environmental manager and the adoption of food safety practices, such as raw materials supply from integrated control farming. Asif et al. (2010a) study an IMS case in a dairy plant, where HACCP is implemented as an independent technical program. Recently, Satolo et al. (2013) analyzed a sugar plant case where quality is integrated with the environmental management having no food safety standard jointly or separately adopted. Furthermore, there is a paucity of research on the approach to integrate food safety MS with other MSs. Proto et al. (2013) address this gap by proposing a model for the integration of MSs and product standards in the agri-food sector. A list of case studies on IMS in the food sector with information on the scope and strategy of integration is presented in Table 1. In the majority of the cases the QMS is either implemented first or concurrently with the other management systems.

Table 1 - Integration strategies in the food industry

Authors	Country	Field of activities	Integration strategy
Asif et al., 2010a; Asif et al., 2010b	Pakistan	Dairy plant	QMS-EMS-OHSMS HACCP
Bernardo et al., 2013	Greece (2)	Food and beverages Food	QMS-EMS-OHSMS-FSMS EMS-QMS-FSMS
Claver et al., 2007	Spain	Farming cooperative	QMS-EMS-EFQM-BRC*
Fresner and Engelhardt, 2004	Austria	Brewery	first QMS, then EMAS and ISO 14001
ISO, 2008	Spain	Beverages	QMS-EMS-FSMS
Kheradia and Warriner, 2013	Canada	Warehouse	FSQMS
Länsiluoto and Järvenpää, 2012	Finland	Food manufacturing	QMS-EMS-PMS
Nowicki et al., 2013	Poland (4)	Bakery and confectionery/ Beverage cans and bottles/ wet spices/ soluble coffee	QMS-FSMS-BRC* QMS-FSMS QMS-EMS-OHSMS-BRC-IFS*-FSMS QMS-HACCP-IFS
Renzi and Capelli, 2000	Italy	Dairy production	QMS-EMS
Proto et al., 2013	Italy	Processed tomatoes	QMS-FMS-BRC-IFS
Satolo et al., 2013	Brazil	Sugar and ethanol	First QMS and then EMS / IMS after several years

(*): BRC (British Retail Consortium) and IFS are retailers' food safety and quality standards

Dairy factories are energy consuming and produce large amounts of wastewater with a high organic load (González-García et al., 2013; Lagodimos et al., 2007). Boudouropoulos and Arvanitoyannis (1999) predicted a high ISO 14001 uptake in the food industry, since relative environmental issues, such as wastewater treatment, can be effectively managed by adopting the standard. Moreover, Augustin et al. (2013) claim that "minimizing waste at all points across the entire supply chain will be a hallmark of a sustainable dairy industry in the future".

However, many food manufacturers show a low perception level of their activities' impact on the environment, which may be attributed to the lack of environmental knowledge and awareness and the confusion between hygienic and environmental management practices (Massoud et al., 2010). In compliance with these findings, Djekic et al. (2014) studied seven Serbian dairy plants and found only one of them with an environmental management system in place.

ISO 22000 certification is meant to improve and guarantee the consumer needs and expectations, to satisfy customer requirements, to support marketing arguments and to assure full supply chain involvement in the food safety process (Teixeira and Sampaio, 2013) by establishing trust and enabling the integration of food safety with other management systems and, hence, reducing the need for customer audits (Escanciano et al., 2014). It is emphasized that the retailers - at the end of the agri-food chain - act as primary drivers for the adoption of management systems standards and the MSs integration in the food industry (Kafel and Sikora, 2014; Soderlund et al., 2008).

Kafel and Sikora (2014) found that food companies with certified management systems acquire higher maturity level and, hence, increased financial performance. Furthermore, the combined implementation of the quality and food safety MSs is found to contribute significantly to both food product quality and operational performance (Kafetzopoulos and Gotzamani, 2014).

Among the principle constraints to ISO 22000 certification are the lack of information and the unawareness of its benefits (Escanciano et al., 2014). Regarding the auditors' competence in the food industry it is argued that it is limited to maximum two management systems with non-compliance assigned to the different management systems (Nowicki et al., 2013).

When viewed from the supply chain perspective the environmental management integration is considered to yield both a competitive advantage and more efficient processes by "understanding the conversion of raw materials into finished goods" (Handfield et al., 2005). Environmental management has become part of the food safety and quality agenda, due to the impact of pesticides, nitrogen and phosphate concentration in water and soil to both food safety and the environment (Grekova et al., 2014). The integration of the EMS into the Performance Management System (PMS) using the Balanced Scorecard (BSC) in a large food manufacturing firm shows how the environmental standard may assist to the performance appraisal by applying integration principles (Länsiluoto and Järvenpää, 2012). Nestlé factories use a TQM framework complemented by environmental and social performance aspects to evaluate the quality, safety, cost, flexibility and sustainability of suppliers' processes (Hamprecht et al., 2005).

Food traceability refers to "all stages in the food supply chain so that the product can be checked for safety and quality control, traced upward, and tracked downward at any time required" (Bosona and Gebresenbet, 2013). More specifically, regarding dairy products consumers it is stressed that traceability is anticipated to address sustainable development concerns about animal welfare, ethical production methods and environmental issues (Augustin et al., 2013). Zhang et al. (2010) reflect the streamlining of the IMS with traceability when they suggest integrating internal traceability with management systems, meaning food safety (hygiene) management, quality management and environmental management, within a production unit.

Size seems to influence integration, since small companies have limited internal resources, both financial and human, to adopt food safety, quality and environmental standards (Grekova et al., 2014; Karaman et al., 2012; Vladimirov, 2011). In this vein, Karipidis et al. (2009) propose the release of an intermediary quality management standard to be adopted by small companies. In particular, as regards the wastewater effluent treatment, it is common that small scale cheese mills have no specific equipment for whey processing and, thus, whey stream is sent together with the wastewater for treatment (González-García et al., 2013). The influence of local business and social structures to small firms is also highlighted (Bourlakis et al., 2014; Grekova et al., 2014). Local sourcing and selling is also linked to the increased profit-margin of micro-manufacturers (Bourlakis et al., 2014). Comparing micro, small and medium-sized firms Bourlakis et al. (2014) contend that small firms excel in sustainability performance. Medium-sized firms are found to be closer to the large firms in terms of environmental practices (Grekova et al., 2014). As regards traceability, it is argued that micro and small food producing and processing companies lack financial capacity, traceability information and knowledge to implement it (Bosona and Gebresenbet, 2013; Bourlakis et al., 2014).

RESEARCH METHODOLOGY

This research uses a single case to enable the understanding of a complex phenomenon, such as integration, through direct observation without experimental control or manipulation considering both temporal and contextual dimensions (Meredith, 1998). However, it should be noted that case research aims at the analytic, not the statistical, generalization of its findings by investigating "decisions, programs, the implementation process, and the organizational change" (Yin, 2003).

Data was drawn from multiple sources, i.e. interviews, records and observations on-site to ensure triangulation (Miles and Huberman, 1994). A semi-structured interview protocol was used. The questions were adapted from the case research protocol of Asif et al. (2010a). Using existing questions is a recommended practice, which facilitates replicability of research and comparability of results (Bryman and Bell, 2007). Questions are addressed to employees of different ranks to reduce "elite" bias (Miles and Huberman, 1994). Interviews and observations data was collected through taking notes while the information was filtered by relevance to the IMS features. Repeated contact with the company also by phone and e-mails was used to clarify any points that were missed during the visits. Literature on technical and managerial topics related to the case was reviewed in order to avoid any possible misinterpretations and increase validity of data.

CASE ANALYSIS AND FINDINGS

The case company is a small dairy mill. Prior to its current ownership, the firm was a family business. The company is currently certified to the ISO 9001:2008 and the ISO 22000:2005 standards. Its products are certified by AGROCERT, which is the national standardisation and certification body for agricultural products and processes.

The new owner's expertise in the food sector and, particularly, in the quality management field was the foundation for the top management's commitment to the quality and food safety management system. According to the interviewees, both the top management and the employees, the firm's culture and the operating conditions have been quality-oriented since the ownership transition. From the external perspective, top management considers the integration of its management systems a novelty in the food industry. Thus, with the fusion of the environmental dimension the firm anticipates to gain competitive advantage by being a front-runner in creating a three-dimensional IMS.

While the integration strategy and approach was investigated, the QMS was found to be implemented first. Yet, the IMS was based on the ISO 22000 standard's requirements, as clearly documented by the IMS manual and corroborated by the interviewees. The procedures were integrated complying with the common elements of the standards. The employees that were assigned to prepare and keep track of the IMS documents and records were not aware of any externally sourced or customized model adopted to integrate the MSs. Management review is conducted twice a year for the food safety MS whereas for the quality MS only once a year. The internal audits are integrated while the third-party audits are performed separately. More specifically, a single team with a unified plan performs the internal audits twice a year while external audits are conducted by different auditors in different time frames. Therefore, taking into account the documents, the records and the interviewees' reports the MSs are considered partially integrated. A summary of the core MS elements' integration level is provided in the following table (Table 2).

Table 2 - MS elements and corresponding integration level

MS element	Fully integrated	Partially integrated	Non-integrated
MSs policy			
MSs manuals			
MSs procedures			
Management review			
Internal audits			
External audits			

Training and extra time were needed for the employees to understand and adopt the integration principles. In addition, a rather increased frequency of audits by the authorities was noticed at the time of the multiple MSs certification. Moreover, it is stated that the three public auditing bodies that share responsibilities in the agri-food chain control often detect conflicted non-conformities. Thus, they assigned different significance degree to the Critical Control Points and requested different flowcharts. It was found that in such cases of state authorities' non-compliance audits the company responded in a reactive way. This was corroborated by both the internal and the third-party certification audits reports, where the detected non-conformities were sometimes irrelevant to the authorities' perspective.

The interviewees reported better understanding of the processes, improved internal communication, and organizational structure, and enhanced corporate image. However, when inquired about the introduction of the environmental component to the existing IMS, the executives distinguished the high cost for the necessary environmental measures and the lack of state funding as the main withholding factors.

At the time of the IMS implementation a barcode traceability system was installed in the framework of a state subsidized project with the aid of an IT consultant. This was highlighted as a major improvement step by top management as a huge amount of paperwork was replaced by an electronic data base. Tracing of batches of milk and other raw materials made processes more transparent and established trust with the authorities. However, this measure was initially seen as a barrier by management and workers, since it required the adoption of a different perspective in collecting information and had to be accompanied by precise identification of tracking nodes backwards to the bulk milk production.

Senior executives consider that the IMS performs at a high level. However, when asked how they support this perception, they found it difficult to explain. Moreover, any relative evidence was missing, that could establish the quantification and the monitoring of the IMS results.

Currently, the highly saline organic waste flows directly to the wastewater treatment plant. According to the interviewees the waste treatment is proven inadequate to handle the specific load and properties of the wastewater. Top management traced several problems in the operation of the waste treatment that range from the original design of the treatment plant to the input of waste. Measures, such as reuse through condensation, recycling, and modifications in the plant are recognized as potential mitigation solutions. However, senior managers emphasize that the cost of equipment, transportation and operation impedes the improvement measures due to the small size of the company and the current economic situation. In the following figure (Fig. 1) the case company's operations are illustrated in the form of a flowchart depicting the inputs, the management and production processes and the outputs of the dairy plant.

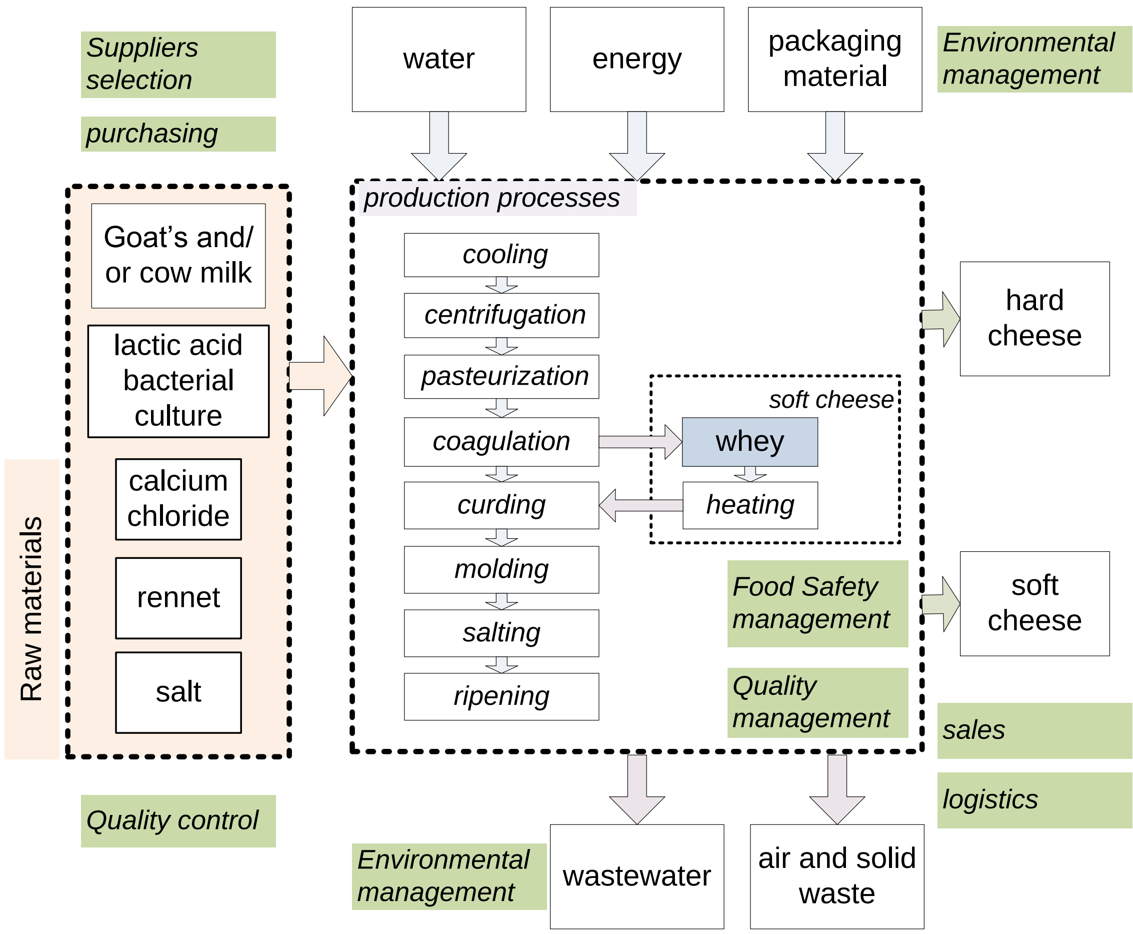

Figure 1 – Dairy plant: inputs, processes, outputs

DISCUSSION

The shift in culture and operations, which followed the proprietorship transition in this case, is supported by prior research findings of quality and food safety management limitations due to family-ownership in dairy plants (Karaman et al., 2012; Vladimirov, 2011). Top management commitment is identified as the primary integration driver, in line with pertinent research (Sampaio et al., 2012). Moreover, corporate management culture encompassing innovation and the anticipation to gain competitive advantage motivated the firm to integrate, as elsewhere highlighted (Simon and Petnji Yaya, 2012; Wagner, 2009).

In this case the integration pattern is found identical to the most common as identified in literature, i.e. 'QMS first and then other MSs" (Karapetrovic, 2002). However, sector specific prior experience and familiarity of the firm with the HACCP framework made it easier for the ISO 22000 standard to be used as the basis for the integrated management system instead of the ISO 9001 standard. The fact that both standards follow the process approach made the two components of the IMS fully compatible and fusible. However, compatibility issues may arise with the adoption of the ISO 14001 standard, since this is based on the PDCA cycle (Karapetrovic, 2003).

The integration approach seems to be operational-oriented, since the documentation is based on the common elements of the standards. Yet, the IMS improvement actions are based on decisions taken at the strategic level and aimed at addressing both the internal weak points and the needs of the stakeholders. This indicates a holistic view of the IMS, which is ensured by a strategic systems approach in compliance with prior research (Asif et al., 2010a). However, there are certain weak points that need to be addressed, such as the reactive approach to the authorities' requirements.

Time and cost for the IMS adoption and human resources training are among the common barriers encountered in this case as well (Simon et al., 2012). In addition, in this case, the low level of integration awareness by the regulatory authorities appears to have caused a bureaucratic burden to the company being obliged to deal with conflicted audits. Having to reach out for help to solve the traceability issue the company realized its size-related weaknesses, such as limited technical and human resources. This understanding, along with the positive experience gained by the outsourcing, may contribute to the successful implementation of the next integration step. In line with prior research (Claver et al., 2007; Grekova et al., 2014), it is found, also in this case, that environmental management requires legislative and technical knowledge background and expertise that a small company has to outsource, probably in cooperation with other food processors.

As regards the IMS expansion, in the case under study the significance of the environment impacts is recognized. However, the progress in the adoption of environmental measures seems rather slow. Sector-related barriers to the EMS adoption are detected in this case, in line with prior research (Claver et al., 2007). The specific type of the dairy waste, which makes it costly to manage, and the need for reduction measures to be taken before the waste enters the treatment plant, such as reclamation of whey protein and the potential use of the waste to produce biogas, are identified as focal points that need to be managed. These issues combined with the small size of the majority of dairy plants need to be treated in a "collective" way with measures planned in a supply chain perspective (Grekova et al., 2014). As such, logistics outsourcing would enhance quality management (Gotzamani et al., 2010) and reduce the waste treatment and recycling cost due to economies of scale (Bourlakis et al., 2014).

The dairy mill, like all other agri-food organisations, has to comply with several control bodies' requirements and satisfy the needs of various stakeholders. In this case, the integrated management approach has proven useful in addressing those diverse requirements in a synergistic way. However, it has become evident that the company assesses the integrated management system's performance in a qualitative, rather incentive way. In order for the firm to have a clear view of the IMS continuous improvement, performance needs to be assessed by the setting and monitoring of objectives and targets that would quantify and document the results in a substantive way (Claver et al., 2007; Van der Spiegel et al., 2005).

The case company addresses the needs of its customers and the food inspection bodies while gradually raising its environmental awareness. However, another significant stakeholder, the employee, seems to be neglected. The harmonized adoption of the occupational health and safety management norm (Occupational Health and Safety Assessment Series - OHSAS 18001:2007) into the existing IMS would enhance its excellence in prevention, in line with prior research (Santos et al., 2013). Furthermore, health and safety management integrated with energy and environmental impacts monitoring and targeting entails triple bottom line consideration towards corporate sustainability in a food manufacturing unit (Olajire, 2012).

As regards traceability, the transition from the paper-trailed to the IT-based tracking and tracing system improved productivity and regulatory compliance bridging quality and food safety management aspects. This system may further assist to the tracing of environment-related aspects of food processes, i.e. herbicides used in farming, animal feed, water quality, in line with previous research (Hamprecht et al., 2005; Zhang et al., 2010).

The authorities' audits are found to be of higher significance and severity, while the regulatory framework for the food industry is complex and hard to comply with. Voluntary standards' third-party audits seem to work only complementary. Furthermore, the integrated internal audits are unable to assure compliance, since the training and expertise needs of internal auditors are costly and difficult for the company. Thus, the small firm size has a negative impact on the system's improvement, in compliance with prior research (Grekova et al., 2014; Karaman et al., 2012; Karipidis et al., 2009; Vladimirov, 2011).

From the environmental perspective, the company under study being fully aware of the dairy plant effluents' highly polluting load seeks sustainable solution for the management of its waste. This contradicts with the low level of environmental awareness of food manufacturers, particularly of the small ones, which is emphasized by researchers (see e.g. Karaman et al., 2012; Massoud et al., 2010). Regardless of the degree of awareness, additional support is needed for the small food companies, such as the standards "adjustment" depending on firm size (Karipidis et al., 2009), state funding and cross-organizational collaboration (see e.g. Fotopoulos et al., 2010).

CONCLUSION

This research aimed to shed light on the integrated adoption of generic and sector-specific standards. Concepts such as innovation and competitive advantage seem to motivate integration of the MSs in the food company. However, there are technical and managerial challenges that need to be addressed for the adoption of the environmental management standard particularly in a small company.

Size and sector-related constraints are found to condition integration. SMEs need to outsource technical and managerial support for assuring the efficient and effective implementation of processes, such as the ones related to the environment, that demand high level of skills and resources. In addition, costly environmentally proactive measures can be taken in cooperation with other companies similar in size and activity.

In the same line of reasoning, food commodities producers are, unlike other industries, strongly attached to all predecessors and antecedents of the agri-food supply chain. This raises many sector-specific issues that need to be addressed in order to facilitate the integration of management systems. Certain such particularities, as in the audits and in the tracing of inputs, processed commodities and outputs, are identified in the case under study. In this context, traceability is indicated as a potential link of management sub-systems in order to achieve sustainable integrated management. However, further research from the supply chain perspective would contribute to the understanding of the way this streamlining potential can be exploited.

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Quality Scoreboard: a proposal

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ABSTRACT

Purpose. The assessment of "macroquality" or the assessment of the degree to which the quality practices are implemented in a country or a region should not be only based on "tangible" indicators such as the number of certified companies according to the ISO 9001 or ISO 14001 standards, or others. By adopting only these two indicators (or similar ones) a large amount of companies, those ones that are not certified, are not considered when assessing the "macroquality". Less tangible features, such as the number of persons trained in quality management or the number of members of quality management associations among other features, contribute themselves and seem appropriate to assess the level of "macroquality". This paper intends to report a "macroquality" index that is composed by tangible and less tangible features, concerning the quality practices implementation concept- The Quality Scoreboard.

Design/methodology/approach. An expert's panel was conducted with the aim of evaluating a set of several indicators that could be used to assess and to monitor the "macroquality" level of a country. Nine tangible indicators were proposed and been analysed by the experts' panel according to an importance scale (1 to 5). Additionally, the experts were encouraged to propose other indicators that could reflect the quality state-of-the-art of a country or region.

Finding*s*. Experts find that tangible indicators are not enough to express the level of "macroquality". According to the results, less tangible features should be considered too. A total of 43 indicators were suggested by the experts. Among them, the following suggested indicators should be highlighted: the number of persons trained in quality management, the number of members of quality management associations, the number of quality related courses at the universities and the number of certified auditors. Based on the survey results a Quality Scoreboard was developed.

Originality/value. As far as we were able to find out this is the first attempt to develop a Quality Scoreboard, as it had been already done to innovation. This new approach allows one to characterize the quality state-of-the-art of a region, based on a set of potential "quality indicators". Furthermore, the results provide an additional important contribution to the worldwide study of quality approaches diffusion and evolution.

Keywords: Macroquality, Scoreboard, Indicators

INTRODUCTION

Some concepts are intrinsically and inherently difficult to evaluate. This fact relates to the identification and the number of variables involved, to the lack of data concerning some variables, to scarce information concerning the relationships between them and to the relative weighing to be ascertained and ascribed to each variable. Among such concepts one may consider happiness, innovation, cleverness, quality of live and “macroquality”.

Some tools have been developed, recently, to assess “macroquality” such as the I9S proposed by Sampaio *et al.* (2014). This tool is focused on the evolution and dissemination of ISO 9001 certified companies considering data from the current year and the last two previous years. A tool enabling the assessment of “macroquality” of a country or region enables benchmarking between the evaluated countries allowing the identification of features that impact on global quality. This tool should consider features concerning the actual “macroquality” and features that consider the roots of potential future “macroquality”. Furthermore, all agents or players involved in quality practices should be present in that tool. No such embracing instrument, considering so many variables and features had been reported as of our days.

The initial attempts aiming at the assessment of the degree of quality of countries have been mainly performed by studying the diffusion of ISO 9000 certifications. On this matter one should mentioned the work developed by Franceschini *et al.* (2006) and Sampaio *et al.* (2009). Other studies, based on a similar methodology, focused on the ISO 14000 certifications diffusion (Corbett and Kirsh, 2001). These studies provided the authors with the data to develop forecasting models of the standards certifications diffusion as reported by Franceschini *et al.* (2004), Marimon *et al.* (2009) and Sampaio *et al.* (2011).

These methodologies were later found to be narrow approaches to evaluate the real “macroquality” concept since they do not consider other features than those concerning the certification of organizations. By one side, the adoption and certification by an organization of the ISO 9001 standard does not assure the quality of the products or services provided. The certification only assures that a peculiar organization is able to achieve the intended degree of quality fulfilling the customers’ expectations and specifications. On the other side, a country or region is not solely the sum of the organizations within. Concerning the “macroquality” concept the organizations are just the “end product” and a set of aspects *a priori* should be considered.

The Innovation Union Scoreboard (IUS), previously known as the European Innovation Scoreboard, is an indicator aiming at the assessment of an equally notorious concept difficult to evaluate: the degree of innovation achieved by a country (IUS, 2014). This Scoreboard considers axes, dimensions and indicators to monitor the innovation between the European countries. The European Quality Scoreboard, reported in the current paper, adopts the same methodology and philosophy underlying the IUS.

MATERIALS AND METHODS

An expert’s panel was conducted with the aim of evaluating a set of several indicators that could be used to assess and to monitor the “macroquality” level of a country. Nine tangible indicators were proposed and had been analysed by the experts’ panel according to an importance scale (1- “Less important” to 5- “Most important”). Additionally, the experts were encouraged to propose other indicators that could reflect the quality state-of-the-art of a country or region. The assessed indicators are presented by Table 1.

Table 1: Assessed indicators by the experts group.

Indicator ID	Indicator
Indicator 1	Number of ISO 9001 certificates/1000 inhabitants
Indicator 2	Number of ISO 14001 certificates/1000 inhabitants
Indicator 3	Number of OHSAS 18001 certificates/1000 inhabitants
Indicator 4	Number of members of the national quality association
Indicator 5	Number of accredited laboratories/1000 inhabitants
Indicator 6	Number of persons with training in quality/1000 inhabitants
Indicator 7	Number of certified products
Indicator 8	ISO 9001 European Scoreboard
Indicator 9	Number of EFQM finalists prize and award winners

IBM SPSS version 21 was the software adopted to perform data analysis.

RESULTS AND DISCUSSION

Experts find that tangible indicators are not enough to express the level of "macroquality". According to the results, less tangible features should be considered too. A total of 43 indicators were suggested by the experts. Among them, the following suggested indicators should be highlighted: the number of persons trained in quality management, the number of members of quality management associations, the number of quality related courses at the universities and the number of certified auditors. Based on the survey results a Quality Scoreboard was developed. Table 2 summarizes the results achieved by each surveyed indicator. A total of 25 experts answered the questionnaire and 56% of them did proposed other indicators than those listed in Table 1. Table 2 presents the mean results and the corresponding standard deviation according to the variable transformation described in the previous section.

Table 2: Mean and standard deviation by indicator.

	Indicator ID								
	1	2	3	4	5	6	7	8	9
Mean	4,0	3,3	3,1	3,6	3,6	4,2	3,5	3,5	3,8
SD	0,91	0,84	0,81	1,04	0,87	0,91	1,05	0,92	1,19
Maximum	1	1	1	1	2	2	2	2	2
Minimum	5	4	4	5	5	5	5	5	5

According to Table 2, Indicator 6 (Number of persons with training in quality/1000 inhabitants) is rated as the most important whereas Indicator 3 (Number of OHSAS 18001 certificates/1000 inhabitants) is rated as the least important of the surveyed indicators. Considering the standard deviation concerning these indicators (low values) one may conclude that there is a considerable homogeneity between the experts opinion.

The assessed Cronbach α (estimation of the test scores reliability) is 0,824 which denote a high internal consistency of the scale.

Table 3 presents the Spearman correlation within variables. Spearman correlation was adopted over Pearson correlation since the data sets were based on less than 30 answers. It is worth noted the correlations between indicators 1 (Number of ISO 9001 certificates/1000 inhabitants), 2 (Number of ISO 14001 certificates/1000 inhabitants) and 3 (Number of OHSAS 18001 certificates/1000 inhabitants). This fact is somehow expected and may be justified since it concerns with different features from a same indicator (Number of ISO 9001/ISO 14001/ OHSAS 18001 certificates per 1000 inhabitants). A half of the correlations are meaningful at a 0,01 level. Strong correlations were also assessed between the indicators 2 (Number of ISO 14001 certificates/1000 inhabitants)↔8 (ISO 9001 European Scoreboard), 5 (Number of accredited laboratories/1000 inhabitants)↔7 (Number of certified products) and 6 (Number of persons with training in quality/1000 inhabitants)↔9 (Number of EFQM finalist's prize and award winners).

Table 3: Spearman correlation (*meaningful at 5%; ** meaningful at 1%)

Indicator ID	1	2	3	4	5	6	7	8	9
1	–	0,650**	0,449*			0,450*		0,447	
2		–	0,757**		0,402*			0,558**	
3			–						
4				–			0,447*		0,530**
5					–		0,674**	0,507**	
6						–		0,418*	0,537**
7							–		
8								–	0,404*
9									–

Figure 1 displays the non-summarized results by each indicator (counts per 1-5 scale). It should be pointed out that none of the respondents considered indicators 2 (Number of ISO 14001 certificates/1000 inhabitants) and 3 (Number of OHSAS 18001 certificates/1000 inhabitants) as the most important. In contrast, indicator 5 (Number of accredited laboratories/1000 inhabitants), indicator 6 (Number of persons with training in quality/1000 inhabitants), indicator 7 (Number of certified products), indicator 8 (ISO 9001 European Scoreboard) and indicator 9 (Number of EFQM finalists prize and award winners) were not classified as the least important by the respondents.

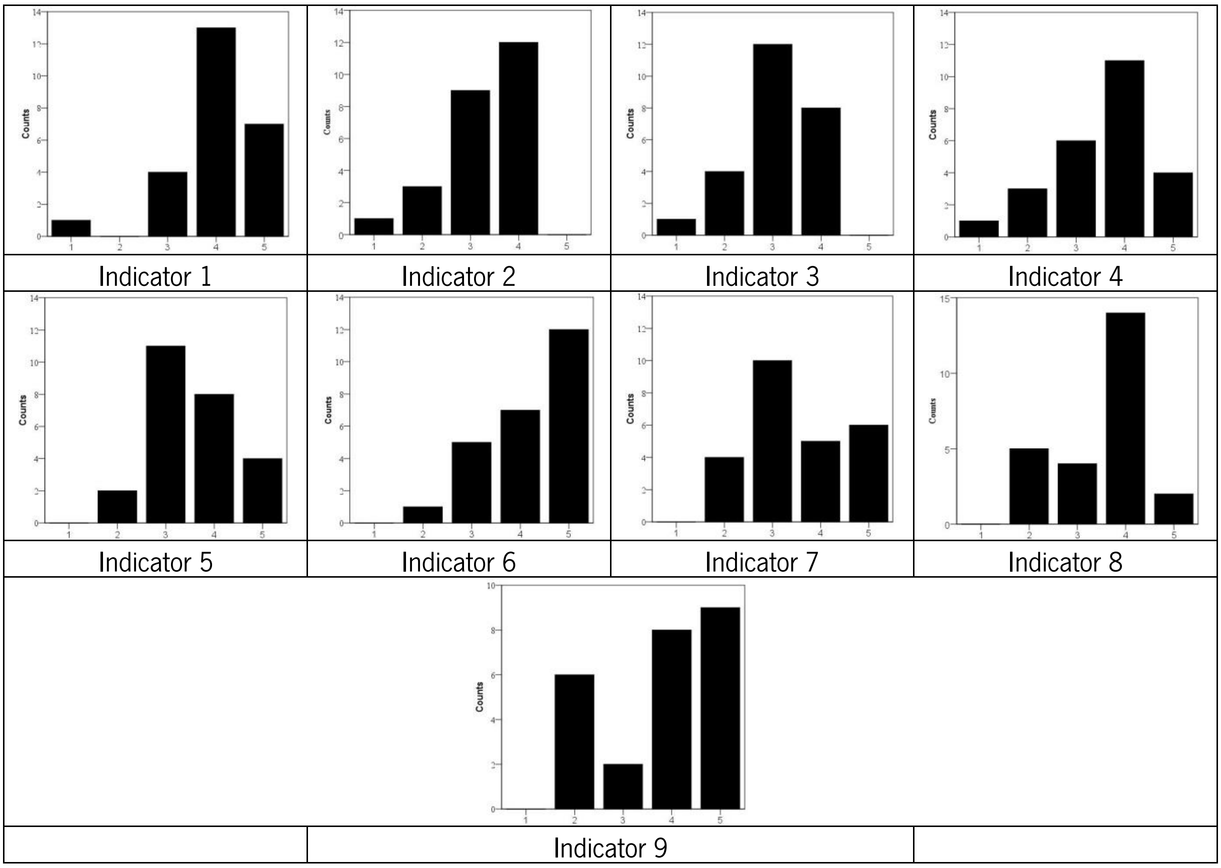

Figure 1: Results (number of answers) by surveyed indicator.

Figure 2 displays the stem and leaf diagram concerning the set of results achieved by each surveyed indicator. One may observe that respondent 10 classifications of the indicators 1 (Number of ISO 9001 certificates/1000 inhabitants), 2 (Number of ISO 14001 certificates/1000 inhabitants) and 3 (Number of OHSAS 18001 certificates/1000 inhabitants) are outliers considering the remaining classifications provided by the other respondents. Similarly, the assessment by respondent 15 regarding the indicator 4 (Number of members of the national quality association) and the assessment by respondent 2 regarding the indicator 6 (Number of persons with training in quality/1000 inhabitants) are outliers considering the remaining assessments.

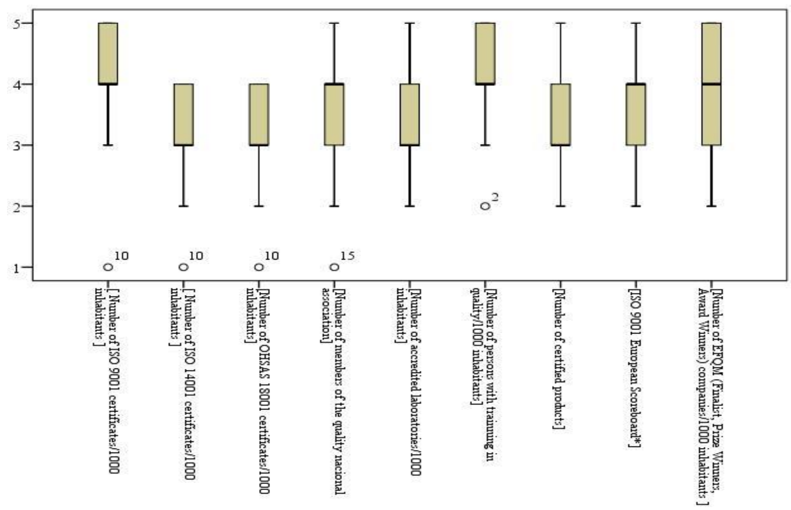

Figure 2: Stem and leaf diagram

Table 4 lists the alternative indicators proposed by the respondents. These indicators have been sorted in Table 4 according to some common features. Additionally, the number of respondents that proposed the indicator is also presented.

Table 4: Other proposed indicators.

Feature	Proposed indicator	Number of respondents	Total
Other management systems not related to the quality management system	Certification by other management systems	2	5
	Number of companies with integrated management systems	2	
	N° of ISO 9001, ISO 14001, OHSAS 18001 certificates per mil millions GDP	1	
Management systems related to quality	Number of quality specific certification (ISO TS, etc.)	1	13
	Number of ISO 9001 certificates/number of companies	1	
	Number of EFQM companies/Number of certified companies (QES)	1	
	Number of companies adopting ISO 9004	1	
	Number of EFQM candidates/1000 inhabitants	1	
	Number of companies certified ISO 9001 more than 10 years/1000 inhabitants	1	
	Number of companies using EFQM or CAF/1000 inhabitants	1	
	Excellence models awards	1	
	6 sigma adoption	1	
	Public certified companies	1	
	Services certification	1	
	Levels of customer loyalty	1	
	Number of companies adopting quality costs on their management	1	
Human resources	Number of quality management consultants	1	3
	Number of top management trained on quality management/1000 inhabitants	1	
	Number of certified auditors, consultants, managers, engineers	1	
Scientific publications	Number of quality magazines	1	5
	Technical publications and scientific publications	1	
	Number of patents	1	
	Number of scientific publications by recognized indexes	2	
Universities	Number of quality courses at universities	2	6
	Percentage (%) of post- quality management graduation courses/University	1	
	Quality training on the education system	1	
	Number of international projects and partnerships on quality related domains	1	
	Number of quality management researchers/1000	1	

	inhabitants		
Associations	Number of members at quality associations than the local one.	1	5
	Number of members of quality management associations/1000 inhabitants	1	
	Number of associations and NGOs related to quality	1	
	Number of national representatives on normalization technical committees	1	
	Number of events related to quality management	1	
Products	Index reflecting quality/confidence on the products of that country	1	3
	Methodologies used on non-conformity products/services complains	1	
	Number of product recalls or serious lawsuits	1	
Regulatory entities	Government responsibility concerning quality	1	2
	Fines from regulatory entities	1	
Accreditation	Percentage (%) of accredited methods/accredited laboratory	1	1
Monitoring	Quality related international barometers	1	1

Table 5 presents the requirements in order to ascribe weighing to each indicator. The main features considered were the average and standard deviation concerning the surveyed indicators and the number of respondents suggesting similar indicators concerning the proposed indicators.

Table 5: Indicators weighing.

Surveyed or proposed indicator	Mean value	Standard deviation	Weighing
Surveyed	Higher or equal to 4,0	–	15%
	Higher than 3,6 and lower than 4,0	–	10%
	Equal to 3,6	Lower than one	7,5%
	Equal to 3,6	Higher than one	7,5%
	Equal to 3,5	Lower than one	7,5%
	Equal to 3,5	Higher than one	5%
	Lower than 3,5		5%
Proposed	–	—	2,5%

Table 6 presents the axes, dimensions and indicators proposed for the Quality Scoreboard. The proposed axes intend to cover all the features that impact on the "macroquality concept". The weighing ascribed to each axis congregate the weighing from the dimensions whereas these latter summarize the weighing from each indicator. This latter value was developed considering the mean and standard deviation from the set of results (Table 2) as described in Table 5. Each indicator had been normalized by a factor of 1000 inhabitants.

Table 6 presents the Quality Scoreboard developed according the methodologies described in the previous sections and in Table 5. The axes considered are the "Organizations", "Universities", "Human Resources" and "Products". The axis "Organizations" congregates the dimensions "Certification", "Accreditation" and "Excellence Awards". The axis "Universities" considers the dimensions "Qualification" and "Research", that is, the features that may impact on the potential future "macroquality". The ability to develop networking, the aspects concerning the qualification and further certification were the features found to be suitable to express the "Human Resources" axis. Concerning the "Products" axis, their certification was the dimension opted by. The weighing ascribed to the each dimension and subsequently to each axis is achieved through the sum of the weighing of the indicators and dimensions, respectively.

Table 6: The European Quality Scoreboard.

Index	Axis	Dimensions	Indicators
EQS (100%)	Organizations (55%)	Certification (32,5%)	Number of ISO 9001 certificates/1000 inhabitants (15%)
			Number of ISO 14001 certificates/1000 inhabitants (5%)
			Number of OHSAS 18001 certificates/1000 inhabitants (5%)
			E9S/ 1000 inhabitants (7,5%)
		Accreditation (10,0%)	Number of accredited laboratories/1000 inhabitants (7,5%)
			Number of accredited methods/1000 inhabitants (2,5%)
		Excellence Awards (12,5%)	Number of EFQM finalists/1000 inhabitants (10%)
			Number of EFQM candidates/1000 inhabitants (2,5%)
	Universities (12,5%)	Qualification (7,5%)	Number of Quality related courses/1000 inhabitants (7,5%)
		Research (5%)	Number of Quality related researchers/1000 inhabitants (5%)
	Human Resources (25,0%)	Networking (7,5%)	Number of members of Quality Management Associations/1000 inhabitants (7,5%)
		Qualification (15%)	Number of persons trained in Quality Management/1000 inhabitants (15%)
		Certification (2,5%)	Number of certified auditors/1000 inhabitants (2,5%)
	Products (7,5%)	Certification (7,5%)	Number of certified products/1000 inhabitants (7,5%)

As one may see in Table 6 the reported EQS (European Quality Scoreboard) takes into account several features than solely the number of certified organizations. At this moment the EQS is a theoretically concept, open to discussion, which should be tested by the targeted countries in order to assess its validity.

CONCLUSIONS

The assessment of the degree to which quality practices are implemented by a country should consider tangible and less tangible indicators. In this paper a potential tool, the Quality Scoreboard, has been reported. This tool differs from others due to the fact that considers less tangible or easily measured indicators. Its wide scope, considering several axes and dimensions, enables that a great deal of features contributes to the assessment.

AKNOWLEDGEMENTS

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Quality Management Principles And Practices Impact On The Companies' Quality Performance

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ABSTRACT

Purpose. The aim of this paper is to expose the conceptual model which pretends to reflect the relationship between the use and implementation of quality management principles and practices and their impact on the companies' quality performance.

Design/methodology/approach. Based on the literature review carried out, we have identified the most common and used quality management principles and practices. Hence, we have proposed a conceptual model relate those quality management principles and practices to the companies' quality performance. In order to validate these quality management principles and practices and consequently the conceptual model developed, we conducted several semi-structured interviews with the Portuguese Quality Leaders. The following phase consisted in developing a questionnaire, based on the literature review carried out and on the main contributions of the semi-structured interviews. This questionnaire was sent to all the Portuguese companies certified according to the ISO 9001 standard. Our main purpose is to validate the model developed based on the structural equation modeling technique (SEM). Currently we are in the survey phase.

Findings. It is expected that the results show a significant and positive relationship between the implementation of quality management principles and practices and their impact on the companies' quality performance.

Originality/value. As far as we were able to find out in the literature review phase, the conceptual model proposed is a new approach to characterize the direct results and effects of quality management principles and practices in the companies' quality performance.

Keywords: Quality management, Performance Measures Indicators, principles, practices and Modelling.

Article Classification - Research paper.

INTRODUCTION

There is a considerable number of publications that is focused in the link between quality management and organizational performance. However, the analysis of the direct effects and results of the quality management principles and practices in Portuguese organizations quality performance is an innovative issue.

The American Society for Quality (ASQ) research entitled "The Global State of Quality Research Overview" (2013) highlight the best quality management organizational structure which includes the quality management principles and practices that lead to a maximization of the organization results.

From the ASQ study, explanatory key factors, which are extensively being used during the whole research and which are highly related to the variability in the application of principles and practices, were established. 1) There are significant differences in the use and application of quality management and practices in organizations from the industry sector as well as in organizations from the service sector. 2) There is a general idea that the organizations of higher dimension tend to use more mature quality practices. Although this idea is appropriate for various practices, in general, the dimension of the organization has less impact than the organization activity sector concerning the application of mature quality practices. 3) There is no relevant indication that the use of quality principles and practices differs per region, generally. Some variations do exist, but normally they are related to the dimension, sector or other unidentified factors. (ASQ, 2013).

The aim of this research is to develop and propose a conceptual model that reflects the relationship between the implementation of principle and practices quality management and their impact on the quality performance of the Portuguese organizations.

The goal of this research is to analyze if the implementation of QMPPs results in an improvement of companies´ quality performance, namely in manufacturing and service sectors.

Our final conceptual model will be statistically validated based on a survey that will be sent to the Portuguese companies. The structural equation modeling (SEM) will be our statistical methodology support.

QUALITY MANAGEMENT

Quality Management (QM) has been defined as a "philosophy or an approach to management" made up of a "set of mutually reinforcing principles, each of which is supported by a set of practices and techniques" (Dean and Bowen, 1994).

QM represents one of the most significant research themes in operations management. Today QM is a widely accepted organizational goal for several companies (Nair, 2006).

With the tremendous growth of literature in both academic and practitioner oriented outlets, the term QM has been diluted to mean different things and the scope of activities underlying QM lack consensus (Watson and Korukonda, 1995).

The study conducted by Sousa and Voss, (2002), commenting on the validity of quality management, conclude that, ''QM as espoused by its founders, can be reliably distinguished from other strategies for organizational improvement and there is substantial agreement in the literature as to which practices fall under the QM umbrella''.

Quality Management Principles and Practices. The quality practices of an organization (which take place within a quality culture or context) are defined as the actions and procedures undertaken by a company or organization to ensure the delivery of a high-quality service or product.

Sousa and Voss, (2002) mention that "practices are the observable facet of QM, and it is through them that managers work to realize organizational improvements. Principles are too general for empirical research and techniques are too detailed to obtain reliable results. The quality management principles can be used by senior management as a framework to guide their organizations towards improved performance. There are many different ways of applying these quality management principles. The nature of the organization and the specific challenges it faces will determine how to implement them.

Some of the conflicting results reported in the literature may have to do with different levels of analysis of QM. Several studies operationalized QM as a multi-dimensional construct (Anderson et al., 1995; Flynn et al., 1995; Mohrman et al., 1995; Powell, 1995; Adam et al., 1997; Grandzol and Gershon, 1997; Ahire and O'Shaughnessy, 1998; Forza and Flippini, 1998; Rungtusanatham et al., 1998; Dow et al., 1999; Samson and Terziovski, 1999; Das et al., 2000; Wilson and Collier, 2000; Ho et al., 2001; Kaynak, 2003) while others conceptualized it as a single construct (Hendricks and Singhal, 1996, 1997; Chenhall, 1997, Choi and Eboch, 1998; Easton and Jarrell, 1998; Douglas and Judge, 2001).

It would be relevant that future studies should make explicit at what level they are addressing QM content: principles, practices or techniques.

Researchers should also strive for a standardization of definitional terms. For example, different terms have been used for "practices", such as "factors" (Saraph et al., 1989; Powell, 1995), "implementation constructs" (Ahire et al., 1996; Anderson et al., 1995) and "interventions" (Hackman and Wageman, 1995).

Based on the literature review carried out, we have identified the most common and the most implemented quality management principles and practices. It is important to refer that this selection was based on two sectors which will be target of our study: manufacturing and service. Hence, it is believed, in fact, that these quality management practices and principles are comprehensive because they:

- Have highest frequency of occurrences by different researchers in the service industries and identified as the key aspects in TQM implementation in both manufacturing and service industries (Saraph et al., 1989; Antony et al., 2002; Zhang et al., 2000; Khamalah and Lingaraj, 2007);
- Represented the hard and soft aspects of quality management;
- Encompass the most prestigious quality award and standards criteria widely accepted by quality management scholars and practitioners;
- Have been considered as critical practices in quality management (Sila and Ebrahimpour, 2002);
- Significantly associated in services and in the promotion of service quality (Behara and Gundersen, 2001).

In order to do a preliminary validation of the quality management practices and principles as well as the quality performance indicators selected, we conducted a series of semi-structured interviews with national and international *Quality Leaders*, such as: academics, specialists in this area, managers and consultants.

Therefore, the eight generic quality management principles identified (P_{A1}-P_{A8}): Leadership, Customer Focus, Employee Involvement and Commitment, HR Management (incentive and recognition), Strategic Planning Management, Process Management, Supply Chain Management, Continuous Improvement and Innovation as well as the quality management practices (P_B): Quality Tools and Business Excellence Models, were valued in a scale from 1 (Nothing Important) to 5 (Extremely Important) by each Quality Leader Interviewee. All data collection and following statistic analysis which is illustrated in figure 1, allowed the presentation of the conclusions presented in the next paragraphs.

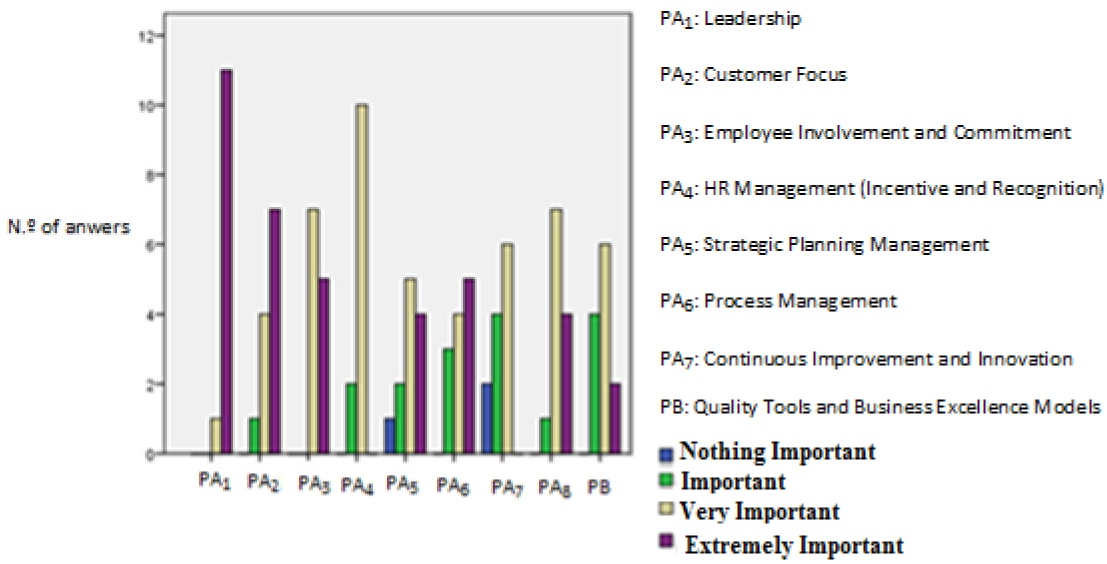

Figure 1 – General view of the quality management principles and practices.

Through figure 1 analysis, one may conclude that from the quality management principles presented (P_{A1}-P_{A8}), we may distinguish as *Extremely Important*: Leadership, Customer Focus and Process Management; as *Very Important*: Employee Involvement and Commitment, HR Management (incentive and recognition), Strategic Planning Management, Process Management, Supply Chain Management, Continuous Improvement and Innovation. The Quality Tools and Business Excellence Models (P_B) were distinguished as *Very Important*.

It is important to mention that, through the course of the interviews, it was proposed that quality management practices category (P_B) could be divided in three dimensions, such as: a) Quality Tools; b) Quality standards and c) Business Excellence Models.

Therefore, in our present research, based on the validation and on the main contributions of the semi-structured interviews phase, the quality management principles that are going to be the target of study are: Leadership, Customer Focus, Employee Involvement and Commitment, HR Management (incentive and recognition), Process Management; Strategic Planning Management, Supply Chain Management and the Continuous Improvement and Innovation. On the other hand, as mentioned above, the quality management practices that are going to be the target of study are the following dimensions: Quality tools, Quality standards and the Business Excellence Models (Figure 4: Conceptual Model: Relationship between QMPPs and their impact in quality performance).

Quality Performance Measures Indicators. Numerous studies have examined the positive and negative (or non-significant) relationships between quality principles and practices and various performance measures indicators. While examining the relationship between quality principles and practices and performance scholars have used different performance types such as financial, innovative, operational and quality performance.

Sousa and Voss, (2002) mentioned that quality management practices have a significant and strong impact on quality (internal process and product) and operational performance.

In some studies a multidimensional operationalization of performance is considered (Mohrman et al., 1995; Das et al., 2000; Wilson and Collier, 2000) while others considered single performance construct (Anderson et al., 1995; Ahire and O'Shaughnessy, 1998; Rungtusanatham et al., 1998; Ho et al., 2001).

In this study, we considered quality performance as our indicator for measuring company's performance. The reasons for choosing quality performance as an indicator for measuring company's performance are:

- It can be measured and reflected into number of ways as articulated in past empirical studies on TQM (Ahire et al., 1996; Flynn et al., 1994; Su et al., 2001; Yang, 2006; Arumugam et al., 2008; Prajogo and Sohal, 2003; 2004).
- It has been used by Malcolm Baldrige National Quality Award (MBNQA) model under the 'quality results', the only criterion used for organizational performance measurement. MBNQA model that represent TQM practices is accepted by several researchers across the world (Ahire et al., 1995; Dean and Bowen, 1994; Juran, 1998; Prajogo and Sohal, 2003; 2004);
- Several past research studies on TQM and organizational performance have taken quality performance as indicator for measuring the performance (Ahire *et al.*, 1996; Zhang *et al.*, 2000; Arumugam *et al.*, 2008; Dow *et al.*, 1999; Flynn *et al.*, 1994; Saravanan and Rao, 2007; Cua *et al.*, 2001; Prajogo and Brown, 2004) and the results were obtained. These studies investigated the relationships between TQM practices and quality performance in different *sectors* and *countries*.

As we mentioned before, in order to do a preliminary validation of the quality performance indicators selected, we conducted a series of semi-structured interviews with national and international *Quality Leaders*, such as: academics, specialists in this area, managers and consultants.

The eight selected quality performance indicators are: Product/service quality level; customer relationship; reliability, productivity, durability, conformance to specification; number of non-conforming products and number of complaints.

This eight quality performance indicators (QP_1-QP_8) were valued in a scale from 1 (Nothing Important) to 5 (Extremely Important) by each *Quality Leader* Interviewee. All data collection and following statistic analysis which is illustrated in figure 2, allowed the presentation of the conclusions presented in the next paragraphs.

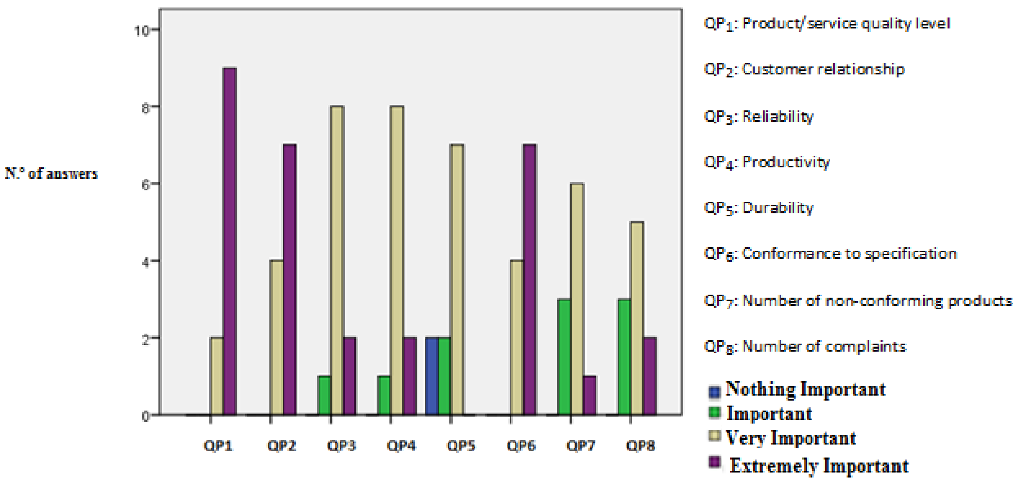

Figure 2 – General view of the quality performance indicators.

In an analogous way, through figure 2 analysis, one may conclude that from the quality performance indicators presented (QP_1-QP_8), we may distinguish as *Extremely Important*: Product/service quality level; customer relationship, conformance to specification; as *Very Important*: reliability, productivity, durability; number of non-conforming products and number of complaints.

Through the course of the interviews others indicators to the quality performance measurement arouse, as well as, changes to the denominations of some indicators that were presented.

Hence, the indicators to the quality performance measurement suggested were:

Customer satisfaction; Flexibility; Quality Management Systems maturity; Complaints management; Employee satisfaction; stakeholders satisfaction.

Regarding to the changes of the denominations of some indicators that were presented, one may detach (Table 1):

Table 1 – Compilation of the change suggestions to the denominations of some indicators.

QUALITY PERFORMANCE INDICATORS PRESENTED	CHANGE SUGGESTION
QP_1: Product/service quality level	Perceived Quality
QP_2: Customer relationship	Customer loyalty
QP_3: Reliability	Product reliability
QP_4: Productivity	___
QP_5: Durability	Product durability and service continuity
QP_6: Conformance to specification	Fulfilment of the customer requirements
QP_7: Number of non-conforming product	Number of non-conforming product/service
QP_8: Number of complaints	___

Therefore, in our present research, based on the main contributions of the semi-structured interviews phase, the indicators that were used to the quality management performance measurement are:

Perceived Quality; Customer satisfaction; Customer loyalty; Product durability and Service continuity; Fulfillment of the customer requirements; Non-conforming product/Service; Product reliability; Productivity; Flexibility; Lead time; Quality Management Systems maturity; Stakeholder satisfaction and Number of complaints.

RELATIONSHIP BETWEEN QUALITY MANAGEMENT AND PERFORMANCE

In general, research studies have argued a direct relationship between quality management principles and practices and performance.

Sampaio, 2009 mentioned that the majority of the studies that try to relate the impact of quality management principles and practices (QMPPs) over organizational performance that have been carried out, conclude that there is a positive relationship between the implementation of QMPPs and organizational performance improvement (Mann and Kehoe, 1994; Maani et al., 1989; Adam et al., 1997; Curkovic and Pagell, 2000; Terziovski and Samson, 1999; Gupta, 2000; Romano, 2000; Dick et al., 2002; Ozgur et al., 2002; Tarí and Molina, 2002; Tarí ans Sabater, 2004; Quazi and Jacobs, 2004). However, others recent research on this link finds contradictory outcomes. That is, quality procedures may not consistently result in a positive or favorable organizational outcome (Foster, 2007; Kaynak 2003; Montes et al., 2003; Zu, 2008).

Note, however, that, there is also evidence of complex cross relations among QMPs in extant literature.

There are some researchers who found that the implementation of QMPs did not improve performance. For instance, Dow *et al.* (1999) showed that some QMPPs contribute to superior quality outcome and others QMPPs do not contribute to the improvement of organizations performance. Terziovski and Samson (1999) investigated the relationship between QMPPs and organizational performance in Australia and New Zealand and obtained mixed results, showed that a typical manufacturing organization is more likely to achieve better performance with QMPPs than without QMPPs implementation.

The mixed findings and the need to gain further insights into generalized QMPPs-performance link provide motivation for several research articles.

Given the inconsistent findings attempting to link quality management to firm performance in the past (Kaynak, 2003), the authors believe that deconstructing quality management into the separate constructs of quality practices and quality context, and examining the causal sequence connecting these constructs, will prove beneficial.

In order to perceive the *Quality Leaders Interviewees´*opinions about the relationship between quality management and performance, it was requested a valuation in a scale from *A* (*weak*, 1 point) to *C* (*High*, 3 points), of the relationship between each QMPPs (P_{A1-8} e P_B) and each quality performance indicators (QP_1-QP_8) presented. All data collection and following statistic analysis allowed the elaboration of the figure 3. This graphic illustrates the most significant relationships between QMPPs (P_{A1-8} e P_B) and quality performance indicators (QP_1-QP_8).

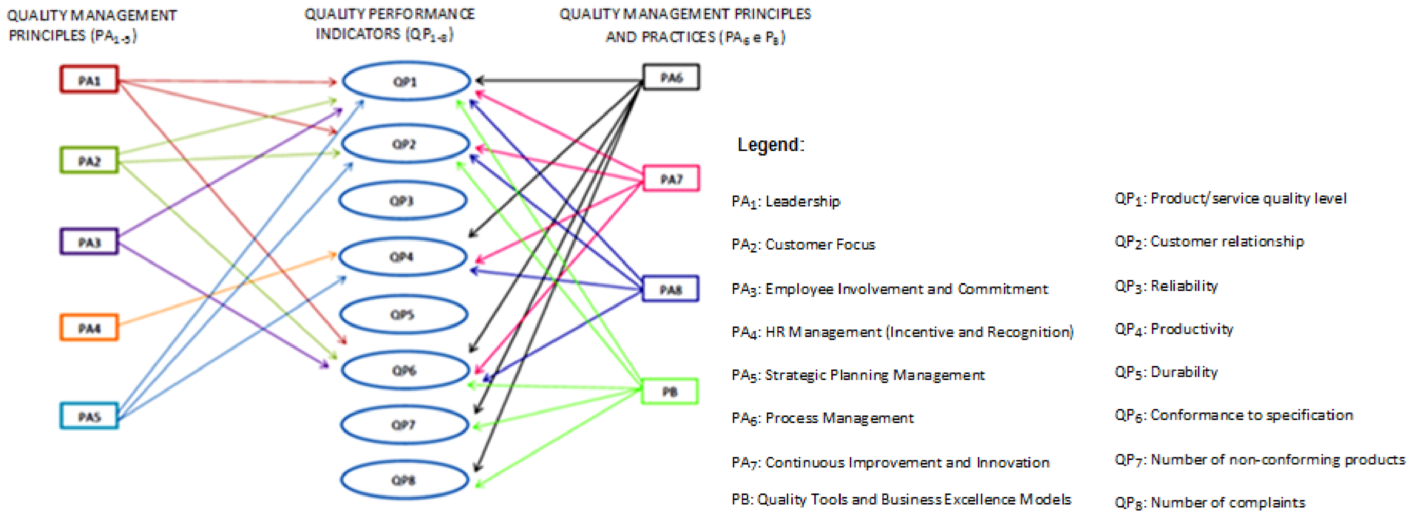

Figure 3 - Most significant relationships between QMPPs (PA_{1-8} e PB) and quality performance indicators (QP_1-QP_8).

CONCEPTUAL MODEL

This interview phase allowed us, in fact, to inquire the national and international acknowledged specialists in the quality management field trying to validate an subquently improving the initial Conceptual Model which was elaborated through literature review. Therefore, the new Conceptual Model proposal is presented as follows:

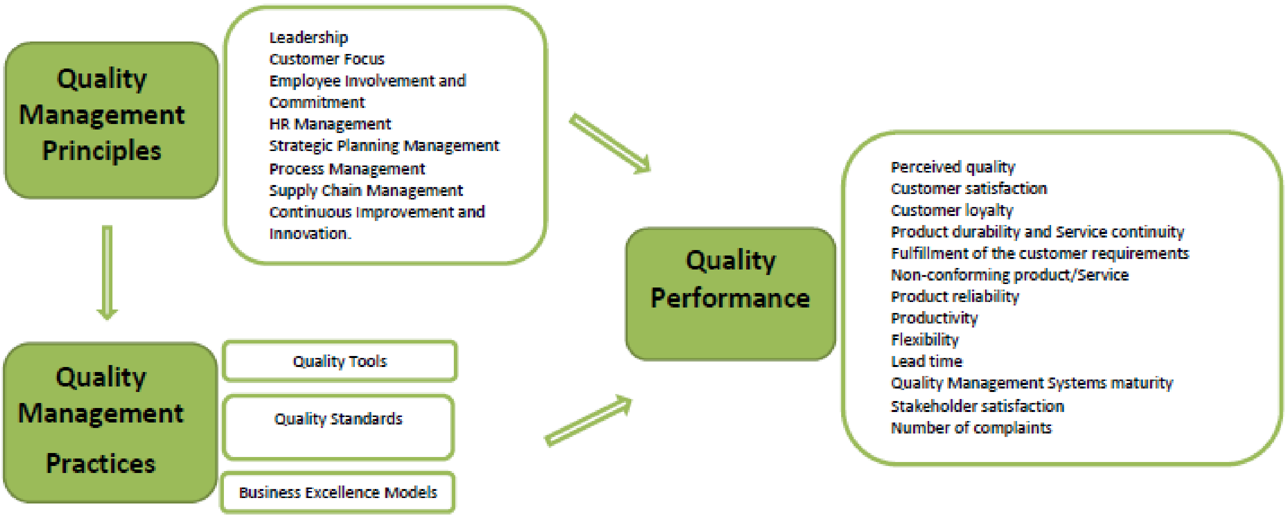

Figure 4 - Conceptual Model: Relationship between QMPPs and their impact in quality performance.

CONCLUSIONS

Based on the literature review carried out, we acknowledge that, in fact, there are still many doubts about the relationship between quality management and performance; hence, it is relevant to study in more detail the causal process that links QMPPs with quality performance in order to try to characterize the direct results and effects of QMPPs in the companies' quality performance.

Our final conceptual model will be statistically validated based on a survey that will be sent to the Portuguese companies. The structural equation modeling (SEM) will be our statistical methodology support. This validated model will not only contribute to bridge the gap, that is reflected in open literature, but it will also provide the quality professionals an approach to an efficient quality management implementation in the organizations. It may also be used by researchers to develop the quality management theory.

Undoubtedly, it will give impetus for practitioners adopting quality management principles and practices in their organizations.

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Failure Modes Effects Analysis (FMEA) For Review of a Diagnostic Genetic Laboratory Process

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ABSTRACT

Failure Modes effects analysis (FMEA) can be used as a process improvement tool to document steps of a process in detail, and interrogate potential failures before they occur. A cross functional team using ordinal scales ranks and prioritizes these risks - the validity of which has been questioned. Traditionally FMEA is viewed as a time consuming process. FMEA was used to analyse a laboratory process, 3 months after an initial quality improvement review. This study shows that FMEA can yield benefits, for prospective risk management and general process improvement within a laboratory setting where time and team input is restricted, and within a process considered during the initial review to have limited evidence of problems for continuous improvement. Findings, shortcomings and possible approaches to increase the utility of FMEA ranking activities are described.

Keywords: FMEA, Laboratory, Process Improvement, Risk Management, Quality Management.

Article Classification: Case Study

INTRODUCTION

Within healthcare settings accuracy and speed of reporting of laboratory results (Turn Around Time or TAT – from receipt to reporting), is vital to clinical management. Delays or mistakes in reporting can negatively influence treatment initiation and procedure choice. These treatments and choices may affect 'critical to health' outcomes. Laboratory tests are evolving as technological and treatment advances are made. Continuous reviews, through Quality Improvement initiatives are important for meeting and adjusting to these changing needs. Within many laboratory settings however, there is often limited time for more proactive formal, team-based and extensive review processes of new and existing tests, with increasing pressure to meet TAT for often clinically urgent results, increasing referral numbers, cuts in staffing, and the increasing complexity of tests. Preventative and corrective actions sometimes result only through audits or root cause analysis after an event has occurred, or a customer complaint has been received.

This paper discusses the results of a year-long project taken as part of studies towards a Masters in Quality Systems at Massey University, New Zealand. The study was undertaken in a large metropolitan Public Health System laboratory – one of the largest in the country. This laboratory is a significant contributor to the health outcomes of patients in the local region, and through its contribution to national laboratory testing and reporting.

Failure Modes Effect analysis (FMEA) is a risk management tool, used to identify prospective failures within a process, product or service, before they occur, so that proactive steps can be taken to design and implement robust processes. FMEA has been implemented in a number of varying scenarios and its name can reflect this usage – for example it can be implemented:

- In the early design stages of a new product or service - and is referred in that instance as Design FMEA (dFMEA);
- Prior to implementation of manufacturing and/or service delivery processes in production or service settings - sometimes referred to as Potential FMEA (pFMEA), FMEA and Criticality Analysis (FMECA), Process FMEA (pFMEA); and
- As part of continuous improvement strategies, and pre and post process alterations.

Within laboratory healthcare, risk management for prevention of failure (particularly an inaccurate result) is imperative, and should underpin the design of all steps of sample handling from receipt to reporting. FMEA in this setting can be used to examine and document in detail, all steps of a process for failures (actual and/or potential), significance (or criticality) to the customer, and possible causes and existing controls to detect, prevent or reduce occurrence. Implementation of FMEA involves the creation of a Risk Priority Number (RPN) which results by rating the severity of each potential failure to the customer (S), the likelihood of occurrence of the failure (O), and the likelihood of detection (D) before the effect of the failure reaches the customer (McCain 2006). The rating numbers are multiplied to determine a RPN, which is then used for prioritizing action (higher numbers generally taking priority), and measuring the effect of change after improvements are implemented (Tague 2004, Rodriguez-Perez & Pena-Rodriguez 2012). FMEA (and its variants) have been seen as a time consuming tool and has not been used in this laboratory setting previously.

FMEA was used to review the 'analytical' and 'post analytical' phases of a new laboratory process – a Gene Mutation Test (GMT), (refer Table 1), 1 year after implementation, and 9 months after a process review (using brainstorming), resulting in improved workflow. The aims of the FMEA were to (1) use the same team to determine if further improvements could be identified, and (2) to examine the utility of the FMEA's structured analysis and ranking system in prioritizing and minimising risk in this setting.

The GMT uses a 'black box' kit for the analytical phase, reliant on steps set by the manufacturer, with restricted variation and limited access to process details. In spite of this, the previous review, and time restrictions on team member participation, new improvements were identified (including the highest RPN), with potential for clinical implications to patient management.

METHOD

The team consisted of three scientists, each involved in the weekly handling and analysis of specimens for the GMT - their experience ranged from 4 - 12 months. It was not possible in this study to obtain input from the clinical (doctor's) perspective. The project owner (PO), responsible for FMEA development and documentation, was the section leader of the team, who was the most familiar with FMEA, and the GMT process as a result of their involvement in the testing process, and an initial GMT protocol review.

As part of the project, a process map from the protocol (developed by the team in a previous review) was developed by the PO as an alternative reference to define and summarise the scope - this was reviewed by the team. A Process Map Framework was also developed to identify the key steps involved in the process - the total process contained 59 process steps and this methodology identified more manageable sized steps to study. A brief training session on the use of FMEA including the aims, methodology for each assessment and use of RPN's for prioritising action was also provided to the team by the PO (Tague 2004). A summary of the scope (steps A-F), and process constraints for the GMT project, is given in Table 1.

Table 1: GMT FMEA Scope: Process Map Framework of the 6 Main Functions.

Note: Specimen receipt & registration processes are not included in the scope

Pre-analytical:

A) *Organize a 'run'* (batch of patients to test- check TAT due dates).

Analytical:

B) Get kits and reagents.
C) *Tumour removal* off slides (match target to be removed with a stained slide) - (Check 1).
D) *DNA extraction* (Check 2) & *quality check*.
E) *Dilute DNA* (Check 3), *'plating'* (transfer each patient's DNA & controls to 3 wells each, on a shared plate - Check 4). '*Analysis'* (enter each patient identification (PID) into analyzer in matching order & start programme).

Post analytical:

F) *Reporting* (transcribe results into hospital report system - Check 5). Organize follow up tests.

Constraints:

Patients must be batched (4-10 /run).

The shared plate (E) cannot be labelled with the PID.

The team chose to go to the 'Gemba' to understand the GMT process, and undertook a 1.5 hour walkthrough 'simulation'. Gemba (or Genba) is a Japanese term referring to 'the real place', 'crime scene', or 'place where value is created'. In manufacturing the *genba* is the factory floor. It can be any 'site' such as a construction site, sales floor or where the service provider interacts directly with the customer (Imai 1997).

Each process step (function) was examined with the process map and documented protocol at hand - potential failures, causes, effects and current controls were identified. Wherever possible, data from evidence of existing issues (collated by the PO) was discussed and incorporated. The effects to the customer focused on the patient & doctor, rather than the scientists involved in specimen processing. Recommendations were identified. After tabulating the findings, the PO reviewed the findings with the most experienced team member before distribution to the team. Due to time restrictions, this 2nd draft was then reviewed separately by each team member. The FMEA ratings and scales used by the team are provided in Table 2. A criticality (C) score was also assigned to each function.

Table 2: GMT FMEA Rating and Scale.

Rating	Scale
Severity to the customer if failure occurred *(Severity - S)*	1 = Least severe 10 = Most severe
Likelihood of the failure occurring *(Occurrence - O)*	1 = Least likely 10 = Most likely
Likelihood of being able to detect the failure *(Detection - D)*	1 = Most likely 10 = Least likely
The Criticality of the step to the process *(Blank, or C, S or I)*	C = Critical to the process S= Significant to the process I = Important to the process

As there was no direct clinical (doctor's) input, the rating scale for severity was based on the laboratories' perspective of customer requirements (accuracy of result, within required TAT), and the perceived clinical impact of not meeting these requirements (see Table 3). GMT is considered a priority test - a positive or negative result determines the course of targeted therapy. Thus a (clinical) Severity score of 10 (Inaccurate Result) would be the worst-case scenario and may seriously impact the course of therapy given by the clinician. A Severity Score of 1 (Accurate Result, within TAT) is the best scenario, and considered the target for all GMT tests. A score between 1 and 10 would indicate a 'delayed result' to 'no result' that might or might not, impact on clinical management (the scale was left open- a fault in this FMEA)

Where failures had more than one effect, the rating applicable to the worst-case scenario (most severe to the customer) was used (Tague 2004). In this study, S, O & D scores were averaged this had the potential for skewing data – outliers were therefore examined first (this point is discussed later in this paper). Where there was a duplication of process steps, data was compared and combined, using the highest score (only if the step and the effect was the same). The S, O and D scores were multiplied to produce a RPN.

Table 3: GMT FMEA 'Severity' Rating and Scale.

Severity Rating Possible Error Scenario (Decreasing Severity)	Scale
Accurate result, no error - for appropriate therapy. *Within TAT* - for clinical management.	1
Accurate but delayed result (repeat test) – does not delay therapy	Not quantified
Accurate but delayed result (repeat test) – delays therapy	Not quantified
No result – cannot repeat	Not quantified
Inaccurate result – undetected	10

Analysis of the final FMEA results took two forms. Firstly, errors were separated into the 6 main process functions (A-F, Table 1), and linked issues clearly to their location within the process flow. Secondly, the RPN, S, O and D scores were compared, in descending order of importance, for each process function. Traditionally process functions with high RPN scores – (those associated with the highest risk), are actioned first to minimise risk – S x O can also be used (Tague 2004). Individually high S, O and D scores may also indicate the need for prioritizing action - S is the highest concern. However, improving controls may improve D and reduce O.

The data therefore was split into two groups, (1) Group A containing the highest 23 RPN scores and all of the S & D scores of 10 (there were no O scores of 10), and (2) Group B was constructed from the remaining 65 RPN scores of less than 10. The ranking system was then examined qualitatively to evaluate the scores for consistency with prioritizing action aligned with meeting the needs of the customer. Key effects of 'delayed run, delayed result, failed result, invalid result / run & inaccurate result' (increasing in severity to the customer –refining the scale from Table 3) were used to search the effect column for consistency with increasing RPN and S scores (Group A results are tabulated within Tables 4 & 5).

Analysis of the FMEA results, enabled priority 'improvement' actions to be determined. Changes deemed 'easy' or 'urgent and critical to the process' were made immediately, or were allocated to a team member with a defined target and review date.

Table 4: Group A FMEA Results (Top 23 RPN's).

	Type of Failure (summary) Listed in order of GROUP A RPN's (highest to lowest)	**Location**	Delayed run	Delayed result	Failed result	Invalid result / run	Inaccurate result	Severity	Occurrence	Detection	Risk Priority Number	Criticality	Action **n=8**, (see Table 5)
1	Patients entered into analyser in incorrect order	E					**Y**	**10**	2	**10**	**200**	**C**	**1**
2	Incorrect orientation of tumour targets	C			Y		**Y**	**10**	3.7	3	111	**C**	**2**
3	Removal of tumour target (no target tissue removed)	C			Y		**Y**	**10**	2.7	4	108	**C**	**2**
4	Removal of tumour target (some removed)	C			Y		**Y**	**10**	2.7	4	108	**C**	**2**
5	Reagent (not mixing)	B			Y			2	3.5	**10**	70	**C**	none* Table 5
6	Removal of tumour target (no tissue at all removed)	C	Y	Y	Y	**n/a**	**n/a**	**10**	2	2	40	**C**	**2**

7	Plating (pt DNA transfer to another pt well)	E			Y		**Y**	**10**	1.7	2	34	**C**	**3**
8	Plating (pt DNA transfer to empty well)	E			Y		**n/a**	**10**	1.7	2	34	**C**	**3**
9	Plating (pt DNA transfer to control well)	E			Y	Y	**n/a**	**10**	1.7	2	34	**C**	**3**
10	Reagent wrong concentration	B	(Y)					1.5	2	**10**	30	S	8
11	Plating (not changing tips)	E					**Y**	**10**	1.5	2	30	**C**	none*
12	Plating (error with seal)	E				Y	**Y**	**10**	1.5	2	30	**C**	none*
13	Plating (reagent to wrong well)	E				Y	**n/a**	**10**	1.7	1.5	25.5	**C**	**3**
14	Plating (positive control to wrong well)	E				Y	**n/a**	**10**	1.7	1.5	25.5	**C**	**3** & 6
15	Result entry (incorrect reporting)	F					**Y**	**10**	1.7	1.5	22.5	**C**	**1**
16	Plating (no seal)	E			Y			2.5	1.7	1.5	19	**C**	**1**
17	Check (incorrect report recipients)	F		(Y)				1.5	5	2	15	I	none*
18	Miscalculation of TAT	A		(Y)				1	4.7	3	14		4
19	Result entry (DNA quality into wrong pt – for DNA dilution)	D			Y			2	2	3	12	S	4
20	Result entry - Failed result	F			Yes!			4	3	1	12	I	6
21	Inadequate slide drying	C			Y			1.5	2	3.5	10.5	**C**	none*
22	Removal of tumour target (into wrong pt tube)	C					**Y**	**10**	1	1	10	**C**	**5**
23	Checker does not pick up mistake	D					**Y**	**10**	1	1	10	**C**	7
	TOTALS (n=23)		**2**	**3**	**12**	**4**	**10**					**18 C**	**13**

Modification of the FMEA Table showing a summary of the top 23 RPN's, associated failures, location in the process & the effect to the customer (increasing severity; delayed run to inaccurate result).

Shaded = most critical to integrity of results (could result in inaccurate result). 2, 3 & 4 could result in either a false negative result (false normal) or an accurate result (if sufficient tumour is outside the target).

Table 5: Group A Recommendations (23 Highest RPN's).

Recommendations Within Group A	# Potential Failures	Location	RPN	Identified At Previous Review?	Immediate 'Quick Fix?
1. New check step - 2nd scientist checks order of patients into analyser	3	E	**200**, 22.5, 19	N	Y (highly critical)
2. Check slides for tumour target sooner (at receipt – *Lean* troubleshooting)	4	C	111, 108(x2), 40	Y	Y
3. 'Well' number on worksheet (Lean)	4	E	22.5, 34(x3)	N	Y
4. Electronic data transfer *(Lean)*	2	**A**, D	14, 12	N	Y
5. All slides in one tray, numbered in order for analyser *(Lean)*	1	C	10	N	Y
6. SOP correction/addition	2	E, F	25.5, 12	N	Y
7. Move check to earlier step C(Lean)	1	D	10	N	Y
8. 2nd scientist performs repeat test (failure of run /result due to reagent mistake) - under consideration	1	B	30	N	(case by case basis)
*None (no action required – (reminders to follow SOP))	5	B,C,E,F	70,10.5,30(x2),15	N	n/a

4 improve controls associated with integrity of results (1, 2, 3 & 5 - shaded). 5 processes to be made 'more Lean' (2, 3, 4, 5, 7), includes the 1 RPN located in pre-processing (A)

RESULTS

88 potential failure modes were identified within the 59 GMT process steps. The FMEA resulted in 8 improvements (within the highest 23 RPN's), 7 of which had not been identified by the previous review (Table 5). The highest RPN (200) resulted in a preventative action, critical to the integrity of test results - a 2nd scientist rechecking the order of patient's samples into the analyser. The development of the FMEA was worthwhile, for improving controls of this one risk alone. Evaluation of RPN's and the S, O and D scores, although undertaken, was not required for prioritization, as all actions were clear, uncomplicated 'quick fixes' (Table 5).

Score comparisons - RPN, S, O and D. The majority of S, O, and D scores had 'low' values - a range of 1 - 4.5 (Table 6). The highest O score was 5.7, in an area that did not require action. However there were 15 S scores and 3 D scores of 10. The S and D scores of 10 were used to form Group A, containing the highest 23 RPN's (range 10-200), with 26% of 88 identified possible failures. Group B had lower S and D scores, and contained the lower 65 RPN's (range 1-9) - 74% of all identified possible failures. Occurrence was roughly the same for both groups (69.6 & 66.1% ≤ 2) - see Group A & B data in Table 6.

Table 6. Ranges and % of Ratings for Group A and B RPN's.

Range of Ratings	RPN	S	O	D
All data (n = 88)	1-200	1-4.5 (83%) 10 (17%)	1-4.5 (94.3%) 4.6-5.7 (5.7%)	1-4.5 (96.6%) 10 (3.4%)
Group A Highest 23 RPN's, & S & D=10	10-200 (26%)	1-4 (34.8%) 10 (65.2%)	1-3.7 (91.3%) 4.7-5 (8.7%)	1-4.5 (96.6%) 10 (3.4%)
Group B Lowest 65 RPN's & S, D<10	1-9 (74%)	1-4.5 (≤2, 93.8%)	1-5.7 (≤2, 66.1%)	1-3 (≤2 98.5%)

Consistency of ratings with 'prioritizing' for customer needs. High O and D scores can produce high RPN ratings, however in this study the majority of rating ranges were low (Table 6). The high RPN's appear to be consistent with increasing severity of effects, high S scores, and the need for action. Comparison of Group A data shows 10/23 risks were associated with possible 'inaccurate result' (most severe failure to the customer) with S=10 (shaded, Table 4). For 5/23 (the remaining 5 with S=10, Table 4, not shaded), 'inaccurate result' was not possible due to technical/internal kit controls. However these steps were classified as critical to the process, and were critical to result integrity (involving tumour removal C, and plating; transfer of all patient's and control DNA to a shared plate, E,) and were therefore rated as S=10.

This shows that the rating system is not discrete. An interplay of factors influences the true meaning of S, and the evaluation of prioritizing actions. Of the 10 risks associated with 'inaccurate result', 2 had no action except reminders to 'take care' in carrying out steps, and 8 had action to 'improve controls' associated with maintaining result integrity through 4 recommendations (shaded in Table 5). The other 4 recommendations were minor.

Although 8 recommendations stemmed from 18/23 possible failures within the high RPN category (Group A, Tables 4 & 5), examination of a failure mode with a low RPN may prompt identification of a related failure mode of higher severity. Two of the 8 recommendations within Group A (1 & 3, Table 5) were prompted by interrogation of failure modes within Group B (data not shown). For example, 'incorrect ID into analyser' (RPN 6.6) prompted possible 'incorrect order' of patients, resulting in identification of the highest RPN (200 - Table 4) with higher severity to the customer, inaccurate result (controls for RPN 6.6 were sufficient, resulting in rechecking patient identification and retest if required).

The remaining Group B failure modes resulted in 7 other minor recommendations involving 9/65 RPN's related to improving workflow and 1 was a correction to the Standard Operating Procedure (SOP). None of these were urgent, and this was reflected in the low RPN and S scores (Table 6).

Two of the D=10 scores in Group A were related to potential errors in reagent making. Although critical and significant to the process, these were generic and less severe to the customer. Controls were in place but limited to checks of the small volumes handled. Recommendation 8 (Table 5) has not been implemented.

Utility of FMEA in identifying improvements. One aim of FMEA is to eliminate or minimise risk by improving controls. The main benefit of the analysis was the preventative action from the highest RPN (200, S=10) 'patients entered into analyser in incorrect order' (at E). The FMEA highlighted this as a high risk not addressed by the team within the previous review. The FMEA brought to light that controls were insufficient, with the potential for 'patient mix up' and the most severe effect for the customer 'inaccurate result' (Table 4), with possible clinical consequences such as not being offered targeted therapy or being given inappropriate targeted therapy. A new check step using a second scientist to recheck patient order with paperwork was introduced. For this one improvement, the FMEA was worthwhile. This control was also introduced for 'result entry at reporting' at F (15th highest RPN 22.5, S=10). FMEA analysis shows its' value here - with a systematic detailed review of process steps. The previous review however, may not have been as thorough, concentrating on pre-processing (A - requiring addition to the SOP, using gemba and brainstorming), whereas B-F had concentrated on review of the manufacturer's SOP (with no prescriptive check steps throughout, and no Gemba).
Table 4 shows that all of the other top 23 RPN's were located within steps B-F. Two areas known to have high risk were confirmed, and the check steps (controls) improved; recommendation 2, Table 5 (for 'tumour removal issues' at C, 2nd, 3rd, 4th and 6th highest RPN's, Table 4), and recommendation 3 (for 5 possible 'plating' errors, at E, 7-9th, 13 and 14th highest RPN's). For the 5 areas not requiring action, controls were considered sufficient.

Revealing Waste. FMEA revealed waste within the GMT process, resulting in 5 'Lean' improvements (Table 5). Unnecessary repetition in 3 separate tube labelling and checking steps (2 identified within group B) were streamlined by moving to 1 'check' step, without introduction of new risk. Manual data entry, identified as a risk within two steps (RPN's 12 and 14, group A) was eliminated, (recommendation 4) increasing efficiency and reducing risk.

DISCUSSION

Research Limitations / Study Design Flaws. This review was the first FMEA analysis conducted within the study organisation. Training given to the project team on FMEA and the use of this tool as a continuous improvement methodology was undertaken by the PO. Time for dedication to the project was limited for all participants due to daily work constraints. There are flaws to be noted in this study:

The Rating Scale:
The rating system was not as clearly defined as it could have been and would be made more specific if the study were to be repeated. For example, criteria were not specified for values between 2 and 9 of the rating scales. This meant that there was an increased level of subjectivity to the assessments of S, O and D scores.

The gap observed in the S & D ranges in Group A (Table 6) may be due to this flaw. This however did not appear to hinder identification and resolution of issues. The modified rating, used in analysis of the final FMEA, which incorporated customer expectations (Table 3) would have been more useful to the team at an earlier stage.

Team Involvement:
Involvement of team members is all steps of the FMEA's development and analysis was limited due to time and work constraints. Not all teams members were able to make face-to-face meetings and elements of the project had to be undertaken via email, with subsequent individual reviews of the draft

FMEA then being compiled by the PO. This may have resulted in a gap in consensus decision-making and a reduction in the reliability of the final scores. More robust data may have been obtained through greater team involvement.

Rating Bias:

The data set in this study was small, consensus meetings were not able to be held, and scores were averaged, thus leaving room for skewed results. Team consensus could reduce bias, and use of a Nominal Group Technique would add robustness to a further study.

Cross-functional Team:

The team was not 'cross-functional'. There was no input from clinical staff. This may result in a rating scale bias as laboratory staff may not have the same extensive knowledge of the consequence of a potential failure to the patient. Thus, the overall 'effects of failure' may not be as reflective of clinical practice as they could be. There was no direct input from the designer and manufacturer of the GMT and reasons for a failed or invalid test within a 'black box' procedure are not always transparent and visible to laboratory staff using the test.

Ambiguity Within Failure Mode Statements:

There is some vagueness within the failure mode statements. For example 'delayed result' is actually an effect. Such ambiguity may unintentionally bias ratings e.g. an S score can be influenced by the length of a delay and how urgently a result is needed. In Table 4, the 20th and 23rd highest RPN's are examples of poorly worded modes.

Benefits Achieved & Alternative Approaches. Although this FMEA study has some failings and there are opportunities for improvement, it yielded benefits, within review of a "black box" GMT process. New improvements were identified in spite of the previous review, including one significant preventative action.

A Reduction in the Scope of the Study:

The PO required extensive time, outside of daily work, to compile findings from the 88 failure modes that resulted in the 8 recommendations from the 26% highest RPN's. A smaller scope (sub-process) may have been more manageable for using the FMEA tool, reducing fatigue from data overload, and making compilation and analysis less taxing. Some authors report a smaller scope can result in more specific recommendations (Van Tilberg, Leistikow, Rademaker, Bierings & van Dijik 2006), as FMEA can result in many potential failure modes that are irrelevant (Lipol & Haq 2011).

Alternative Approaches To FMEA Ratings:

Several alternative approaches have been identified in the literature rather than the linear approach used here, and have been recommended to improve the efficiency of analysis. These include:

a) *Prioritization Matrices:* To determine which areas to investigate further, a prioritization matrix could be used before tabulation, to narrow efforts to process steps and inputs that have the biggest effect on customer [6]:

b) *Hazard Scoring Matrices:* These could be used after listing failure modes (Van Tilberg et. Al. 2006);

c) *Pareto Analysis:* A Pareto Chart could be used to rank and display the top RPN's [(McCain 2006, Lipol & Haq 2011).

d) *Multiple Analyses:* Analysis could be split between 2 teams for S and O & D rankings after cause and effect analysis (Ramu 2009) thus adding another level of assessment and robustness to the analysis process.

Utility of FMEA as a Model:

Regardless of the approach, there are questions regarding the utility of FMEA. Studies have questioned the validity of the ranking system, with calculations for the RPN being mathematically flawed (Shebl et.al. 2012 & Bowles 2004). The same RPN number is possible from different combinations of the S, O and D scores, however the meaning behind each rank is different, and there is a limited number of possible RPN scores (Shebl et.al. 2012 & Bowles 2004). Where the same RPN is found, prioritization by S, then O then D may be used [Lipol & Haq 2011). An alternative method uses S, O and D or S and D scores without multiplication (Reid 2009).

Definitions of Scales:

Doubt over validity of RPN's for prioritization is further strengthened by possible subjectivity when choosing scores for each failure mode. Definitions of scales used should be customised to the area of review (McDermott, Mikulak & Beauregard 2009), and designed by the team for clear understanding to reduce variation of interpretation. Data from the current situation, collected beforehand, may reduce variation. Insitu simulations can strengthen scores, rather than relying on brainstorming 'from memory alone' (Davis, Riley, Gurses, Miller & Hansen 2008). Voting can bring consensus, or using 2 teams to share and peer review results (Ramu 2009). Interpretation of the importance of a factor – S, O and D, regardless of approach, are however, still influenced by personal values and belief. One study illustrates the interaction of factors with the outcome of FMEA conducted simultaneously and independently by 2 teams on the same process, with different (but both useful) results, influenced by the definition of the scales chosen, the approach (use of a SOP or walk through) and subjectivity of individuals (Oldenhof et. Al. 2011).

Interpretation of Modes & Effects:

Analysis is not always straightforward for failure modes. Modes can be confused with effects (Teng, Ho, Shumar & Liu 2004), or may have multiple possible effects, and ideally should be listed and ranked separately (Ramu 2009). Rating each possible effect separately, and for all customers, would be cumbersome, particularly for a large scope.

Severity scores may not be discrete due to a variety of environmental factors outside of the analysis scope. Within healthcare S to a patient can vary depending on their symptoms and clinical needs. Additionally the effect of the same failure and S, could vary from patient to patient due to the inherent variability in health. Thus S is not discrete – and should the majority or the average situation be used? It is difficult to rate S without bias when occurrence for the majority (and thus S), is low. If a serious adverse event is possible however then one could argue that this cannot be ignored.

This FMEA, study used the most severe possible effect to the patient for S scores thus even with an O of 1, data is skewed. An example of this is for the 2nd, 3rd and 4th highest RPN's (Table 4), with low O -

all could result in 'some tumour' or 'no tumour' being removed, depending on the content of the whole specimen (outside of the intended target), varying from patient to patient. In this study the 'worst case scenario' was used.

Use for Prioritizing:

The interacting factors mentioned, suggest that RPN's should not be used on their own, and should be more of a guide, particularly within healthcare (Shelb et. al. 2012). A low RPN does not exclude the possibility of O. Improvements may also have unintended upstream or downstream effects; RPN can be calculated to examine possible unintended effects (Williams 2010). Where prioritization is unclear however, ratings may be useful. High scores of S, O and D are worth examining, individually and together. Reducing S (severity to the customer) is a priority, however high O and D with low S may also be harmful to the internal / external customer, particularly in healthcare. For example, if results are frequently delayed, work could be lost, or clinical management delayed, thus having possible compounding effects outside of the scope of the review.

Some approaches support examining issues over a certain number with an aim to reduce RPN's by a chosen amount. However this approach may detract from the true objectives, of improving procedures to consistently meet customer requirements. FMEA is a living document, with the contributing factors to risk, changing with the varying influences of the environment. An FMEA should be reviewed regularly to identify new risks, and after implementation of a corrective or preventative action (McCain 2006, Tague 2004 & Rodriguez-Perez et. al. 2012). In analysis, it should be remembered that FMEA is a snapshot in time of many interacting factors.

CONCLUSIONS

For any improvement tool to be successfully integrated into an organizations' quality improvement or risk management programme, it needs to be relatively easy to use and proven to provide benefits to the customer and organisation. Many healthcare organisations are facing fiscal constraints and increasing complexity of tests, putting strains on resourses, particularly for involvement of those on the 'shop floor, and who are 'hands on' in the production of a product or service.

FMEA was useful within this review. Two relatively brief reviews by the team, increased awareness of risk and improved controls, documentation and workflow within the MRT. The ranking system illustrated concordance with needed actions (8 recommendations from 18/23 top RPN's, and 7 minor changes in the lower 63 RPN's). However prioritization using the scores were not required as needs to fulfil customer requirements were obvious and solutions simple to implement.

FMEA broadens the scope for improvement, improves the depth of understanding of a process and identifies the possible failings within process steps. Within this study, the FMEA provided further improvements to an already reviewed process that was perceived to have few problems.

FMEA is used as an accreditation requirement for proactive risk management within healthcare organisations overseas (Shelb et. al. 2012 & Van Tilberg et. al. 2006). Within New Zealand, ISO15189, 4.11 (NZS/ISO), stipulates that laboratories shall have documented procedures for determining where potential non-conformities exist, through review of data and information - but it does not specify a method. Audits have the capacity for preventative action limited to the scope of each review. FMEA is a proactive 'self-auditing' improvement tool that provides for a detailed review and analysis of processes, and a structured systematic format for proactive identification of corrective and preventative actions to reduce risks to the customer.

FMEA is an extension of Shewhart's PDCA Cycle (Deming 1986), examining not only the current, but the potential 'situation' for each process step, 'planning and doing' through recommended actions, 'acting and checking' from following through and re evaluation for continuous improvement (McCain 2006). FMEA can be used at the development stage, or for review of an existing process or product (Teng et. al. 2004).

FMEA does not require complicated statistics however, it does require time, patience and planning for efficient and effective application. A team with current detailed knowledge of the area under review, including all inputs and all customers (a cross functional team) will increase the power of its application.

A clear scope with defined scales for ranking are also required. The rating system can be a useful guide however, analysis of the causes, controls and effects of the possible failures may be enough in itself to point the way for action to minimise risks to the customer. When definitions of S are clear and focused on the customer, actions may be obvious or urgent. Where risks can be minimised with simple solutions to improve controls without introducing new risks, it may be possible to implement improvements immediately

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Literature review of QM and SCM: a perspective of integration

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ABSTRACT

Purpose. To explore the practices of supply chain management and quality management, in order to study the integration of both management fields by means of a structural model.

Design/methodology/approach. An overview of the main concepts of supply chain management and quality management were reviewed from the literature, and some practices have been identified in order to understand how these areas are related to each other, and the benefits that this integration can bring to companies' performance.

Findings. The use of integrated approaches to quality management and supply chain management becomes necessary to accomplish some objectives as produce value and optimize sustainability. Due to similar characteristics of these two management areas as: the adoption of holistic approaches, the promotion of continuous improvement and innovation; customer satisfaction; leadership; strategic planning, among others; they can been seen as complementary, and improved global performance can be achieved from their synergies. Thus, they offer a unique framework to integrate participation and partnership between stakeholders.

Research limitations/implications. This paper presents a structural model that is based on a literature review. A comprehensive validation process is required to get further insight on the subject, allowing to understand how companies implement supply chain management and quality management strategies and the way it impacts on the overall organization performance.

Originality/value. There are some studies concerning the relationship between supply chain management and quality management, although, as far as we were able to find out based on the literature review carried out, there is a lack of studies that covers downstream and upstream dimensions of the whole supply chain. For that reason, we present a conceptual model proposal where it is possible to see the major areas that affect both quality management and supply chain management. We also present some practices that affects quality management and others that affect supply chain management, that the authors consider being of great importance for the integration of these two areas. With this model we consider that we can embrace the most important issues concerning both areas.

Keywords: Supply chain management, quality management, integration.

Article Classification: Research paper

INTRODUCTION

The supply chain management (SCM) extends the concept of integrated management to all organizations involved in the process, from suppliers of raw materials to end customers.

The growing competition, globalization of economies and the need to increase the competitiveness of organizations through operational efficiency, promote new opportunities and challenges in the management and organization of the entire supply chain. Thus, the SCM appears as an essential tool for competitive advantage in the market, since it allows the development of a link between the market, the distribution network, the production process and procurement activities, offering to customers a service of excellence at a low cost.

Likewise, quality management (QM) is another concept that promotes the competitiveness of organizations. Considering that customers are becoming more demanding, they are increasingly looking for companies that meet their needs in terms of products/ services, and companies that can indeed outweigh their expectations. Thus, QM influences the performance of companies and customer satisfaction, as well as other stakeholders.

The understanding of how quality management and supply chain management are related in a particular organization and the impact that this integration has in the organizational performance is still very limited (Ramos et al., 2007; Agus, 2011). Flynn and Flynn (2005) realized that organizations that pursue both quality and supply chain goals achieve a competitive advantage. Also, other researchers found mixed results of the effect of QM practice on supply chain performance. This suggests that more research is required in order to provide some guidance to both researchers and supply chain managers. New findings could help managers to understand, how they can effectively distribute resources to issues that are critical for the QM integration in order to improve supply chain performance and consequently analyze the impact of this integration in companies' performance (Fynes et al., 2005; Flynn and Flynn, 2005; Min and Mentzer, 2004; Forker et al., 1997; Yeung, 2008).

Thereby, the main goals of this paper are to discuss the key topics related to the integration of these two crucial organizational areas and to develop a conceptual model that provides new insights about their impact on the organization.

In the next section, the literature concerning QM, SCM and the integration of both areas will be reviewed. Based on the literature review, a conceptual model is proposed and presented in section 3. Section 4 contains final considerations about the work.

LITERATURE REVIEW

There are several definitions concerning Quality Management (QM). Many authors defined QM as a "management philosophy" (Perry and Sohal, 2001, Khan, 2014, Bon and Mustafa, 2013). In any case, QM corresponds to a type of management that can be characterized by the constant search for continuous improvements in the processes and procedures, in order to achieve excellence. Therefore, this philosophy supports the companies to attain efficiency, sustainability and competitiveness (Oakland, 1993, Terziovski, 2006). With that, companies can improve their organizational performance and business, customer and employees' satisfaction, relationships with suppliers and positive attitudes, by improving organizational quality culture (Talib et al, 2011; Reed et al., 2000).

The measure of the quality performance is fundamental to effective manage an organization. Thus, it is necessary to determine how QM is implemented and to measure the impact that their practices have on the organizational performance. Saraph et al. (1989) and Lu and Sohal (1993) were the first ones to try to measure how the QM practice affects organizations.

The research on QM has been progressing over the last two decades and therefore empirical research has defined and measured a set of practices (Kaynak and Hartley, 2008). It is known that there is a strong relationship between those practices and organizational performance including non-financial performance in small and medium enterprises (Hassan et al., 2012; Chung et al., 2008; Demirbag et al., 2006; Hendricks and Singhal, 2001). Hassan et al. (2012) demonstrated that QM philosophy improves the production performance and all the performance indicators related to customer. With the increasing of market´s competitiveness, the importance of the QM practices will become increasingly important, namely, customer focus, product design among others (Chong et al., 2004).

The globalization of the economy and also the rivalry that exists between companies, leads to the necessity of increasing companies competitiveness. This competitiveness can be achieved through operational efficiency which promotes challenges and opportunities on managing and on the organization of the entire supply chain.

Since the 80s, the interest in supply chain management (SCM) topic is increasing because companies realized that collaborative relationships within and beyond their organizations brought benefits for all the interested parts (Lummus and Vokurka, 1999). Since then, different descriptions of SCM have been proposed. One of the definitions is that SCM "*encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies"* (CSCMP).

The SCM help companies to find suppliers that can offer better services with lower prices, allowing companies to become more specialized and competitive. Therefore, it is fundamental for companies to manage all the network of supply in order to optimize the performance of the whole system. Robinson and Malhotra (2005) also noted that each time a certain company deals with another one that will provide the next phase of the supply chain, both stand to benefit from the other's success.

Cooper and Ellram (1993) suggested that the implementation of SCM has three major objectives that are: to reduce inventory investment in the supply chain; to increase customer service through increased stock availability and reduced order cycle time; and to help build competitive advantage for the network in order to create customer value.

Some researchers stated that companies have to focus on their products, production and quality improvements, not just because of the market requirements, but especially to make their company more competitive than the others, ensuring its survival (Agus, 2011).

QUALITY MANAGEMENT AND SUPPLY CHAIN MANAGEMENT INTEGRATION

Quality management has been considered an important strategic management tool over the past two decades, which involves the application of principles and practices of quality at all levels of an organization (Talib et al., 2011).

Some studies define the integration between QM and SCM as the concept of Supply Chain Quality Management – SCQM (Lin and Gibson, 2011). From the perspective of quality management, SCM could be recognized as providing quality products and services across every organization in the supply chain, to address client's expectations. Robinson and Malhotra (2005) stated that SCQM "*is the formal coordination and integration of business processes involving all partner organization in the supply channel to measure, analyze and continually improve products, services, and processes in order to create value and achieve satisfaction of intermediate and final customers in the marketplace".*

SCM assumes a methodical and integrative methodology to manage all the operations and relationships between all the stakeholders of a supply chain. In other words, it integrates all parties of a value chain into one whole entity and manages them as assets of a wide company (Simchi-Levi et al., 2000, Mentzer et al., 2001; Kannan and Tan, 2005; Wang et al., 2004).

The improvement of quality in all supply chain processes leads to cost reductions, improve resource utilization, and improve process efficiency (Wang et al., 2004). There are some studies that investigate how QM can be used to improve the performance of the entire supply chain. Some of them are related with troubleshooting concerning supply network (Lin and Gibson, 2011; Dowlatshahi, 2011; Flynn and Flynn, 2005; Fynes et al. 2005) and other studies identify numerous theoretic and methodological features of the way in which knowledge management applications are proposed in the supply chain context (Robinson and Malhotra, 2005). However, there are still some issues that remain unexplored (Yeung, 2008 Forker et al., 1997). Some authors suggest that further research is still needed in order to provide a better understanding about quality practices along the supply chain and also the relationship between quality practices and the overall performance. Therefore, some authors suggest some directions for future research that could be very helpful for the companies (Marra et al., 2012; Kim, 2007; Cao and Zhang, 2011; Craighead et al., 2009; Bozarth et al., 2009). For example, Terziovski and Hermel (2011), presented an exploratory study about the role of QM practice in the performance of integrated supply chain, concluding similarly to Robinson and Malhotra (2005), that traditional QM programs should be transformed in a SCM perspective, so that quality initiatives cooperate and coordinate across all the network of companies in the supply chain. In this study, Terziovsky and Hermel (2011) proposed that future research should focus in why quality practices are strong predictors of an integrated supply chain, and suggested that future models of quality and SCM integration need to empirically examine the aforementioned research question using different methods, as survey and case study approaches with multinational samples.

Lin et al. (2005) concluded that if key QM practices could be integrated in the supplier participation programs, that would provide collaboration between a company and its suppliers, which would have as a consequence an enhanced organizational performance. The organizational performance can also be optimized if a company considers its suppliers as member of its own firm. Although, they consider that more research is needed to extend these conclusions to other countries or regions.

Kannan and Tan (2005) have empirically examined the level to which just in time (JIT), SCM and QM are correlated, and consequently their impact on business performance. Their study validated that at both strategic and operational levels, there are relationships between how these areas are held by organizations. For example, both organizational areas are seen as a part of their operations strategy; and that there is a commitment to quality and an understanding that supply chain dynamics have the greatest effect on performance. Their empirical study although interesting is like others studies, limited in scope for all the supply chain and quality practices.

Based on the literature review carried it is possible to state that the integration between SCM and QM is a natural evolution of management practices, because, to the best of our knowledge, this integration is so far focused on specific features such as purchasing, manufacturing and distribution in order to support logistics processes. But due to the competitive environment, it is essential to improve the performance controlling some points such as: cost, efficiency, service levels, rapid response and quality of products and services (Lin et al., 2005).

The practices that will be used in this research have been analyzed and proposed by some researchers. In table 1 one can find a few examples of those practices.

Table 1. SCM and QM practices

Practices	SCM	QM
Leadership	Cooper and Ellram (1993), Andrews and Stalick (1994)	Bon and Mustafa (2013), Talib and Idris (2014)
Management and strategic planning	Li et al. (2005), Talib et al. (2010)	Bon and Mustafa (2013), Talib et al. (2010), Talib and Idris (2014)
Stakeholders involvement and commitment	Yu et al. (2013), Li et al. (2005)	Bon and Mustafa (2013), Talib et al (2010)
Information management	Li et al. (2005), Talib et al. (2010), Kushwaha and Barman (2010)	Li et al. (2005), Bon and Mustafa (2013), Talib and Idris (2014)
Continuous improvement and innovation.	Soosay et al. (2008)	Bon and Mustafa (2013), Talib et al. (2010)
Sustainability	Pagell and Wu (2009), Seuring and Müller (2008), Carter and Rogers (2008), Svensson (2007)	Fotopoulos and Psomas (2009), Ahmad and Schroeder (2002), McAdam and Leonard (2003), Isaksson (2006)
Product/service quality		Saravanan and Rao (2004), Samat et al. (2006), Ueno (2008), Baird et al. (2011),
Quality culture		Black and Porter (1996), Harvey and Stensaker (2008), Irani et al. (2004), Kanji and Yui (1997), Kanji and Wong (1998)
Procurement	Koh et al. (2007), Thomas and Griffin (1996), (Spekman et al., 1998)	
Internal logistics	Ulusoy (2003), Kim (2006), Stock et al. (2000),	
Distribution	Vidal and Goetschalckx (1997), Croom et al. (2000), Cooper and Ellram (1993),	

STRUCTURAL MODEL PROPOSAL

In the recent past, a few number of contributions have been proposed to address the integration between SCM and QM. As referred before, they focus on specific aspects of the logistic system leaving out key aspects of SCM.

Integration of QM and SCM has already been described as a process that will improve (Casadesús and Castro, 2005), for example, customer satisfaction and the performance of supply chain parties, but it is also important for the improvement of the competitiveness of the companies (Kaynak and Hartley, 2008).

To further study the potentialities and hurdles of integration of these two areas we propose a structural model (Figure 1) to represent, in a comprehensive way, the key areas of both domains and the relationships between them.

Leadership is a practice that is common to these two areas. It is focused on creating and maintaining an environment within the organization, where people become fully involved and committed to achieve the quality objectives of the organization. Also in the context of supply chain management, leadership is responsible for maintaining stability in the supply chain that promotes the performance improvement (Sharif and Irani, 2012).

As stated before, the main objective of QM and SCM is the continuous improvement and the innovation of the companies. Thus, the innovation capacity is of great importance in terms of competitiveness and to promote a dynamic capability to respond to active markets and customer needs. This means that companies should be prepared to quick changes in the market by continuously innovating.

Sustainability is related to the achievement of a sustainable performance in three dimensions: economic; social, and environmental. Supply chain sustainability is crucial and necessary to ensure long-term profitability, and is related to structural and organizational changes throughout the chain, promoting robust collaborations with suppliers and customers, reducing costs and environmental impacts (Seuring and Gold, 2013). In the quality perspective, sustainability can help companies develop their long-term success, and for this it is necessary to optimize procedures and systematize the structures that comprise an entity (Reed et al., 2000). Thus, there is a commitment between all parties involved, which certifies that the sustainability criteria are respected.

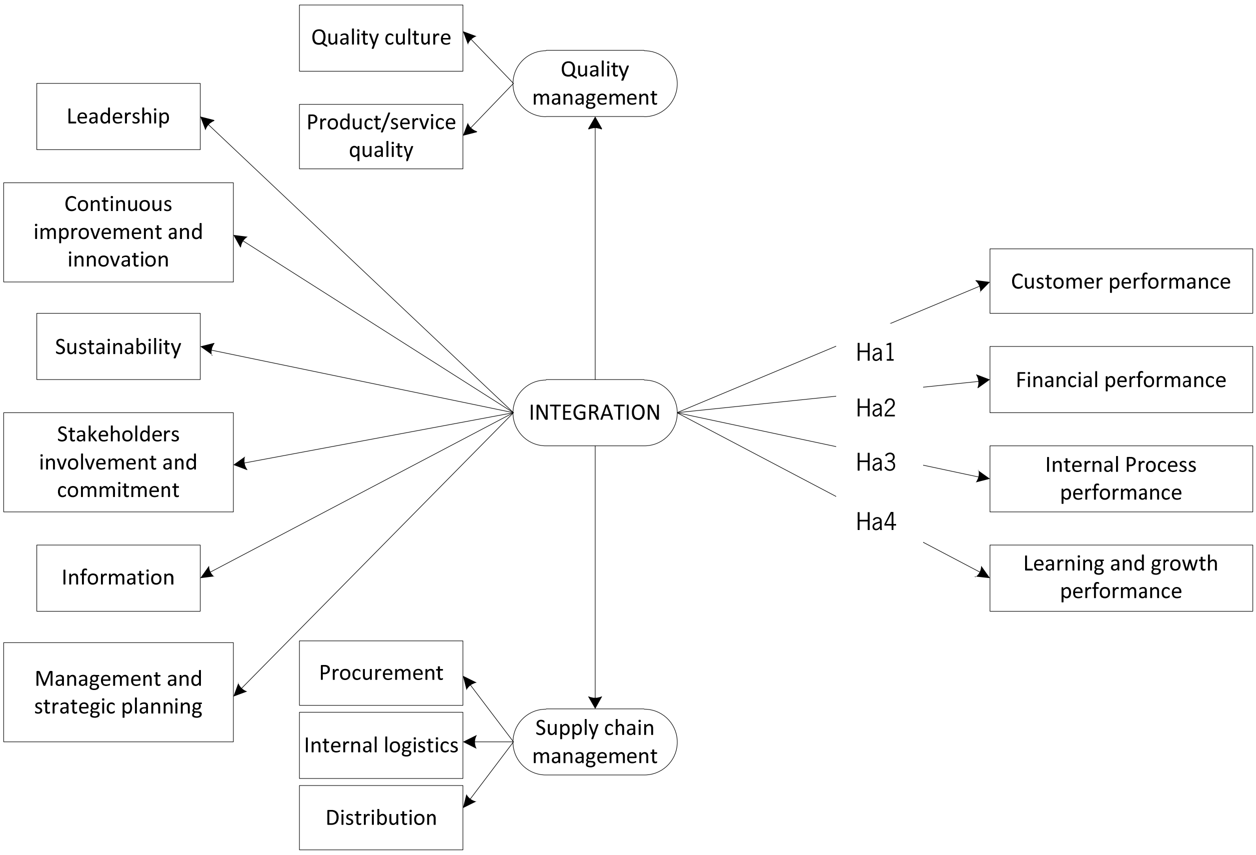

Figure 1. Structural model developed with hypothesis.

The stakeholders' involvement and commitment consider all the interested parts that could influence the success of a business. Concerning the employees, their involvement and commitment at all the levels of an organization is crucial, since their complete involvement allows their capacities to be used for the benefit of the organization (OSHA, 2005). Additionally, the involvement and commitment of the supply chain is critical to the internal and external integration and will have a significant impact on organizational performance.

Information systems allow the production of a well -timed information, which makes this a critical tool for managers struggling in highly competitive environments. In fact, it has been stated by some researchers that the performance of supply chain is influenced by managing and integrating key elements of information into the supply chain (Gunasekaran and Ngai, 2004). Thus, it is imperative that firms can have information technology system implemented, in order to plan, control and make adequate decision, balancing trade-offs between quality, costs, level of service, profit, among others aspects. Additionally, information and communication technologies are a key element for a fully integrated relationship between stakeholders and the drivers for the implementation of coordinated relationships.

Management and strategic planning in SCM includes a large set of complex issues, such as: network design, inventories location and management, suppliers' management, production planning, information management and quality. On the other hand, QM involves: human resources; quality strategy; planning; responsibility; authority; communication, and commitment.

Two major QM practices were identified: product/service quality, and quality culture. We believe that these two practices are well correlated with organizational performance. Product/service quality is what a customer expects in the product/service that he is acquiring. If a customer expects 'excellence' in everything he purchases, then his expectations are very high (Murthy, 2007). Therefore, it is important that company financial policies, marketing strategies, and products are well designed and established. It is also imperative for the company to establish quality assurance steps and follow them.

The development of a quality culture is an approach that is related with sharing of values, beliefs, attitudes and patterns of behaviour that characterize the members of an organization, and aims to improve the overall organizational performance (Woods, 1998). In a healthy corporate culture, all transactions are carried out correctly and the relationships between all the people involved (employees, suppliers and customers) are successful.

Regarding SCM, three main practices were proposed: procurement, internal logistics and distribution. Procurement activity defines all the actions and processes in order to acquire goods and services. All inbound supply processes are executed by procurement (Stadtler and Kilger, 2000). This activity includes all the actions engaged in the establishment of fundamental requirements, such as, identification and featuring material requirements, receipt of orders, goods selection, and payments, among others.

The internal logistics should be seen as a value-adding supply chain process (Stank et al., 2001), since it ensures the movement and storage of product inventories throughout the company. Thus, logistics has a critical importance to organizational performance, since it is responsible for the reduction of stocks and tasks that do not add value to the final product.

The distribution includes a wide range of activities related to the effective and efficient movement of material from the source of supply to the point of use or consumption (Sanders, 2012). Those activities include, not only the choice of the most adequate distribution channel, but also a set of activities, such as the freight transportation, warehousing, material handling, packaging, inventory management systems and information systems management.

The measure of the organizational performance is related with the balance of the current results with its planned goals. In this study, organizational performance will be measured based on the balanced scorecard perspectives. The balanced scorecard is a performance measurement matrix designed to capture financial and non-financial metrics that link the critical success factors of an organization in a cause-and-effect manner, to organizational strategy (Houck et al., 2012). The balanced scorecard covers four perspectives: customer; financial performance; internal processes; and the learning and growth environment. Each one of these areas contains multiple measures.

When analysed separately, different QM and SCM practices have a positive impact on organizational performance. Kaynak (2003) has stated that quality performance is related to higher organizational performance, considering different quality practices - management leadership, training, quality data and reporting, product/service design, etc. Concerning SCM, Ou et al. (2010) analyzed the relationships among SCM practices such as: customer focus; management leadership; process management; among others, and their impact on the organizational performance. Similarly to Kaynak (2003), they also concluded that there is a positive relationship between those practices and the organizational performance.

Thereby, in this research, to get insight into relationship between the integration of these practices and various aspects of organizational performance, the following hypotheses are suggested:

- Ha1: The QM and SCM integration will have a significant impact on the customer perspective performance.
- Ha2: The QM and SCM integration will have a significant impact on the financial perspective performance

- Ha3: The QM and SCM integration will have a significant impact on the internal process perspective performance.
- Ha4: The QM and SCM integration will have a significant impact on the learning and growth perspective performance.

As a consequence of the stated above, we consider that this model is an adequate representation of QM and SCM integration, and it is expected that it could contribute to understand the integration of these two areas, taking advantage of their complementarities and similarities, and may, in fact, be important to the overall organizational performance.

CONCLUSIONS

Much attention has been dedicated to SCM concepts in recent years. However, the analysis of the relationship between SCM and QM and their integration is still very limited (Robinson and Malhotra, 2005). There are many similarities and differences between those areas and the understanding of those points can contribute for future operations management future research.

In order to go deeper in this topic, this paper presents the first result of a research project that we are conducting in order to analyze the integration of SCM and QM and its impact on the companies' performance. This is important since both areas are seen as management philosophies which can have an unlimited potential for scope and applications in organizational context.

There are a high number of studies that suggest that more research is needed, and we think that this conceptual model can help to fill some of the gaps stated in other works.

Therefore, the conceptual model proposed in this paper will be statistically validated using the structural equation model technique, based on a survey that will be performed on an international basis.

A comprehensive validation process of the model is required to get further insight on the subject allowing to understand how companies implement and integrate SCM and QM strategies and how that integration impacts on the overall organization performance. For that purpose, it is necessary to implement different investigation lines in multiple contexts.

Currently, a questionnaire has been developed and a large-scale survey is conducting. Based on the results, the research model can be validated and the relationship between the QM and SCM integration and organizational performance can be established.

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A literature review on internalization of quality standards

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ABSTRACT

Purpose. This paper presents a literature review about internalization of quality standards and identifies antecedents and the effects of internalization.

Design/Methodology/approach. The ScienceDirect, ProQuest and Emerald databases were used in order to carry out searches with the following keywords: "daily usage of ISO 9001", "substantive versus symbolic adoption", "integration", "depth of implementation", "level of adoption", "basic, advanced and supportive implementation", "internalization". The references in the papers identified by these searches were also reviewed.

Findings. Results of this literature review show that organizations can implement quality standard requirements in different ways. This leads to either an in-depth or a symbolic adoption of the quality standard requirements. Moreover, a higher degree of internalization may have positive effects on performance. In this context, different factors can play a role in the relationship between internalization and performance, such as reasons for seeking certification, quality culture, leadership, training activities, stakeholder pressure, innovation and the way ISO 9001 system is coordinated with suppliers and customers.

Originality/value. This paper identifies the antecedents of internalization and the factors which may influence the relationship between internalization and performance.

Keywords: Quality management standards, internalization, quality certificate, performance

Article classification: Literature review

INTRODUCTION

The implementation of quality management systems has been, and still is, very important for many firms as a strategy allowing them to improve their results. Also, quality management systems have attracted wide attention from the academic sphere, although the findings have not always been conclusive (Terziovski and Power, 2007; Martínez-Costa et. al., 2009; Lo et al., 2011; Sampaio et al., 2012).

Most studies on the implementation and certification of quality management systems have measured such implementation through a variable that distinguished those organizations which did have a quality certification from those which did not (Sharma, 2005; Zaramdini, 2007; Benner and Veloso, 2008), thus assuming a homogeneous implementation of the quality standard. In the same line, more recent studies have gone beyond this notion and analysed a heterogeneous adoption of the quality standards (Naveh and Marcus, 2004; Briscoe et al., 2005; Prajogo et al., 2012), that is, they have considered that those firms implementing a quality standard (e.g. the ISO 9001 standard), may develop its requirements in different ways.

A heterogeneous adoption of a quality standard implies, on the one hand, that a firm may show a greater commitment towards the quality philosophy, and therefore develop the standard's requirements to a greater extent. On the other hand, another firm might show a lower interest towards the standard and, as a result, implement its requirements in a more symbolic way. In this latter case, the firm might be interested in obtaining a certificate which allows it to show its customers that it has some quality system, without any concern for what lies behind the certificate, i.e. the requirements of the quality standard.

All these studies, focusing on the way the quality standards have been internalized, have helped to: (a) better explain the relationship between quality certification and performance (for instance, Naveh and Marcus, 2004; Nair and Prajogo, 2009; Boiral, 2012) and (b) as a result, expand the results of previous studies on the relationship between quality certificates and performance. This line of research is a very interesting one, and further studies are required on various sectors and countries in order to better understand the internalization process of quality standards (Nair and Prajogo, 2009; Heras-Saizarbitoria and Boiral, 2013).

Thus, although research on operations management has increased our understanding of the relationship between quality certification and performance (Terziovski et al., 2003; Singh et al., 2006; Lo and Chang, 2007; Dick et al., 2008; Magd, 2008) and on internalization (Naveh and Marcus, 2004; Heras-Saizarbitoria, 2011), there appears to be limited research on the effects of internalization on the various dimensions of performance, and on which factors might influence such relationship. Therefore, it is interesting to review the literature on the internalization of quality standards which may expand our knowledge on this issue. This will help future researchers to measure internalization and the variables which may influence the relationship between internalization and performance.

This paper carries out a review of the literature on internalization, identifying the antecedents and the effects of internalization. Studies on the internalization of quality standards are identified and analysed on the basis of a computer search in the ScienceDirect, ProQuest and Emerald databases.

METHODOLOGY

This paper identifies and analyses studies on the internalization of quality standards on the basis of a computer search in the ScienceDirect, ProQuest and Emerald databases. The purpose has been to identify theoretical and empirical works on the internalization of quality standards. To this end, a search has been made for studies whose title, abstract and/or keywords included any of the following expressions: "internalization", "daily usage of ISO 9001", "integration", "depth of implementation", "level of adoption", "substantive versus symbolic adoption", "basic, advanced and supportive implementation". Also, the bibliographic references in the studies analysed were also checked.

This review identified theoretical contributions and qualitative and quantitative contributions. Besides, since the focus of the review was internalization, those papers which measured quality certification as a dichotomic variable and did not discuss internalization were excluded. Therefore, we considered only those contributions that measured the implementation and certification of a quality system through a set of items that make it possible to measure the degree of implementation of the standard's requirements, i.e. internalization. Finally, 20 studies have been identified, as may be seen from Tables 1 and 2 in the following section, indicating the type of study, the sample, the analysis carried out, the main results and the type of variables measured.

RESULTS

The experience of many managers and the results of different studies in the manufacturing and in the service sectors show a variety of results regarding certification. A first perspective holds that certification improves efficiency, customer and employee satisfaction, and service quality (Lee *et al.*, 2009; Mak, 2011). These studies indicate clear operational benefits. The second perspective states that certified firms have improved their financial performance (Chow-Chua *et al.*, 2003; Mokhtar and Muda, 2012). The third considers that certification does not have an influence on a firm's performance (Martínez-Costa, *et al.*, 2009; Lo *et al.*, 2011). These results show that some ISO 9001 certified firms have improved their performance, whereas others have not.

This may lead to wondering which aspects reinforce a positive relationship. It can be said that if the quality standard is efficiently implemented, it can have positive effects on financial, operational, customer and people performance (Casadesús and Karapetrovic, 2005). In order to supplement the results of this type of studies and better explain the factors that may favour a positive relationship between certification and performance, scholars have carried out studies on the internalization of quality standards which are helping to better understand the effects of these systems upon performance.

The studies on the effects of quality certification upon performance have analysed the "certification" variable as a dichotomic one, studying whether having or lacking a quality certificate has positive effects upon performance. On the other hand, the studies on internalization have considered a heterogeneous implementation, measuring the implementation and certification of a quality system as a set of items.

Table 1. Theoretical and qualitative studies on internalization

Study	Sample	Analysis	Results
Boiral (2003)	47 semi-structured individual interviews with managers and employees from ISO 9000 certified organizations in Québec	Qualitative analysis	The study shows the coexistence of several ways of integrating and interpreting the ISO 9000 standards. The quality enthusiasts were a driving force in promoting the standard's requirements. The ceremonial integrators appeared to be fundamentally unconvinced followers of the standard. Finally the dissidents succeeded in coming to terms with the very flexible requirement of the certification audit
Boiral (2011)	189 interviews with managers (89), environmental and quality specialist (50) and employees (50) working in ISO 9001 or ISO 14001 certified organizations in Canada	Qualitative study	Organizations can obtain very real, accrued benefits in terms of quality and environmental management by adopting ISO 9001 and ISO 14001 standards. Nevertheless, such benefits are far from automatic. They are due less to the standards themselves and more to attitudes towards them and the way they are implemented
Heras (2011)	Eight case studies in Spain (20 semi-structured interviews with general managers, 17 semi-structured interviews with middle managers and 28 semi-structured interviews with employees)	Qualitative study	Seven factors and 22 sub-factors were identified to categorize the concept of internalization of the ISO 9001 standard
Boiral (2012)	Semi-structured interviews with 60 managers, quality specialists and non-managerial employees in 60 different ISO 9000 certified organizations in Quebec	Qualitative study	The study shows that the rationale of learning and motivation can and does coexist with ceremonial, symbolic and superficial aspects
Heras and Boiral (2013)	Theory	Literature review	

The studies in Tables 1 and 2 show the theoretical and empirical scholarly studies dealing with internalization of quality standards that were found during the search. From Tables 1 and 2, mention may be made of the following:

- 1 literature review work (Heras-Saizarbitoria and Boiral, 2013).
- 4 qualitative studies asking open questions on internalization: Boiral (2003), Boiral (2011), Heras (2011) and Boiral (2012).
- 2 papers which only analysed reasons and benefits, but related them to internalization: Boiral and Roy (2007) and Martínez-Costa et al. (2008). These studies did not measure internalization by means of items, but they dealt with internalization when explaining the relationship between the standard and performance through internal and external reasons.
- 7 papers measuring internalization by means of a set of items analysing the degree of implementation of the various requirements of the ISO 9001 standard (Huarng et al., 1999; Arauz and Suzuki, 2004; Jang and Lin, 2008; Singh, 2008; Prajogo et al., 2012; Psomas et al., 2013a; Psomas et al., 2013b).
- 6 papers measuring internalization through a set of specific items: Naveh and Marcus (2004), Briscoe et. al. (2005), Naveh and Marcus (2005), Christmann and Taylor (2006), Nair and Prajogo (2009), Prajogo (2011).

Table 2. Quantitative studies on internalization

Studies	Sample	Analysis	Results	Variables		
				Internalization	Reasons	Other variables
Huarng et al. (1999)	370 certified companies in Taiwan	Regressions	Internal motives have positive effects on quality improvement and cost reduction. Similarly, external motives impact on sales. The results also show that when companies develop requirements to a higher extent they can improve benefits.	X	X	Benefits of ISO 9001
Arauz and Suzuki (2004)	292 ISO 9000 certified companies in Japan (manufacturing and service organization)	t-test, factor analysis and regression	If the standard is integrated with new quality programs like six sigma, the road to customer impact may be more effectively achieved	X	X	Maintenance activities (10 items), quality measures (10 items) and performance measures (24 items)
Naveh and Marcus (2004)	1150 ISO 9000 managers in manufacturing and service organizations	Regression models	Adoption of ISO 9000 can be superficial or in-depth. Greater degrees of assimilation and efforts to go beyond the minimum requirements of the standard are associated with improved operational and business performance	X		Business performance Operating performance
Briscole et al. (2005)	275 ISO 9000 certified small-firm manufacturers in U.S. and Canada	Structural equation modelling approach	A proactive quality culture reduces the behavioural reticence to ISO 9000 implementation. Quality consciousness reduces the behavioural barriers to ISO 9000 implementation. Then, organizations that build a culture that value quality are much more effective at internalizing ISO practices.	X		Innovative environment Quality culture Coordination of the ISO with supplier/customer In-house infrastructural analysis Barriers Operational performance Market Performance

Naveh and Marcus (2005)	1150 managers from 924 manufacturing and service organizations with ISO 9000 registrations	Hierarchical linear models	When ISO 9000 was used in daily practice and as a catalyst for change, the organization could achieve a distinct operating performance from implementation but this better operating performance improvement did not necessarily lead to better business performance. The direct effect of operating performance on business performance was supported only partially	X		Business performance Operating performance
Christmann and Taylor (2006)	172 responses from quality certified firms from the China Quality Certification Center database	Regressions	If symbolic implementation is enough to satisfy customers, or if monitoring is so weak or sanctions so slight that firms see no economic justification to do more than the minimum, then firms will choose symbolic implementation.	X		Pressure from customers/suppliers
Boiral and Roy (2007)	872 certified Canadians firms	Factor analysis of ISO statements, differences	Internally driven organizations experienced more benefits and fewer internal difficulties in implementing ISO 9000		X	Benefits Potential problems The audit process Opinion of the 2000 ISO version
Jang and Lin (2008)	441 ISO 9000 certified companies in Taiwan	Structural equation model	Internal motives are positively correlated with the implementation depth and no significant relationship between external motivation and the implementation depth, but the study shows that internal motivation mediates the relationships between external motivation and ISO 9000 implementation depth	X	X	Operational performance Market performance: Market share Business performance
Martínez-Costa et al. (2008)	713 industrial companies in Spain	ANOVA	Internally motivated ISO 9000-certified companies do improve after certification. However, the externally motivated ISO 9000 companies failed to show improvement after certification		X	Quality measures Performance measures
Singh (2008)	418 ISO-registered organizations in the manufacturing industry in Australia	Structural equation modelling technique	Leadership plays a ubiquitous roles and influences on other practices and performance of organization	X		Quality performance Business performance
Nair and Prajogo (2009)	281 ISO 9001 certified manufacturing and non-manufacturing companies in Australia	Structural equation model	Internalization is associated with operational performance. ISO 9000 has no direct relationship with business performance and operational performance mediates the effect of internalization of ISO 9000 on business performance	X	X	Operational performance Business performance
Prajogo (2011)	328 ISO9000 certified manufacturing and non-manufacturing organizations in Australia	Multiple regression analysis	Internal motives align the implementation process with the intent of ISO 9000 standard in building a sound QM system. External motives, while showing a relationship to implementation, do not show any statistically significant relationship with operational performance	X	X	Operational performance

Prajogo et al. (2012)	321 manufacturing and non-manufacturing ISO 9000 organizations in Australia	Structural equation modelling	Advanced and supportive implementation has direct relationship with activities, which subsequently lead to enhanced operational performance. However, basic implementation only has an interactive effect on activities, meaning that its effect is dependent on other aspects of the implementation process	X	Internal process management Supplier process management Customer process management Operational performance
Psomas et al. (2013a)	335 ISO 9001 certified Greek food manufacturing companies	Exploratory factor analysis and confirmatory factor analysis	Development of a measurement instrument of ISO 9001 effectiveness including three measures.	X	
Psomas et al. (2013b)	100 ISO 9001 certified Greek service companies	Multiple linear regression analyses	ISO 9001 effectiveness has positive effects on operational performance and product/service quality. Operational performance impacts on financial performance and ISO 9001 effectiveness impacts on financial performance indirectly through operational performance	X	Financial performance Operational performance Product/service quality

Most of these studies are of a quantitative nature, while four of them are qualitative and one is a literature review. The theoretical paper is a literature review on the ISO 9001 and ISO 14001 standards which analyses studies on reasons for certification, benefits from adopting the standards, differences in standard adoption (internalization), integration of the standards, and issues related to consultancy and auditing for ISO standards.

Regarding the qualitative studies, they deal with internalization and its effects through semi-structured interviews with managers and employees of certified firms (Boiral, 2003; 2011; 2012) and how to measure internalization (Heras, 2011). The remaining 15 quantitative studies in Table 2 examined internalization and its effects using significant difference analysis, factor analysis, HLM and mainly regression analysis and structural equation analysis in order to identify causal relationships, indirect or mediating relationships and/or moderating effects. Concerning the geographical scope, the 19 empirical studies were carried out in Australia (4), Canada (4), North America (2), Taiwan (2), Greece (2), Spain (2), United States and Canada (1), China (1) and Japan (1). From Tables 1 and 2, it may be observed that the results of these studies have focused on:

- The relationship between reasons and benefits.
- Internalization and its effects.
- The factors that may influence the relationship between internalization and performance.

Reasons and benefits. The reasons for the implementation of a quality system may be of an internal and/or external nature, and both may have an influence upon benefits. For instance, internal reasons may have positive effects upon quality improvement and cost reduction. For their part, external reasons may improve sales due to the improved image obtained through certification.

The studies in Tables 1 and 2 show that, the greater the weight of internal and external reasons, the greater the benefits (Boiral and Roy, 2007). Although both reasons may have an influence upon benefits, some studies also indicate that internal reasons are more important. For instance, when internal reasons are more important than external ones, better results may be obtained (Boiral and Roy, 2007; Martínez-Costa et al., 2008). However, Prajogo (2011) pointed out that external reasons do not generate profits.

These results indicate that internal reasons have an influence on performance, while the effects of external reasons do not appear to be so clear. Therefore, further research may be required towards a better understanding of this relationship.

Internalization. Studies show that the higher the internalization level, the greater the operational and marketing benefits (Briscole et al., 2005; Naveh and Marcus, 2005; Jang and Lin, 2008). This is the case because firms develop the quality standard requirements to a greater extent.

However, the effects on business performance are not so conclusive. According to Naveh and Marcus (2005), there could be direct effects of operational performance on business performance, although other factors which might affect this relationship should also be considered. Similarly, Jang and Lin (2008) pointed out that operational performance has an impact on business performance. Thus, internalization is related to operational performance because, in principle, employees receive more training on quality and are more committed, are more aware of the quality policy, objectives and documents, quality practices following the ISO 9001 standard are implemented in daily routine, periodical audits are carried out and information is used to a greater extent in order to improve quality, more quality control activities are put in place in order to reduce costs, etc. (Huarng et al., 1999). These ideas show how internalization creates improvements which may impact operational performance such as, for instance, cost reduction, innovation and quality improvement, etc. (Nair and Prajogo, 2009). In turn, this may create a more open organizational culture which may increase sales (Huarng et al., 1999) and, therefore, may help to improve business performance. In this way, one might think that certification has no direct effects on business performance, and that operational performance could be a mediating factor on the effects of internalization on business performance (Naveh and Marcus, 2005; Nair and Prajogo, 2009).

Factors with an influence on internalization. It seems clear that internalization increases the likelihood that firms may obtain benefits. Nevertheless, the studies in Tables 1 and 2 show that there are some factors which may influence this relationship, amongst which those more clearly analysed are the reasons for certification. In this respect, the results of these studies have led to various conclusions. Firstly, internal and external reasons have an influence upon the level of implementation of the requirements of quality standards (Prajogo, 2011). Secondly, other scholars have pointed out that the influential reasons are the internal ones, rather than the external ones, although some authors found that internal reasons mediate the relationship between external reasons and the degree of implementation of the ISO 9001 standard (Jang and Lin, 2008; 209). Thirdly, other studies have concluded that internal reasons are more important than external ones (Prajogo, 2011), pointing out that external reasons have a negative moderating effect: the greater the commitment to external reasons, the weaker the relationship between requirement implementation and performance (Prajogo, 2011).

These results showed that internalization mediates the relationship between reasons for certification and performance (Nair and Prajogo, 2009). Clearly, internalization mediates the relationship between reasons and performance, internal reasons have an influence upon the degree of internalization, and the effects of external reasons are not as clear. Alongside the reasons for certification, the studied reviewed here have also analysed other variables which might be considered in the future in order to explain other factors which might facilitate internalization, and thus an impact upon benefits. These other factors which might play a role in the relationship between internalization and performance are the following:

- Quality culture. A proactive quality culture reduces reluctant behaviours towards the implementation of quality standards, such as the ISO 9001 standard. This quality awareness may reduce the barriers to the implementation of the ISO 9001 standard and help the organization to develop a culture facilitating the internalization of quality practices (Briscoe et al., 2005).
- Leadership. Leadership plays an important role, and has an influence upon other practices and upon organizational results in a quality environment (Nair, 2006; Sila, 2007; Tarí et al., 2007; Molina-Azorín et al., 2009). In the case of a quality standard, for instance, the policies, plans and acts by the management may also help the firm to become more customer-focused, train employees, improve its relationships with suppliers and its internal communication system, etc. (Singh, 2008). This clearly helps towards a more advanced development of quality practices which, as the literature has pointed out, leads to improved results.
- Training. Firms which offer better training to their staff may find it easier to implement and integrate the practices of quality standards in their daily routines (Naveh and Marcus, 2005). Properly trained employees may know how to do their tasks better and thus develop quality practices in a more efficient way.
- Pressure by interest groups. Pressure by interest groups, such as customers, may lead firms to internalize the quality standard to a greater extent (Christmann and Taylor, 2006). This indicates that a greater interest by customers in compliance with the quality requirements may, for instance, lead an organization to develop such practices more efficiently in order to improve product quality and/or increase customer satisfaction.
- Innovation environment. Firms facing more dynamic environments are more likely to invest in creating a quality culture (Briscoe et al., 2005).
- System coordination with suppliers and customers. Coordinating the system with suppliers and customers increases the level of internalization (Briscoe et al., 2005; 327; Naveh and Marcus, 2005). Firms which need to coordinate their work with suppliers and/or customers may develop these practices more efficiently in order to make the most of these relationships with its customers and suppliers.

CONCLUSIONS

Quality standards may be implemented in different ways. Some firms may show a greater commitment to the quality standard requirements and some may show a lower commitment, or even concern themselves only with the certificate. This may lead in some cases to an in-depth implementation of the quality standard requirements and in others to a symbolic implementation. In turn, greater internalization leads to greater benefits, because the firm may improve its management system, for instance, by improving the following processes: (a) planning control (the management may define objectives and indicators more clearly and may carry out periodic reviews of the quality system), (b) training (the firm may offer more training to managers and employees, which clearly will lead to improvement in their work), (c) customer satisfaction (the firm may use methods in order to obtain feedback from customers and use such information in order to improve its processes and its products/services), etc.

The reasons why a firm may desire to obtain certification are usually internal and/or external ones, and depending on the importance of such reasons, the effects on the degree of implementation of the standard may vary. Thus, when the standard is implemented mainly for internal reasons, the firm is more likely to develop the quality standard requirements to a greater extent than when such implementation is carried out for external reasons. This higher degree of implementation of the quality standard leads to greater benefits than when in those cases where a symbolic implementation is made of the quality standard. However, some firms may start out for internal reasons and with time develop a greater interest in internal reasons, which indicates that, in some firms, the relationship between the two groups of reasons may influence the internalization of the quality requirements. Also, other factors may be mentioned that may influence the relationship between internalization and benefits. Such factors might be the quality culture, leadership, training, pressure by interest group, and innovation environment and coordination with suppliers and customers.

This review of the literature may suggest a number of lines of research. Firstly, it would be interesting to continue analysing whether internal and external reasons have an influence upon the relationship between internalization and performance, and when external reasons may have an influence or not. In this respect, it might be worth looking at the way the internal reasons for quality certification may cause external reasons to lead to higher internalization, and thus to greater benefits. Secondly, it might be interesting to analyse which factors, other than internal and external reasons, may impact both internalization and the relationship between internalization and performance. Such factors could be those listed earlier (for instance, leadership and the staff's commitment to documentation). This will help to better explain the critical factors for the implementation of a quality standard. Thirdly, although it seems clear that internalization has direct effects upon operational performance, and it also appears to have indirect effect on business performance, it might be interesting to analyse the impact of internalization on other dimensions of results, such as customer results, people results, and society impact. Fourthly, it might also be worth continuing the analysis of these issues in other industries beyond the manufacturing sectors, and in various countries, in order to expand the present knowledge on internalization to other industries and to other countries which have been little studied. Research on internalization has focused on the ISO 9001, and given the importance of the Q certificate by the Spanish Institute for Tourism Quality (ICTE) for the Spanish tourist industry, in Spain it would also be interesting to analyse these issues in Spanish tourist organizations possessing the ICTE Q certificate. Thus, present knowledge could be enriched by further qualitative studies based on interviews with various managers and employees, and even other interest groups, in order to look at different perceptions of the standard and better understand the quality culture associated to the quality standard. In the fifth place, it would also be relevant to carry out this type of studies both on quality standards (for instance, ISO 9001) and on environmental standards (such as ISO 14001), given the similarities between the two standards and the integration of the quality systems which takes place in many firms. Finally, it is also necessary to continue examining the various levels of internalization, and how each internalization level may lead to a different level of performance.

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An innovative approach for planning and execution of pre-experimental runs for Design of Experiments

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ABSTRACT

Purpose. This paper addresses the study of pre-experimental planning phase of the Design of Experiments (DoE) in order to improve the final product quality. The pre-experimental planning phase includes clear identification of problem statement, selection of control factors and their respective levels and ranges.

Design/methodology/approach. To improve production quality based on the DoE a new approach for the pre-experimental planning phase, called Non-Conformity Matrix (NCM), is presented. This article also addresses the key steps of the pre-experimental runs considering a goods manufacturing process.

Findings. This paper discusses comprehensively the application of a NCM to identify the problem definition and also when and how to perform pre-experimental runs for the manufacturing processes. Results of the application for an industrial case show that this methodology can support clear definition of the problem and also correct identification of the factor ranges in particular situations.

Practical implications. The proposed approach allows modelling the entire manufacturing system holistically and correctly defining the factor ranges and respective levels for a more effective application of DoE.

Originality/value. This paper reports a new tool for the pre-experimental planning phase and application of pre-experimental runs, using an industrial case. This new approach can be a useful resource for both research and industrial practitioners who are dedicated to large DoE projects with unknown factor interactions, when the operational levels and ranges are not completely defined.

Keywords: Pre-experimental runs, Non-Conformity Matrix, Design of Experiments.

Article Classification: Technical paper

INTRODUCTION

Design of Experiments (DoE) is one of the most powerful tools for process improvement and optimization in the scientific and engineering disciplines. It is widely used to develop robust processes, so that they are less affected by external sources of variability. Objectives of DoE are to study the performance of processes and systems and to better understand the behavior of the process factors, as well as their impact on the quality characteristics of the product and process under analysis. In other words, experiments are performed to (Montgomery et al. 2000):

- Determine which controllable factors have most influence on the response(s);
- Determine where to set the significant controllable factors in order to assure that the response(s) are close to their target value;
- Determine where to set the significant controllable factors in order to assure that the effects of the uncontrollable and noise factors on the response(s) are minimal.

Application of DoE in process improvements can result in improved process yields, reduced process variability and reduced overall costs (Montgomery 2008). Over the past many years, industries have successfully applied DoE to improve process performance and reduce variability (Montgomery et al. 2000) and (Javorsky et al. 2014a). However, other applications of DoE are also realized in the areas of product development (Fowlkes & Creveling 1996) and performance optimization of automation technologies (Subulan & Cakmakci 2011).

DoE consists of three important phases: pre-experimental planning; execution of the experiments; and statistical analysis of the data collected. Pre-experimental planning is a key phase for the successful implementation of the experiments because final conclusions largely depend on the way in which the experiments are planned. At the end of the pre-experimental planning phase, it is expected that the objectives of the experiment, the selection of response variables, factors and their levels and ranges required are clearly defined.

Definition of the problem and selection of factors and their levels and ranges are thus critical steps in any DoE analysis. Incorrect identification of the problem will lead to final recommendations that are not meaningful. Typically, in order to define and characterize the problem, cause-and-effect-diagram and Failure Mode and Effect Analysis techniques are usually applied as simple and straightforward methods to identify potential design factors. However, these techniques are applied once the region of interest is identified (Taguchi et al. 2005). In order to better identify this region, a Systems Engineering tool called Non-Conformity Matrix (NCM) is presented in this paper. This tool enables to model the entire system (e.g. industrial process) holistically, also allowing a systematic analysis of the interactions between its elements that, in our particular case, are the non-conformities identified along the production process.

After the region of interest is clearly defined, it is important to select the right factors and ranges that will be the subject of optimization through DoE, thus improving the quality of the final product. Factors are the input variables of a process that affect directly the response variables. In order to select factors and their levels and ranges, it is required that the experimenter has a deep process knowledge, based on a combination of practical experience and theoretical understanding, as well as historical data and/or previous experimental results. Though, even considering all these information, there are still particular situations where the correct identification of factor levels and ranges is hard to accomplish. This might be due to a variety of causes, such as a certain immaturity of the process, a random behavior of the factor levels and ranges each time the production is run or even to the presence of unpredictable noise factors. The ideal way to address these problems consists in performing the pre-experimental runs to identify the factor levels and ranges for the above-discussed situations. In fact

(Czitrom 2003) and (Coleman & Montgomery 1993) have also mentioned that if additional information is required on factor levels and ranges it is advisable to consider performing pre-experimental runs.

The objective of this paper is to study the pre-experimental planning phase of the DoE for an industrial case in order to improve the final product quality. The pre-experimental planning phase includes: (1) a clear identification of the problem, that was better achieved with the help of the NCM, as well as (2) the correct selection of control factors and their respective levels and ranges. Furthermore, application to the industrial case comprises studying practical problems typically faced while performing pre-experimental runs and selecting factor levels and ranges, highlighting the most important problems and cautions that should be taken into account at this phase of the experiment.

In the following sections, a brief introduction is presented on design of experiments and the techniques used in the pre-experimental planning phase. Also in this section an overview of the basics and principles of the non-conformity matrix (NCM) is presented. Then, a comprehensive study is provided for the experimenters (scientists or engineers) in order to determine when the pre-experimental runs are required and what the key steps for its successful implementation are.

GUIDELINES FOR DESIGN OF EXPERIMENTS (DOE)

The successful implementation of DoE is comprised of eight steps, as summarized in Table I. The first four steps are normally termed as the pre-experimental planning phase (Montgomery 2008).

Table I: Guidelines for Design of Experiments

Problem statement and/or definition	Pre-experimental planning phase
Select factors and their levels and ranges	
Select the response variable(s)	
Choose the experimental design	
Perform the experiment	Execution phase
Statistical analysis of the acquired data	Statistical analysis and recommendation phase
Results validation using confirmatory runs	
Conclusions and recommendations	

The pre-experimental planning phase is one of the most important and critical phases of a DoE analysis that compromises the validity of the final results. In this phase, the statisticians or consultants, who design the experiments together with engineers and experimenters, have to bridge a gap in experience, available resources and knowledge. The current paper discusses in detail what is critical in steps I and II from Table I and then applying these steps to the industrial example.

PRE-EXPERIMENTAL PLANNING PHASE TECHNIQUES

Cause-and-effect-diagram techniques (Ishikawa diagrams), Quality Functional Deployment (QFD), and Failure Mode and Effects Analysis (FMEA) are typically used in the pre-experimental planning phase (Fahmy et al. 2012) and (Montgomery 2008) and (Taguchi et al. 2005) to identify potential design factors. These techniques are often applied once the region of interest (where DoE is performed) is identified (Taguchi et al. 2005). First, all the controllable and uncontrollable factors that could influence the quality of the product are identified. This process is normally held in brainstorming sessions bringing together process engineers, quality engineers and line operators. Then, these factors are hierarchically organized using cause-and-effect-diagrams. This technique is also referred as fish bone diagram, because the effect of interest is drawn along the spine of the diagram and the causes are written along the ribs. The causes listed in the fish bone diagram are a big help in the correct identification of the failure modes.

FMEA can also be used instead of cause-and-effect diagram with additional advantages of identifying the seriousness of effects, how frequently effects occur, and how they can be detected. These metrics are represented by a risk priority number (RPN) for each effect and are calculated on a subjective basis (Fahmy et al. 2012).

Another technique that can be utilized to develop process matrix exhibiting interactions between the system elements is Quality Functional Deployment (QFD) (Browning 2001). This technique is a four-phase process: understanding customer requirements (product planning), develop design planning matrix, develop process planning matrix, and develop operations planning matrix (Taguchi et al. 2005) and (Hassan et al. 2010).

The technique proposed in this paper to identify potential key area consists of a systems engineering tool called Non-Conformity Matrix (NCM). This matrix models the entire system holistically, presenting the cause-and-effect relations between the system elements in a matrix form. The proposed tool, once compared to the more traditional quality tools, has three additional advantages: (i) Identification of the region of interest by analyzing the entire manufacturing system (QFD has been used for similar purpose however in different context); (ii) Cause-and-effect relations are identified in a systematic and innovative manner, i.e. if the relations need to be updated then they can be easily modified; (iii) It also allows applying mathematical operations and algorithms (through the use of mathematical operations and algorithms, optimisations of the matrix are possible, thus reinforcing what are the most relevant interactions between the elements).

Non-Conformity Matrix. The Non-Conformity Matrix (NCM) is a Design Structure Matrix (DSM) (Browning 2001) and (Steven D. Eppinger & Tyson R. Browning 2012) based tool developed to systematize all non-conformities (NCs) originated along a production line in a matrix form, highlighting relations and interactions between them. This is the first time that DSM based methodology is used for the process improvement phase. Tavares et al. (2013) developed a ten-step methodology for the application of a NCM to a manufacturing system. Applying the DSM principles on a NCM tool allows identifying clusters of NCs for prioritizing quality improvement actions. Farooq et al. (2014) discusses comprehensively how a NCM is built and what are the relevant phases of this process in order to effectively capture the knowledge from the industry experts. The ultimate goal is to use this tool to highlight critical manufacturing process points and then applying quality improvement techniques to improve the final product quality.

INDUSTRIAL APPLICATION

Three-piece tin plate aerosol cans are a mass produced product in the consumer goods packaging industry. Although the aerosol can seems simple at a first glance, customer requirements are varied and demanding. In fact, a simple aerosol can must satisfy a variety of internal and customer technical requirements including leak tightness, appearance, as well as safety requirements to withstand under certain pressure. Although packaging industries producing this type of aerosol cans are obliged to follow strict international rules and regulations, customers are always demanding for even higher quality levels. Like many such firms, the industry under analysis is also constantly pursuing quality improvement of its products and processes.

Application of DoE to other similar problems in the electronics, pharmaceutical, automotive and semiconductor industries has shown convincing results and successfully found the operational conditions that simultaneously minimize the variation and maintain an average value of the process (Konda & Guha 1998) and (Montgomery et al. 2000) and (Javorsky et al. 2014b) and (Antony 1999). Therefore, in the case of three-piece tin plate aerosol can, application of DoE to a specific problematic step of the industrial process seemed as the correct approach to improve the final product quality of the manufacturing process. The first step in any DoE implementation is to define clearly the problem statement: in the case under analysis, a NCM was applied to obtain a more thorough understanding of the process, acting as a key input in the pre-experimental planning phase of DoE. In the following sections, first a brief introduction is given about the product and its manufacturing process and then the application of NCM is presented.

Description of the product. An aerosol can has the objective of containing a product that is dispensed with the aid of a propellant. The product can be dispensed in the form of a mist of liquid particles or foam, depending on the propellant and on the product properties. The aerosol can produced by the company is a three-piece tin plate aerosol can, a simple product composed mainly by three major parts: the top, the bottom and the body, as shown in Figure 1. The company manufactures both the empty and filled aerosol cans. However, the objective is to improve the final quality of an empty aerosol can, therefore study of the valve, actuator and cup, which are the additional parts in filled aerosol can, are out scope for this research.

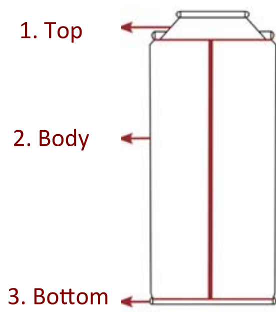

Figure 1: Three-piece tin plate aerosol can.

Description of the production process. The complete aerosol manufacturing process is fairly complex and with a high number of intricate steps, but for the current research, a comprehensive understanding of the high-level production processes is sufficient. A three-piece tin plate aerosol can passes successively by the following production areas: primary cutting, varnishing & lithography, secondary cutting and stamping & assembly.

In the primary cutting step of the production process, the tin plate is unrolled from a large coil, straightened and cut into smaller sheets. The top and the bottom are made up from tin-plates with the same thickness whereas the body, according to specifications, has always a relatively lower thickness.

In the varnishing and lithography step, the visual attributes of the aerosol are printed on the tin plate and, according to the customers´ requirements, different types of varnish protection are applied to the body before it is cut. The top and the bottom are generally not lithographed.

In the stamping stage, the top and the bottom cup are stamped from a tin-plate sheet. These parts are then transported to the assembly line where the body, which is generally not lithographed, is winded to give a cylindrical shape and then welded. Then the cylindrical shape is assembled together with the top and bottom parts via seaming joints (one seaming joint between top and body, and another seaming joint between bottom and body).

Non-Conformity Matrix. The application of NCM to the three-piece tin plate aerosol can has begun through modelling the entire production system in fine detail, highlighting all the quality control points and the NCs traced in each of the quality control points. Figure 2 shows a 44x44 NCM obtained after interviewing comprehensively the experts of the industry (Farooq et al. 2013) and (Farooq et al. 2014). NCM is an NxN square matrix with corresponding rows and columns. The matrix elements represent non-conformities and are listed in time sequence from left to right in the horizontal axis. Non-conformities in the vertical axis represent the same elements as in horizontal axis from top to bottom. Off-diagonal cells indicate the dependency of one non-conformity on other non-conformity. Reading across a row shows input sources; reading down a column shows output sinks. When a non-conformity depends on another non-conformity than the corresponding matrix cell is marked with 1 otherwise left blank.

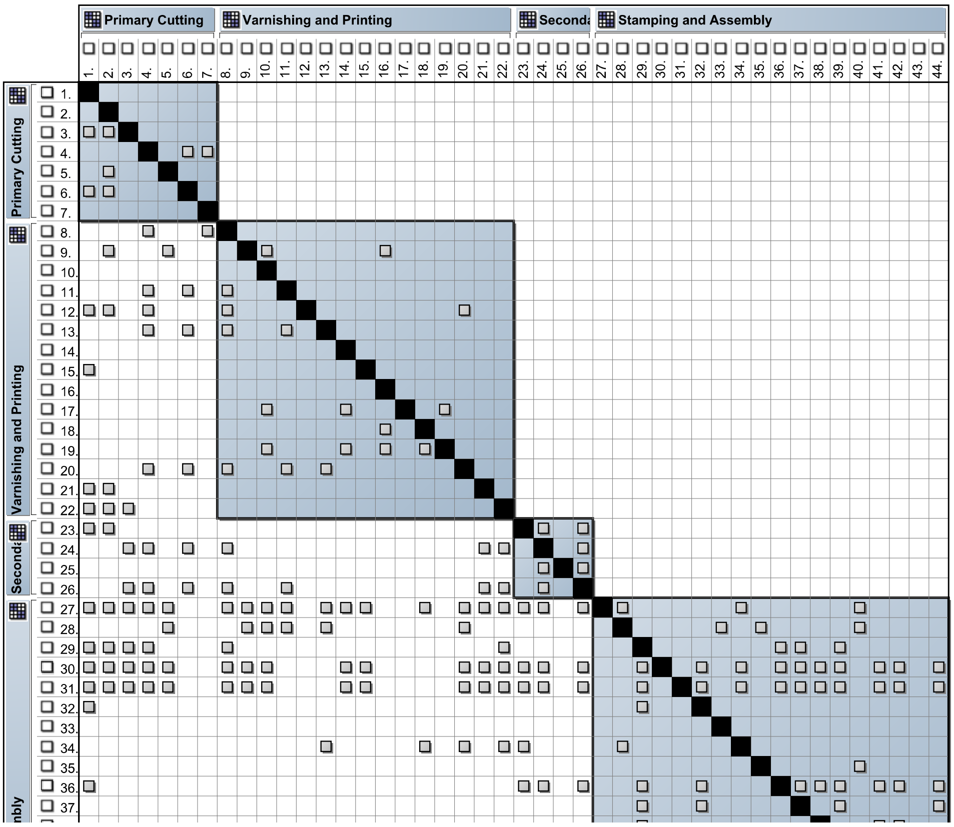

Figure 2: Non conformity matrix – before applying mathematical operations

Figure 3 shows NCM obtained after application of the sequencing algorithms. These algorithms are applied within each of the high-level production process, so that the non-conformities remain within their production process. Furthermore, type of the sequencing algorithm applied is the lower block triangular matrix algorithm that organizes most of the NCs below the diagonal. The NCs that remained above the diagonal show complex feedback relations. Moreover, these mathematical algorithms identified four important clusters of NCs. Varnishing and Printing NCs are influenced mainly by primary cutting NCs. Secondary cutting NCs are influenced mainly by varnishing and printing NCs and also Secondary cutting NCs. Flanging and seaming NCs are mainly influenced by themselves, which is called modularity. Finally, it can also be seen that the output quality parameters, which logically appear at the matrix end, are influenced by NCs generated all along the production process.

Among the four key areas highlighted, the most influenced area (output quality parameters) was further analysed through Pareto Chart analysis. The analysis, which is made hidden due to confidentiality clause, has shown that the high majority of aerosol can defects is due to problems related with the welding process. Therefore, welding process was elected as the primary area of analysis to further improve the final quality of the process.

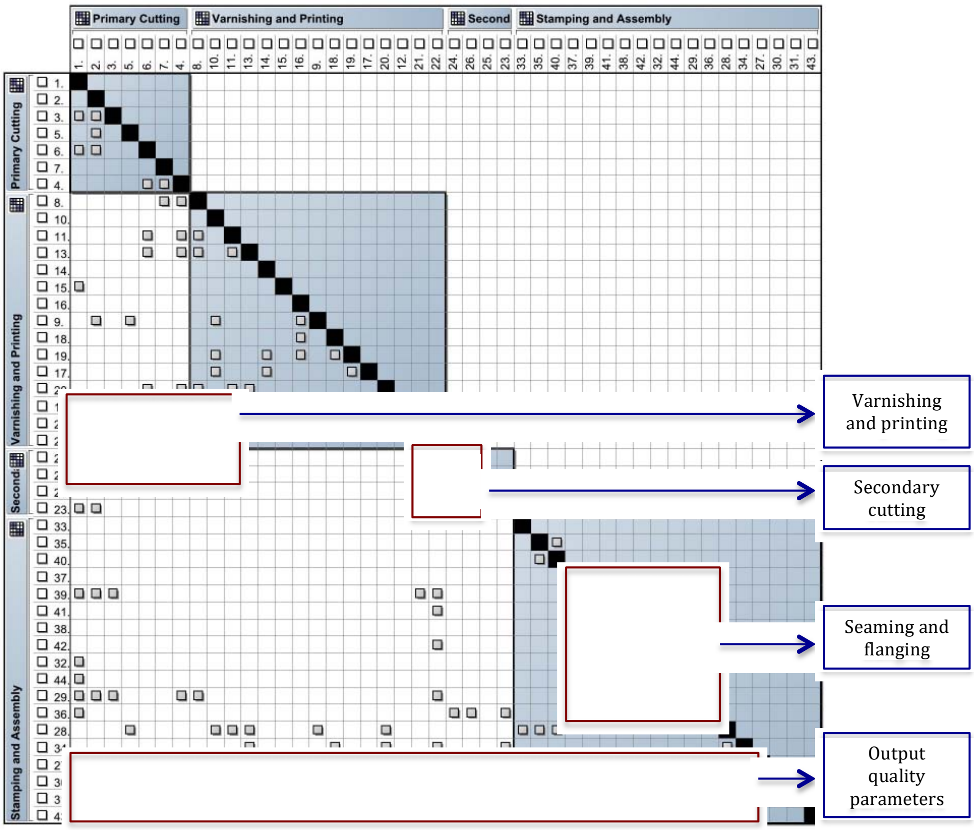

Figure 3: Non conformity matrix – after applying mathematical operations

The second step of DoE is to select the right factors to analyze, as well as their levels and ranges. In the case under analysis, this step involved a complete understanding of the welding process. In fact, after a careful analysis of this process, experimenters found that the current operating conditions of the welding process could be significantly improved, thus enabling a finer control of the process. Furthermore, due to the presence of a considerably number of noise factors, it was not possible to replicate similar operating conditions each time the production is run and it was not possible to define the correct ranges of the selected welding factors unambiguously.

In order to solve this problem, an approach of pre-experimental runs was put in place, enabling a better definition of the ranges of the factors. As to what should be the correct levels of the factors, they were initially set based on expert opinion and process knowledge. In the next sections, the approach used is further explained.

AN APPROACH TO SELECTING FACTORS AND THEIR LEVELS AND RANGES

The NCM and Pareto Chart analysis facilitated the process of identifying the key areas of the manufacturing process that required particular attention, also helping in a better definition of the problem. These analyses, together with brainstorming with key experts, helped in listing down the controllable, uncontrollable and noise factors that affect the problem. At a second stage, and after all the factors have been identified, brainstorming further reduced the number of factors, simplifying the subsequent DoE analysis. Table II shows the final list of identified controllable factors, which corresponds to the first part of step II of DoE in Table I.

Table II: Control factors

Control factors
Welding current
Welding force
Welding speed
Space between welding bodies

The second part of step II of DoE is to select factor levels and ranges, which are input to the experiments that determine the magnitude and direction of each factor´s effect on the response variable(s), therefore directly affecting the results. If the factor levels and ranges are not correctly chosen, the subsequent statistical analysis and final recommendations might be misleading.

Selection of factor levels and ranges has to go through an iterative process. The first iterations of factor levels and ranges may contain experimental design with too many experimental runs and might not be practically feasible. Therefore, it may require reducing the experimental runs based on available resources and experimental objectives. The tools used for a comprehensive selection of factor levels and ranges are experimental objectives, theoretical knowledge, expert opinion, process knowledge, available resources, previous experimental results and performing pre-experimental runs (Montgomery 2008) & (Czitrom 2003).

Generally, factor levels and ranges are selected based on the definition of the factors, namely whether it is a quantitative factor or a qualitative factor. For the current industrial case and as shown in table II, only quantitative factors are applicable. As the objective of the experiment was to determine whether or not the factor has an effect on the response variable, the size and direction (sign) of the effect, as well as to potentially study the curvature in the response, three levels for each factor were selected. Furthermore, it was the first time such experiments were performed in this industry and therefore it was required to design and start with a simple model.

In order to select a proper range for a quantitative factor, process knowledge, previous experimental results and expert opinion is required. However, in the current industrial example, it was not possible to clearly identify the factor ranges due to presence of noise factors (e.g. coil properties) and also due to the reason that the process is not completely controlled. Therefore, in order to overcome these problems, it is advisable to proceed with pre-experimental runs, further explained in the following section.

Pre-experimental runs. Pre-experimental runs are the experiments that are performed on specific situations. It is therefore essential to know when they are required. Pre-experimental runs should be performed before designed experiments, if the tools (process knowledge, expert opinion, experimental objectives, theoretical knowledge and previous experiments) are not sufficient enough to define clearly the levels and ranges of a factor. Explicitly, there are the following two cases when pre-experimental runs are required:

- When it is not completely known that a quantitative factor will have a linear (2 levels) or a non-linear (3 or more levels) response and also the objective of the experiment is depending on the natural effect of the factor. Generally, two levels are studied if the objective of the experiment is to determine whether or not the factor has an effect (size and direction) on the response. Three or more levels are studied if the objective of the experiment is to study also the full relation with the response;
- When range of the levels, for quantitative factors, is not possible to define clearly and it is required to explore the process behavior over a wide area of factor ranges.

Practically, selection of factors and their levels and ranges, and selection of response variable(s) are done simultaneously or in reverse order as showed in Table I. However, if it is required to perform pre-experimental runs, then it is recommended to select response variable(s) and study measurement system(s) prior to selecting factor levels and ranges. This is because the response variable(s) and measurement system(s) help in studying the process behavior and defining the correct factor levels and ranges. Furthermore, it is also recommended to list down all the noise factors before performing pre-experimental runs and then note down their values during the tests. These noise factors should be controlled as far as possible, in order to assure that they will have almost the same values while performing the pre-experimental runs as well as on the designed experiment, enabling a better identification of factor levels and ranges. Due to confidentiality clause, response variable(s), measurement system(s) and noise factor(s) are made hidden for the current industrial application.

A brainstorming session was conducted with the experts in order to estimate the values of selected factors. This helped in saving some time during pre-experimental runs implementation because it has provided valuable hints to set the factor around estimated values. The selected factors and estimated factors' values are shown in Table III.

Table III: Control factors and their estimated values

Control factors	*Estimated values (low-high)
Welding current	598-611
Welding force	117-130
Welding speed	151-169
Space between welding bodies	3.9-5.2

***** Due to confidentiality clause, the exact figures are not presented (a scale of certain value is adopted).

Table IV defines comprehensively the guidelines used for the implementation of pre-experimental runs.

Table IV – Guidelines for Pre-experimental runs

1. Calibration of the selected response variable(s) and measurement system(s);
2. Note down the values for all the possible noise factor(s);
3. Adjust the machine to standard operating condition and start producing the units;
4. Note down the standard values for all control factors when satisfactory units are produced;
5. Increase first control factor from the standard value *intermittently until the factor reaches a maximum value while still producing relatively good units by analyzing the response variable(s);
6. Maintain all other factors at the standard values for maximum or minimum values;
7. Note down the value of the factor, this is the factor´s maximum value;
8. Decrease the same control factor from the standard value *****intermittently until the factor reaches a minimum value while still producing relatively good units by analyzing the response variable(s);
9. Note down the value of the factor, this is the factor´s minimum value;
10. The range for two levels can be defined by low level (minimum factor value) and high level (maximum factor value);
11. The range for three levels can be defined by low level (minimum factor value), center point (standard value) and high level (maximum factor value);
12. Adjust the minimum and maximum values so that the standard value is at the center of both, which is highly recommended. However there are ******situations when standard value might not be adjusted at the center, therefore maintain the settings to non-central values.
13. If the factor is required to perform with more than three levels then take more center points between the levels or take points where there is a region of interest;
14. Repeat the steps 5 – 13 to all other selected factors.

* Increase the value of control factor by 5%, 10%, ... of its value or randomly depending upon the objective of the experiment.

** It is dependent on the objective of the experiment.

After successful implementation of the pre-experimental runs for the industrial case, ranges for all the selected control factors were clearly identified as shown in **Table V**.

Table V – Control factors´ ranges

Control factors	*Low	*Standard	*High
Welding current	611	650	666
Welding force	104	112	115
Welding speed	120	151	166
Space between welding bodies	0.25	5.2	13

***** Due to confidentiality clause, the exact figures are not presented (a scale of certain value is adopted).

The registered range of each control factor was then successfully modeled, in order to assist the selection of the experimental design (fourth step in DoE), and, subsequently, the performance of the selected experiment (fifth step in DoE). These steps are not part of the current paper and therefore are considered future work.

CONCLUSIONS

A clear definition of the problem and a correct selection of factor levels and ranges are one of the key elements in any DoE´s implementation. FMEA, QFD and cause-and-effect techniques have long been used as key tools for identifying the potential design factors during the pre-experimental planning phase of the DoE, provided that a region of interest was identified. For the same purpose and in order to better identify this region, a new Systems Engineering tool is introduced in this paper, termed Non-Conformity Matrix (NCM), a tool that is used for the first time in a quality improvement project. This tool models the entire system holistically, highlighting key problematic areas of the manufacturing system, through a systematic analysis of the interactions between the non-conformities identified along the production process.

The NCM methodology is then applied to the three-piece tin plate aerosol can product of a large consumer goods packaging industry. The industry under analysis is constantly considering improving its manufacturing process and final quality of its products, namely aerosol cans. Application of the NCM together with Pareto chart analysis have shown that a high majority of the problems occurred due to the welding process, which is one of the key elements in the improvement of the final product quality. However, while studying the welding process in detail for the DoE, it was found that due to the unknown behavior of noise factors and also due to the fact that the process is not completely monitored and controlled, it was not possible to clearly define the factor ranges. This particular problem was solved by the successful implementation of pre-experimental runs, thus further defining the appropriate ranges for all the factors.

Future work will involve the execution of the next steps of a DoE implementation (table II), thus providing a valuable input to what should be the best operating conditions for the welding process that minimize the non-conformities of three-piece tin plate aerosol cans.

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Assessing Customer Satisfaction and Loyalty in the Retail Sector

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ABSTRACT

Purpose. The effects of customer satisfaction on loyalty have been widely discussed by the academic community. Although the results of the studies reported in the literature are often contradictory, the existence of a relationship between satisfaction and loyalty is acknowledged, despite the influence of moderators and constraints of various kinds. The purpose of this study is to discuss this relationship in the specific context of a retail store, since this sector presents major challenges in terms of competition and the efforts placed on customer satisfaction and loyalty are more evident.

Design/Methodology/Approach. A survey based on the ECSI model (European Customer Satisfaction Index) was applied to the particular case of a retail store in Portugal. This model has its roots in Switzerland, where in 1989 Claes Fornell developed a new complementary method for measuring the overall quality of the companies output, through the calculation of an aggregated customer satisfaction index. The proposed model is based on a set of causal relationships established between a set of constructs. The ultimate goal is to calculate both satisfaction and loyalty indexes as well as estimating the relationship between both constructs. Structural Equation Modelling (SEM), based on a Partial Least Squares (PLS) estimation methodology, is the statistical technique used to estimate the model parameters, as well as to compare the aggregated indexes. PLS is based on the principles of linear regression and combines multiple regression aspects with factor analysis, in order to estimate a series of interrelated relationships.

Findings. The results confirm a positive influence of satisfaction on customers' loyalty to a retail store. The study has also shown the importance of the Image construct, due to its strong direct effects on Satisfaction, which makes it essential for influencing both directly and indirectly the Loyalty index. The impact of this construct is also evident on the Expectations one, as this last one has shown a considerable direct effect on Perceived quality.

Research limitations. The study is based on a single case study of a Portuguese sports retail store. In future it would be interesting to study a representative sample of the retail sector.

Practical implications. The study is useful for the specific retail store where it was undertaken to help it devise better customer service in order to inscrease satisfaction and loyalty. It is also useful for the entire network of stores for that retailer and other retail chains.

Social implications. The systematic application of customer survey to whole sectors of the economy will improve competition, customer service and ultimately contribute to development and economic growth

Originality The ECSI has been applied to various industry sectors in different countries, including Portugal. It has never been used in the context of the Portuguese retail and it adds to the discussion on the relationship between satisfaction and loyalty, which is indeed a topic of interest for researchers in quality management.

Keywords: customer satisfaction, customer loyalty, partial least squares, European Customer Satisfaction Index, retail industry, Portugal

Article Classification: Research paper

INTRODUCTION

The importance of client satisfaction and loyalty for the sustainability of organizations has been widely discussed by the academic community. Over the last decades, authors such as Reichheld (1996) and Oliver (1999) have dedicated their research to the topic of loyalty and its degree of importance to organizations, relegating the topic of satisfaction to a status of less importance and giving precedence to the phenomenon of loyalty. In general terms, satisfaction is understood to have a positive impact on loyalty, even though this impact is subject to differing factors and influences, such as, for example, the type and setup of the industry under analysis.

The most competitive industry is that of retail chains (Collins, 1992), which is characterised by the most diverse buying habits (Dowling & Uncles, 1997). The challenges faced by this sector are evident, both at a global (chain) level and at a local level (store), which leads to a focus on the maximization of the range of goods on sale, as it is this which influences consumers' choice (Kotler & Armstrong, 2006). In this industry there are a series of common practices designed to maximize client satisfaction, whether they be price cuts and the implementation of a discount system, or whether it be by means of improvements in the quality of goods and, more importantly, of customer service. But are these having the desired effect? Are these contributing to building up a satisfied client-base and potentially more loyal clients, thus enabling the survival of companies in an ever increasingly competitive and global world? The study presented in this paper aims to analize these questions and to discuss the possible relationship between satisfaction and loyalty in the specific context of a large retail store. This sector presents significant challenges in terms of competiveness, which in turn, is evidenced by the need to develop efforts to increase client satisfaction and loyalty.

CLIENT SATISFACTION AND LOYALTY IN BUSINESS-TO-CONSUMER INDUSTRIES

Questions related to consumer satisfaction date back to the 60s, when Quality Control (put forward by Armand Vallin Feigenbaum, in his book *"Total Quality Control"*, published in 1961) served as an inspiration for the current concept of Total Quality Management (TQM), in which client satisfaction is the ultimate goal (and condition) of quality management in companies. TQM basically defends a culture of quality through the integration of a series of activities which promote the same throughout the life of a product: right through from raw materials up to when the finished product is sold (Elshennawy et. al 1991). The impacts of TQM on client satisfaction are a reality and can be consulted in the literature on the subject (see, for example: Mehra & Ranganathan, 2008). The modern day notion of loyalty came to be about two decades after the publishing of Armand Vallin Feigenbaum's book, whilst literature on *marketing* starts to be more focussed on the declining efficiency of product-based strategy, in favour of the logic of concentrating on service in organizations as the key to sustaining competitive advantage (Grönroos, 2007).

Based on the continuous technological evolution which is driving the rapid spread of information and knowledge and the successive opening up of economic markets, it is easy to understand the latest developments regarding these matters. The sophistication and demands of consumers, together with increasing global communication brought about by these phenomena, puts the manager in a quandary as to whether their principal objective is (which applies to all managers) sustained growth of the business and maximising it's worth. As a result, the focus is evermore on the "satisfaction" and "loyalty" of clients, principally in businesses where, typically, the emphasis on both is scarce and/or temporary.

The principal aim of this study, as has already been mentioned, is to add data to this debate and to try and discover whether there is a relationship between customer satisfaction and loyalty in this specific sector, and should this be the case, then go on to quantify this relationship.

CUSTOMER SATISFACTION

In general, satisfaction can be defined as the judgment, or weighing up, of the balance between *expectations* and *perceptions* of the performance of the product or service purchased (Johnston et al., 2012; Kotler & Armstrong, 2006).

Oliver (1981) describes satisfaction as being the summary pyscological state of the customer, which results in a meeting of the ensuing emotions resulting from the confimed, or unconfirmed *expectations* and previous feelings towards the experience as a consumer (Parasuraman et al., 1988). In his opinion, *expectations* are probablities, as defined by the consumer, of positive or negative events ocurring should they carry out a certain type of behaviour (Parasuraman et al., 1988).

Consumer expectations are subject to various factors. Johnston et. al (2012) mention as contributive factors: price, marketing, alternatives, past experiences and even the psychological state of the consumer. From this, one can detirmine the important and dynamic character which leads to the challenge for businesses of ensuring customer satisfaction.

Perceptions can be divided into two distinct groups:

- The perception of quality, or "perceived quality";
- The perception of value, or "perceived value".

Perception of quality has to do with judgements regarding the inherent characteristics of the product being sold, the tangible forum regarding goods (e.g.: reliability) and both the intangible and tangible forum regarding services (e.g.: courtesy, waiting times). The literature has stressed, in increasing terms, the importance of quality of service in formulating client satisfaction, principally in long-established businesses and independent of the nature of the client-supplier relationship (if this is continuous, or scarce), as any moment is a good moment to increase client satisfaction (Johnston et al., 2012). It is from this perspective that comes the importance given to the quality of internal service (within an organization) and the satisfaction of internal customers (employees) in the perception of external service and the satisfaction of external customers (Heskett et al., 2008; Bellou & Andronikidis, 2008; Yoo & Park, 2007).

The *perception of value* takes into consideration all the aspects involved in the purchase of goods or services, weighing up costs with benefits. For Grönroos (2007):

$$Perceived\ Value = \frac{[Core\ Solution\ (what) + Additional\ Services\ (how)]}{[Price + Relationship\ Costs]}$$

"What" being the technical solution which results from the goods or services acquired, and the *"how"* is the way that it is delivered (or received by the client) to the client, which includes billable and non-billable services (e.g., home delivery or faster service). The "price" is the short-term tangible sacrifice for the consumer and the "relationship costs" arise from the perspective related to marketing, which the author shares and advocates, may they be of a direct nature (investments and depreciation); indirect (complaints and long delays); or psychological (lack of confidence, which obliges contact with the supplier). Put more simply, "perceived value" can also be understood to be:

$$Perceived\ Value = Trasaction\ Value + or - Relationship\ Value$$

Or, in Dodds et al.'s words (1991), *"the cognitive tradeoff between perceptions of quality and sacrifice results in perceptions of value"* (p.308). This "perceived value" or "value prospect" is decisive in the specification of supply in that, according to Kotler & Armstrong (2006), the consumer opts for the company whose perceived value as a supplier is superior.

Trust and an organization's image. Amongst other factors that contribute to the formulation of expectations and perceptions, the roles of trust and an organization's image stand out. The role of trust is particularly decisive in winning potential clients. This is compared to an "act of faith" in the organization, its employees and its supplied product or service, which affects the predisposition towards the organization, rather than depending on a direct contact with the same (Jonhston et al., 2012).

Image represents the values that customers, potential customers, lost customers and others relate to the organization (Grönroos, 2007). It exists as much in the local sense (e.g.: establishment; store) as the global sense (e.g.: chain; brand). Its management is important in terms of satisfaction, as image (Grönroos, 2007):

i. communicates expectations;

ii. is a filter of perceptions;

iii. is just as much a function of expectations as experiences;

iv. has an internal impact (amongst employees) as well as an external one (amongst the general public);

Measuring satisfaction. From what has been mentioned above, it can be concluded that customer satisfaction is subject to constraints of a multiple nature, as it has an idiosyncratic side and a dynamic one. However, it is possible to verify the positive relationship that satisfaction has on business performance (Johnson & Hart, 1999, Bernhardt et al., 2000; Anderson et al., 2004; Gómez et al., 2004), which leads to the development of tools which attempt to measure it, amongst which the most important are:

- Questionnaires and interviews, which are the tools most commonly used by businesses. An example is SERVQUAL (Parasuraman, et al., 1988), which is a questionnaire which aims to measure the level of client satisfaction through detecting the "gaps" between expectations and perceptions of levels of service. Another type of questionnaire which is often used is the basis for the ECSI model – European Customer Satisfaction Index (inspired by the SCSI model - Swedish Customer Satisfaction Index, which was developed by Claes Fornell, in Sweden, in 1989 (Vilares & Coelho, 2005)). The answers to the questionnaire, when analysed according to the ECSI model, enable not only the creation of a customer satisfaction index, through the study of simultaneous linear relationships between expectations, perceived value, perceived quality and the organization's image (the determinants of satisfaction considered in the model), but also a loyalty index. Thus, whilst SERVQUAL only serves as a quality of service indicator, ECSI gives an indication of the overall quality of that being supplied by the organization studied (products and services), whilst allowing for an assessment of overall customer satisfaction, as well as loyalty.
- Critical incident method. First referenced by Flanagan (1954) (quoted in Villares & Coelho, 2005), is based on obtaining relevant information from customers about incidents that occurred when using the products or services provided.
- Complaints analysis. A complaint is an opportunity to create and retain customer satisfaction (Michel et al. 2009). This is because, according to Edvardsson (1998), dissatisfied customers who complain, can be managed so as not to switch suppliers, whilst those who are apparently satisfied and never complain, may end up making the switch (in Edvardsson & Roos, 2003).

Despite the importance of these tools, some authors warn of the dangers of the "*satisfaction trap*", which is the blind pursuit of customer satisfaction as a guarantee for sustaining an organization, whereas studies indicate that approximately 60-80% of ex-clients of a company claim that, although they are no longer customers, they are satisfied with the company (Reichheld & Hopton, 2000). It is this dilemma that gave rise to research on loyalty, which defends that the right relationship with the right customer is a key factor for the success of an organization (Kotler & Armstrong, 2006).

Client loyalty. The concept of customer loyalty has been discussed by many authors over the last years. In 2003, Reichheld defined loyalty as *"the willingness of someone - a customer, an employee, a friend - to make an investment or personal sacrifice in order to strengthen a relationship"* (p. 48). Oliver (1999) describes it as a deep commitment by the customer to continue to consistently repurchase the same product or service, despite circumstantial influences and *marketing* strategies of competitors, which have the potential to cause a change in buying behavior.

As can be seen, the concept of loyalty lends itself to two types of interpretations:

- Loyalty as an intention: to either repurchase, or to recommend to family and friends or to remain a client, despite the competition.
- The loyalty as a behaviour, or, in other words, carrying out repurchases over extended periods of time.

Both are important in that, for true loyalty to exist, the second interpretation should follow on from the realization of the first. This is because repetitive purchase behaviour does not necessarily depend on consumer preference, but may arise from constraints such as the high cost of switching, inertia or convenience (Lovelock & Wirtz, 2011; Reichheld, 2003; Reinartz & Kumar, 2002).

Dick e Basu (1994) clarify this paradigm, distinguishing between various types of "loyalty" observed amongst consumers, although only one of them corresponds to "true", or desired, loyalty by organizations (Figure 1 – The four types of loyalty (adapted by Dick and Basu, 1994).

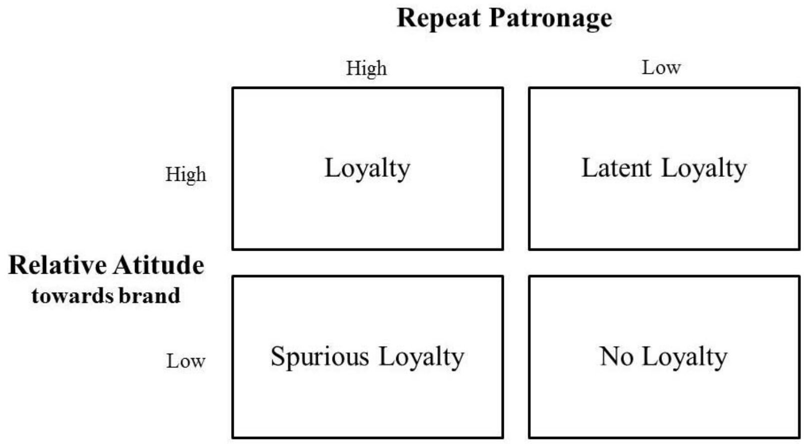

Figure 1 – The four types of loyalty (adapted by Dick and Basu, 1994)

As can be seen in Figure 1, a relatively low affection for a brand, combined with a low pattern of repeat purchasing, indicates "no loyalty". Logically, the opposite extreme is true customer "loyalty". The authors classify as "spurious loyalty", cases where the consumer has a high pattern of repurchasing, without considering the product or brand to be significantly different from others. Factors such as the development of interpersonal relationships between supplier and consumer, inertia or familiarity with the brand (e.g.: provided by strategic shelf-positioning), can contribute to this kind of loyalty. This means that a circumstantial change can easily alter consumer buying behaviour, which is not a desirable phenomenon for the supplier at all. Finally, "latent loyalty" is one where the consumer gives preference to a product or brand over its competitors; and yet takes to having (usually on account of situational constraints) a dispersed behaviour of purchasing. An example of this is a customer of a particular restaurant who also frequents other restaurants, depending on the preferences of those who accompany him. It is therefore clear that companies need to develop procedures that promote truly loyal behaviour.

Measuring client loyalty. In terms of measuring loyalty, the literature lists several possible indicators, the following being among the most used (in Vilares & Coelho, 2005):

- The intention to remain a client for a certain period of time;
- The intention to recommend an organisation (or its products);
- The intention to end up becoming a client of the competition, at a certain time;
- The intention to change the level of business (turnover) with an organisation;
- Sensibility to the organization's price, in comparison to the competition.

The most popularly used tools highlight the "*Net Promoter Score*", whose result is calculated based on the difference between the percentage of "promoters" of the organization and the percentage of "detractors" of the same. Reichheld (2003) stresses its importance, advocating the existence of promoters as a necessary requirement for profit improvement, especially in well-established enterprises. Another instrument is the above-mentioned ECSI questionnaire, which seeks to measure loyalty, considering it to be a consequence of satisfaction.

The relevance of loyal clients for an organization. It is a given fact, accepted by most organizations, that the effort to acquire a new customer is much higher than that needed to maintain the relationship with a current customer (Fornell & Wernerfelt, 1987). Moreover, there is evidence of a positive relationship between loyal behaviour and long-term financial performance (Reichheld, 1996). Dick and Basu (1994) point out as consequences of loyalty: a decrease in searching for alternatives, resistance to the persuasion of the competition and positive "word-of-mouth" recommendations. Similarly, Reichheld and Sasser (1990) confirm that the profit margin of customers increases according to their longevity as clients. Increases in profits are due to four different reasons:

i. loyal customers make ever-increasing purchases over time;
ii. operating costs decrease because of the involvement of loyal customers, who contribute positively to the productivity of a company (for example, by not repeating certain procedures);
iii. recommendations made by loyal customers as part of their personal relationship with the company, are an effective advertising tool;
iv. price sensitivity decreases with years of loyalty as a customer, leading to achieving profits through increased margins.

Nevertheless, and despite the efforts made by organizations with regards to this issue, Lovelock e Wirtz (2011), stress that many of them are not successful in creating true loyalty. It is the embodiment of this idea that relationship *marketing* can, in a certain form, be the answer, pointing to (although it is not sufficient) the central role that relationships have in fostering customer loyalty (Grönroos, 2007). This type of mentality has consequences regarding the way that companies see, treat and manage their clients.

The relationship between client satisfaction and client loyalty. It is possible to find references in the academic literature that defend the positive relationship that satisfaction has on loyalty. In Johnston et al. (2012) one can read that: *"Satisfied customers who perceive value from the service are more likely to return and also more likely to provide positive word-of-mouth and recommend the organization and its services to others"* (p.15). Lovelock e Wirtz (2011) argue that the basis for true loyalty lies in customer satisfaction. In the same line of thought, Kotler and Armstrong (2006) argue that highly satisfied customers repeat buying and share their experience with others, as shown by empirical studies such as those of Johnson and Hart (1999). Oliver (1999), in turn, distinguishes six types of representations of the satisfaction-loyalty relationship (Figure 2 – Possible types of satisfaction-loyalty relationships, as seen by Oliver (1999).

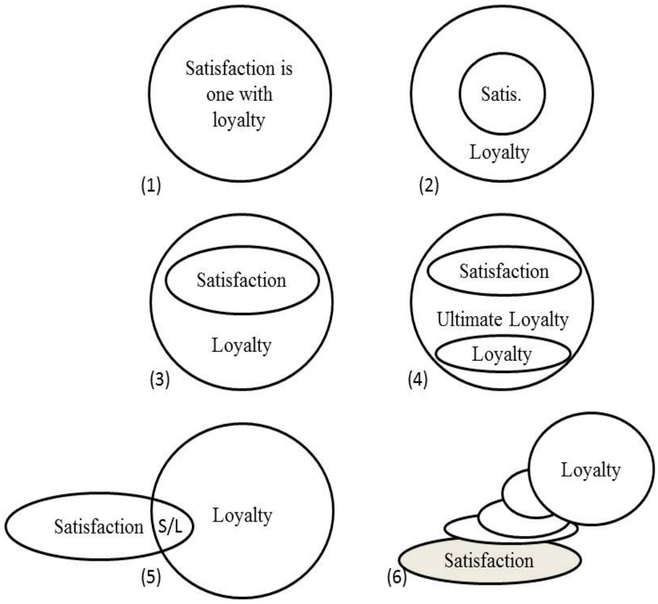

Figure 2 – Possible types of satisfaction-loyalty relationships, as seen by Oliver (1999)

Diagram (1) reinforces the notion that customer satisfaction and loyalty are different manifestations of the same concept. Diagram (2) places satisfaction as the core concept for loyalty, without which it cannot exist. In Diagram (3), satisfaction ceases to have a central role, but remains a necessary condition, albeit not sufficient, for achieving loyalty. Diagram (4) admits the existence of "Ultimate Loyalty", comprised of customer satisfaction and loyalty, which occurs when a customer goes against all circumstances and constraints to faithfully continue to purchase a certain brand. Diagram (5) illustrates the existence of a fraction of satisfaction in the concept of loyalty, even though this is not pivotal to its existence. Finally, Diagram (6) illustrates satisfaction as being the first of several transient states, which culminate in a state separate from the first, that of loyalty. This means that, once this state is reached, a change in satisfaction does not imply a change in customer loyalty. From the point of view of the author, this is the best interpretation, taking into account that there are other factors, of a social and psychological nature, that lead to the transitional states that lead to loyalty. Without these ingredients, a satisfied customer does not evolve beyond this primary state of satisfaction (Oliver, 1999).

Simultaneous measurement of satisfaction and loyalty: a little more about ECSI. The European Index of Customer Satisfaction (ECSI) started to be developed in 1999, as an initiative of the *European Organisation for Quality* (EOQ), of the *European Foundation f*or *Quality Management* (EFQM) and of the *Customer Satisfaction Index University Network* (CSI), and was inspired by the methodology developed in 1989 for the SCSI: *Swedish Customer Satisfaction Index*, by Claes Fornell.

Aware of increasing global competition, a phenomenon that has increased the competitive environment and "pushed" many industries to compete in terms of costs, Fornell saw in the CSB (*Customer Satisfaction Barometer* - its original name), a supplementary way of measuring productivity (and therefore competitiveness) of companies and industries. Instead of measuring the amount of *output*, this index provides information about the quality of that same *output*, in the eyes of those who buy it (Fornell, 1992). Thus, in 1989, the first national satisfaction index was developed in Sweden. This is measured in the context of other interrelated variables (antecedents and consequences of satisfaction), which, besides allowing for a greater reliability and validity of results, enables the prediction of behavior in the light of certain alterations, which was innovative at the time (Fornell, 1992). As this was a study carried out at a national level, involving various companies and industries in the country where it is applied, it also serves ultimately as an indicator of competitiveness between nations.

Aspects of customer satisfaction and loyalty in the retail sector. Let us now focus on the critical aspects of the topic in the retail industry, currently one of the most dynamic and competitive areas of business (Collins, 1992), where the pattern of purchases tends to be dispersed (Dowling & Uncles, 1997). These are:

- the quality of customer service. The Heskett et al. model (2008), designated the "*service profit chain*", aims to illustrate how the quality of internal service (eg, employee working conditions) influences customer satisfaction and, ultimately, customer loyalty. In fact, the services deserve a prominent role, since their perceived performance affects satisfaction to a large degree (Grönroos, 2007; Tsai, et al, 2011; Lusch et al 2007, Yoo & Park, 2007.), when it is measured by interaction with the public. In this way, there is a growth in the importance given to quality management in customer-supplier relationships, be they personal, telephonic or even virtual. Still on this subject, Maxham et. al (2008) explain that, in the case of retail, aspects such as feelings of justice and identifying with a company by employees who deal directly with the public affects, ultimately, store performance, and hence the quality of service experienced by customers.
- loyalty programs. Usually in the form of cards, these programs are based on the frequency of use by the consumer and provide immediate benefits, such as discounts, as a way of fostering customer loyalty. Dowling and Uncles (1997) pointed out that such investments are inefficient, and, in general appear more as a competitive factor in industry, rather than as a factor of differentiation.

Other studies, supported by research in the areas of social sciences and psychology, add data to the research on these topics, providing valuable information for managers. Some of these studies focus on the observation of the in-store customer experience, both in terms of the physical layout as well as aspects of human interaction. Puccinelli et al. (2009) explain how the layout of the store, i.e.: where items are purchased and services are produced and purchased ("servicescape" in the terminology of Johnston et al., 2012) interacts with the customer perceptions, affecting their behavior; Mägi (2003) presents the customer characteristics (especially interpersonal interaction or price-related issues) that have an impact on the effects of satisfaction on loyalty.

From the available literature on the subject, it is important to retain the subjective, circumstantial and dynamic nature of these issues, which on one hand explain the challenges presented to organizations in their management, and on the other hand does not justify or promote apathy regarding these challenges. It is possible to identify common denominators for satisfaction, as one can also see the role of satisfaction on loyalty, although this relationship is dependent on a variety of factors.

Because of this, the importance of measuring these phenomena has to be mentioned, especially because there is empirical evidence for the existence of a positive impact of the loyal behavior of customers on organizations' financial performance over time (Reichheld, 1996; Maxham, et al., 2008; Morgan & Rego, 2006).

METHODOLOGY

To serve the purpose of the study, which refers to the existence of a positive relationship between customer satisfaction and loyalty, a questionnaire based on the ECSI model was given to customers of a store belonging to a chain of sportswear and sports equipment. This questionnaire facilitated the calculation of aggregate levels of satisfaction and loyalty through the simultaneous consideration of former values, as mentioned in the previous section. Since the model considers, as a precursor, customer satisfaction as an antecedent of loyalty, the study was focused, in formal terms, on the testing the following study hypothesis:

H1: customer satisfaction for a large retail store has a positive impact on customer loyalty to this store.

A model of multiple equations: the statistics of the ECSI. To simultaneously deal with a set of interrelated variables, the ECSI is converted into a system of multiple equations, making use of SEM methodology (*Structural Equation Modelling*), or structural equation modelling. According to Hair et al. (1992), SEM is a multivariate statistical technique which combines aspects of multiple regression and factor analysis to simultaneously estimate a series of interrelated dependence relationships.

Because it is a simple and direct method of simultaneously dealing with multiple relationships, whilst at the same time guaranteeing statistical efficiency, and as it allows exhaustive assessment of relationships (which permits confirmative research), SEM has been widely used in the areas of the study such as psychology, marketing or medicine. Another feature is the role of theory, without which the design of the structural model (the set of dependency relationships that connect the various dimensions of the model) would have been impossible. Observation, experience and past studies, as well as the very definition of the study objectives are crucial for the specification of this model, which distinguishes between the independent and dependent variables and establishes causal relationships *a priori*.

The structural model and the measuring model. For a SEM approach, there are two models: structural and measuring ones.

The structural model (Figure 3) establishes the relationship between latent variables (not directly observable). In the ECSI, the variables of *image*, *expectations, perceived quality and perceived values* are antecedents to *satisfaction*; *loyalty* and *complaints* are thee consequences. Competing for *loyalty* is *image*, either directly or indirectly (through satisfaction), *satisfaction* and *complaints*.

In these models, the direction of causality is read from left to right. The straight lines represent the coefficients of direct impact (the effect of a unit variation of one variable on another), and total impacts can also be calculated. These flow from adding direct and indirect impacts.

As the foundation of the ECSI structural model design lies on the theoretical principles explained on the previous section, and according to Figure 3, one can read:

- Image has a direct impact on expectations, satisfaction and loyalty;
- Expectations, which are influenced by the image variable, have a direct impact on perceived quality, perceived value and satisfaction.
- The perceived quality, being directly influenced by expectations and indirectly influenced by the image, has a direct impact on the perceived value and satisfaction.
- The perceived value is a function of the perceived quality and expectations' influence, while contributing directly to the satisfaction index.
- With this said satisfaction is both directly and indirectly influenced by the impact of the former variables, while influencing the loyalty variable, as well as the complaints one.
- Complaints, as a function of the satisfaction impact, influence the loyalty index.

The loyalty variable is the only one that has no direct (thus, no indirect) impact on any variable, being a result of the image, satisfaction and complaints influence.

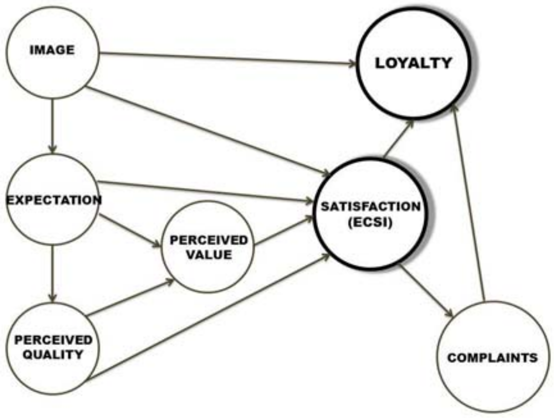

Figure 3 – The ECSI structural model

The measurement model (Table 1) relates each latent variable to a set of empirical indicators (or measurement variables).

Table 1 – ECSI: measurement model

LATENT VARIABLE	ECSI INDICATOR
IMAGE	An innovative company, geared for the future;
	A company in which one can trust;
	A stable company that is well-established in the market;
	A company that is concerned for its clients;
	A company that makes an important contribution to society;
EXPECTATION	Global expectations about the company;
	Expectations about whether the company is capable of supplying goods that satisfy clients' needs;
	Expectations regarding reliability;
PERCEIVED QUALITY	The overall quality of the company;
	The quality of goods and services;
	Customer information;
	Accessibility to goods and services
	Diversification of goods and services;
	Clarity and transparency of information supplied;
	Difficulty in assessing quality;
PERCEIVED VALUE	Quality assessment of goods and services in relation to price;
	Price assessment for goods and services in relation to overall quality;
SATISFACTION	Overall satisfaction with the company as a whole;
	Satisfaction in relation to expectations (realisation of expectations);
	Comparison of the company with the ideal company;
COMPLAINTS	Identification of those clients that made complaints about the company;
	The way the last complaint was handled (from the client's point-of-view);
	Perceptions about how complaints are resolved (from the point-of-view of those who don't complain);
LOYALTY	Client's intention to remain a client;
	Sensibility to price variations (both ascending and descending);
	Probability of recommending the company to family and friends;

There are three types of measurement models: *reflective*, *formative* and *mixed* ones. In the first case, the indicators are seen as a reflection or manifestation of the phenomenon represented by the latent variables to which they relate. This implies that the indicators are correlated between themselves and that the coefficients of the measurement model are obtained by simple regression. In the second type, the indicators are treated as integral parts of the related latent variable, or in other words, it is formed by the set of indicators to which it is connected. In this way, the notion of correlation between indicators is no longer applicable, and the correlation coefficients are obtained through multiple regression. In mixed models, it is possible to find two types of links between indicators and the respective latent variables described.

The reflective model is the most commonly used one for satisfaction studies, such as the ECSI, as the stability of the coefficients of the measurement model is not affected either by the size of the sample, nor multicollinearity problems, as a simple regression method is applied (Fornell & Bookstein, 1982).

DATA COLLECTION AND PROCESSING

Data collection was made, as appropriate for a conceptual model, and as is usual for satisfaction studies, by applying a questionnaire to store customers, consisting of 31 questions, each of which is wholly or partly an ECSI indicator. Each indicator was, in turn, associated to one, and only one, latent variable, as shown in Table 2.

Table 1 – measurement model applied to a case study

Question	Denomination	Latent variable
1. The variety of goods on sale at the store met my expectations.	EXP1	**EXPECTATION**
2. The store staff would understand my needs, and attend me in a competent and exemplary way.	EXP2	
3. The good that I was going to buy was totally reliable and wouldn't breakdown during use.	EXP3	
4. If there was a problem with the good, then the store would resolve it quickly and efficiently.	EXP4	
5. My overall expectations in relation to the store were very high.	EXP5	
7. The staff who attended me was well prepared to give me the correct advice.	QUA7	**PERCEIVED QUALITY**
8. I had access to clear and transparent information about the good that I purchased.	QUA8	
9. I was clearly informed about the services available at the store.	QUA9	
10. The goods and services are very diversified and totally satisfy my needs.	QUA10	
11. The staff was friendly and available.	QUA11	

12. The overall quality of customer attendance at the store was very high.	QUA12	
13. I had no type of problem with the good.	QUA13	
14. The good was available at the time and place that fitted my needs.	QUA14	
15. In general, I purchased a good of high quality.	QUA15	
16. The price of the good is very cheap in relation to its function.	VAL16	**PERCEIVED VALUE**
17. The price of the services (e.g. the workshop) is very cheap, bearing in mind the advantages that they offer.	VAL17	
Have you ever made a complaint at this store?	(filter)	**COMPLAINTS**
20.1 The problem was resolved well.	COMPLA	
20.2 If you had to complain, do you think that the problem would be resolved well?		
22. The store inspires confidence with regard to the goods on sale.	IMA22	**IMAGE**
23. The after-sales attendance can be relied on.	IMA23	
24. As a client, I feel that I am the centre of the staff's attention.	IMA24	
25. The store positively contributes to the community as a whole.	IMA25	
26. The store has been around for many years.	IMA26	
27. The store is modern and has launched innovative initiatives.	IMA27	
6. In general, my expectations have been met.	SAT6	**SATISFACTION**
21. It represents the ideal store.	SAT21	
29. As a regular customer, in general, I am totally satisfied with the store.	SAT29	
18. Bearing in mind this price, if you needed to purchase such new sports equipment, is it probable that you would return to the store to buy it?	LOY18	**LOYALTY**
19.1 By how many percent could our prices go up, before you would consider buying at the competition?	LOY19	
19.2 If the competition was to maintain its prices, by how many percent would our prices have to go down before you would consider returning to our store?		
28. It is very probable that I would recommend the store to family and friends.	LOY28	

In a form analogous to the ECIS questionnaires, respondents replied to scale of 10 points (Likert, 1932), in accordance with the level of agreement submitted affirmations (1 - strongly disagree, 10 -

strongly agree). A response between the values 1 and 5 corresponds to an unfavourable evaluation, and between 6 and 10, to a favorable review. Only those questions related to price sensitivity were treated differently: the value 1 corresponds to a price change between 1% and 10%, and the value 10 to a range of between 91% and 100%. Demographic data was also collected, in order to characterize the study population.

Once the questionnaires had been collected, the answers to the different questions were processed. Processing was carried out in two different ways:

1) Descriptive Statistics: collection and descriptive analysis of the responses, with information on frequencies, means, medians, modes and standard deviation.

2) Application of the ECSI model: estimation of model parameters based on the data collected through PLS methodology (Partial Least Squares).

SAMPLE

The survey was made available via an *online* platform and its presence was announced through messages sent to the E-mail addresses of customers who had made purchases during the weekends of the first three months of 2013.

Before its implementation, the questionnaire was tested with 5 employees of the store, who made improvement suggestions, mainly in order to adapt its extent and language to the characteristics of the individuals who were planned to be interviewed. In total, 117 responses were successfully collected, with 42% of respondents being female, and 48% male. Almost half (42%) of the sample consists of individuals aged between the age of 36 and 50, and the most common level of schooling was up to the 12th year (33% of the sample). After this level of educational, 30% had a Bachelor's degree, which was a similar level to the percentage employed as an expert in scientific and intellectual activities (29%). This phenomenon can be explained by the method used in collecting the data (an *online* questionnaire). Of the respondents, 86% have a profession, 4% are unemployed, 7% are students, 2% are pensioners, and 1% were in housekeeping.

THE PRESENTATION AND DISCUSSION OF RESULTS

Regarding the responses obtained to the questionnaire (table 3), it can be stated that, in general, they were very positive (always at least above 6). The only exception corresponds to the question on price sensitivity (Q19.2), which obtained average scores of 2. This is easily explained by the nature of the question and the answer to it. Indeed, the question is: "Up to what level could our prices be increased (...) until you would consider buying the competitors' products?", with a response scale of one percent, as mentioned in the previous section. Now, much as an individual show intentions to return to the store, it is unlikely that an increase of 100% on the end price would be easily supported. According to the answers given, on average, store prices could increase by 20%, without affecting customers' intention to return.

Regarding the dispersion of responses, i.e.: their distribution relative to the mean, this is, in general, low. Special attention should be given to the issues of price sensitivity (Q19.1) and the handling of complaints (Q20.1), which have the highest values (about 3). This indicates that, on the one hand, customers are affected differently by the possibility of a price reduction in relation to their return to the store and, secondly, that there is a consistent perception about how in-store complaints are resolved.

Table 3 – Descriptive statistics: Answers to the questionnaires

	Relative frequencies											Descriptive Statistics			
	1	2	3	4	5	6	7	8	9	10	Ns/Nr	**Mean**	**SD**	**Median**	**Mode**
Q1	0%	1%	0%	4%	9%	13%	21%	28%	14%	10%	0%	7.38	1.65	8	8
Q2	0%	0%	0%	2%	8%	12%	13%	27%	23%	15%	0%	7.87	1.56	8	8
Q3	0%	0%	1%	1%	7%	9%	13%	34%	21%	15%	0%	7.90	1.51	8	8
Q4	0%	0%	1%	4%	10%	6%	13%	25%	17%	24%	0%	7.88	1.82	8	8
Q5	6%	6%	7%	2%	10%	8%	20%	23%	10%	9%	0%	6.43	2.55	7	8
Q6	0%	1%	1%	1%	4%	9%	15%	32%	21%	17%	0%	7.98	1.56	8	8
Q7	0%	0%	2%	1%	3%	4%	8%	26%	31%	25%	0%	8.42	1.50	9	9
Q8	0%	0%	0%	2%	6%	5%	9%	32%	26%	19%	0%	8.20	1.45	8	8
Q9	1%	0%	2%	1%	7%	8%	16%	31%	17%	18%	0%	7.83	1.72	8	8
Q10	4%	3%	3%	2%	8%	9%	17%	30%	15%	9%	0%	7.10	2.22	8	8
Q11	0%	0%	1%	2%	3%	3%	8%	27%	25%	32%	0%	8.58	1.46	9	10
Q12	0%	0%	0%	3%	4%	5%	14%	32%	21%	21%	0%	8.15	1.47	8	8
Q13	0%	2%	2%	0%	5%	3%	12%	25%	21%	31%	0%	8.32	1.76	9	10
Q14	0%	1%	3%	3%	5%	11%	20%	25%	15%	18%	0%	7.61	1.85	8	8
Q15	0%	0%	1%	2%	3%	5%	26%	30%	17%	15%	0%	7.90	1.43	8	8
Q16	1%	1%	1%	6%	11%	19%	25%	24%	8%	5%	0%	6.83	1.68	7	7
Q17	1%	0%	1%	4%	11%	9%	14%	10%	5%	3%	42%	6.63	1.82	7	7
Q18	0%	0%	1%	3%	13%	3%	11%	26%	21%	23%	0%	7.97	1.77	8	8
Q19.1	1%	0%	0%	0%	2%	1%	6%	4%	1%	1%	85%	6.58	2.46	7	7
Q19.2	43%	9%	7%	6%	1%	0%	3%	1%	0%	0%	31%	1.93	1.61	1	1
Q20.1	1%	1%	1%	0%	0%	3%	1%	2%	1%	5%	86%	7.25	3.04	8	10
Q20.2	3%	0%	0%	1%	6%	12%	20%	21%	11%	14%	14%	7.49	1.88	8	8
Q21	0%	0%	2%	4%	10%	16%	27%	16%	13%	11%	0%	7.19	1.70	7	7
Q22	0%	0%	1%	1%	7%	6%	19%	29%	20%	18%	0%	7.97	1.53	8	8
Q23	1%	0%	0%	1%	9%	5%	19%	31%	15%	19%	0%	7.86	1.64	8	8
Q24	2%	1%	3%	4%	9%	21%	21%	17%	7%	15%	0%	7.01	2.01	7	7
Q25	0%	0%	5%	7%	14%	14%	21%	21%	8%	10%	0%	6.85	1.89	7	8
Q26	0%	0%	1%	1%	9%	10%	20%	26%	16%	17%	0%	7.77	1.59	8	8
Q27	1%	3%	1%	5%	8%	5%	11%	23%	20%	24%	0%	7.77	2.13	8	10
Q28	0%	0%	1%	3%	3%	9%	15%	20%	26%	25%	0%	8.21	1.61	9	9
Q29	0%	0%	1%	1%	5%	8%	15%	30%	22%	18%	0%	8.04	1.49	8	8

The low response rate to the question on the price of services offered by the store (Q17, with 42% of non-responses) needs highlighting, which can be explained by the fact that not all customers take advantage of such services. Questions regarding the quality of complaints resolution by the store (Q20.1 and Q20.2) present complementary response rates as they are mutually exclusive questions.

Regarding the value calculated for the response categories, the following stood out as they obtained the maximum value on the response scale (10): diversification of products and services (Q10), reliability of products (Q13), resolution of complaints (20.1) and an innovative and forward-looking image (Q27).

The estimation of the parameters of the proposed Conceptual Model was made by PLS methodology, using *SmartPLS software*. PLS, or the method of partial least squares, refers to a way to solve SEM problems through using simple linear regressions. The method focuses on the computation of estimators for the latent variables by minimizing the variance of the dependent variable residues. An estimation of the model is made, initially, by calculating the value of the latent variables and of the measurement model, and, at a second stage, the values of latent variables are substituted in the structural model, which in turn enables global estimates (Vilares & Coelho, 2005).

This methodology has the advantage of not having to establish hypotheses about the distribution and independence of the observed data. In addition, it presents low demands regarding sample size requirements. In this case, taking into account that the variable of satisfaction depends directly on four linear relations, only 40 observations (four ratios multiplied by ten observations each) would be needed for PLS to function properly. Despite the advantages, PLS does not permit considering the heterogeneity of data, or in other words, it does not detect when a certain population presents different elements for each of the modalities of the attributes, depending on the subpopulation that is being processed. Where heterogeneity is found, the impacts on the results obtained can be considerable, which suggests the need to use techniques additional to PLS, which allow for dealing with this problem, as is the case of FIMIX-PLS – Finite Mixture Partial Least Squares (Hair et.al, 2011).

Based on the original model suggested by ECSI, the measurement and structural models were designed on SmartPLS software, in accordance with Figure 4.

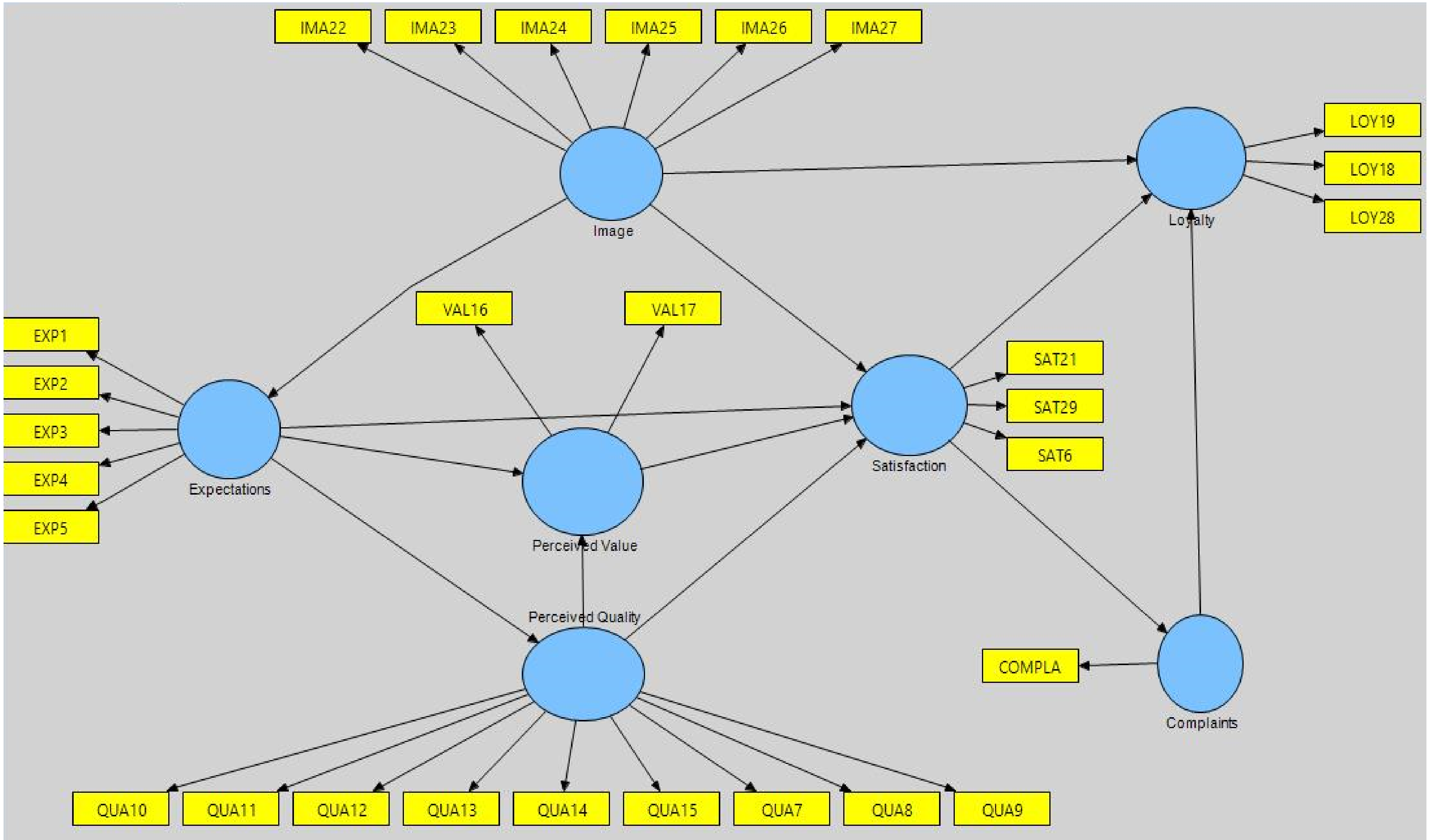

Figure 4 – The design of measurement and structural models on PLS software

Before proceeding to the analysis of the estimated model, some measures of statistical quality provided by SmartPLS are presented which are relevant to the evaluation of such models:

- The average extracted variance (AVE) indicates the proportion of all the variances of the indicators used in a given block, which is explained by the latent variable associated with this block (Villares & Coelho, 2005). It is recommended that the AVE presents values greater than, or equal to, 0.5, indicating that at least 50% of variance is explained.
- R2 represents a measure of quality for fit, as is the case of classical linear regression. Only values from 0.35 are considered, as these represent significant explanatory impact (Vilares & Coelho, 2005).
- Cronbach's Alpha represents the internal consistency of the measure, i.e.; it is an estimate of its reliability, ranging from 0 to 1 For Murphy and Davishofer (1988), values below 0.6 are considered unacceptable; and values up to 0.7 are considered to be of low reliability.

The estimation of the model shown in Figure 4 resulted in low R2 for *complaints* and *perceived value* (0.27 and 0:23, respectively). Likewise a value deemed unacceptable (0.35), was obtained for *Cronbach's Alpha* regarding *perceived value* variable, whilst in the case of the *loyalty* variable, the value obtained was considered impossible (-0.18). According to Murphy & Davidshofer, a negative value may reflect a serious error in the coding of the points of items (through a miscoding and / or mixture of items of different sizes), which demands a reassessment of the scale (in Maroco and Garcia -Marques, 2006). Suspecting that this unwelcomed value is a consequence of the LEA19 variable regarding price sensitivity, whose response scale, as previously discussed, proved poorly adjusted, a new model was used that did not contemplate this variable (Figure 5). As result of this amendment, there is room for an increase in the observed value of the latent loyalty variable (which before was 0.67 and is now 0.71), and for the coefficient linking complaints to loyalty, which ceased to be negative, although it remained very low, which nevertheless complies with the results obtained from studies using this model (e.g.: Fornell 1992, p.17). With regard to the statistical quality of the model (Table 5), we have, for loyalty:

- A higher AVE that the previous case (0.78);
- A Cronbach's Alfa, which, as well as being positive, is also statistically significant (0.73).

With regard to the perceived value variable, and despite the low values obtained for the R2 and Cronbach's Alpha measures of statistical quality (0.23 and 0,35 respectively), it is possible to consider their inclusion in the model if we only consider the AVE value, which is acceptable to do for the quality analysis of such models.

Also noteworthy is the relatively small direct impact of the *expectations* variable on *satisfaction* (0.013) and *perceived value* (0:21), which, after all, is in accordance with other studies that adopted the ECSI model (or an adaptation of it) (Han & Zhou, 2008; Wallace et al., 1999).

The results obtained from the estimation of the model, highlight two important points related to the question under study:

- Satisfaction Coefficient → Loyalty: 0.4958 (Table 4)
- The Total Satisfaction Effect → Loyalty: 0.5046 (Table 6)

Table 4 – Latent Variables Correlations

Latent Variable Correlations							
	Expectation	**Image**	**Loyalty**	**Perceived Quality**	**Complaints**	**Satisfaction**	**Perceived Value**
Expectations	0	0	0	0.5968	0	0.0135	0.2062
Image	0.5955	0	0.3866	0	0	0.4613	0
Loyalty	0	0	0	0	0	0	0
Perceived Quality	0	0	0	0	0	0.3027	0.3306
Complaints	0	0	0.017	0	0	0	0
Satisfaction	0	0	0.4958	0	0.5169	0	0
Perceived Value	0	0	0	0	0	0.1385	0

Table 5 – Statistical Quality Measures

Statistical Quality Measures			
	AVE	**R Square**	**Cronbach's Alpha**
Expectation	0.5678	0.3546	0.7635
Image	0.6343	0	0.8827
Loyalty	0.7827	0.7096	0.7269
Perceived Quality	0.6354	0.3561	0.9204
Complaints	1	0.2672	1
Satisfaction	0.7671	0.6585	0.8487
Perceived Value	0.5221	0.2332	0.3551

Thus one can conclude that there is empirical evidence to support the hypothesis of this study, i.e.: that satisfaction positively influences consumer loyalty. More precisely, it can be said that a unit change in the level of satisfaction contributes (directly and indirectly) to an increase loyalty of half this value (0.5). This is, incidentally, the variable that contributes most strongly to consumer loyalty, even when the total effects are considered. Image presents a higher impact (0.7) for this variable. In this latter case, it is important to verify that the total effect comes from the effect that *image* has on *loyalty*, via *satisfaction* (which directly exerts the highest value) and *complaints* (whose impact is virtually nil).

Table 6 – Total Effects

Total Effects							
	Expectation	**Image**	**Loyalty**	**Perceived Quality**	**Complaints**	**Satisfaction**	**Perceived Value**
Expectation	0	0	0.1262	0.5968	0.1292	0.25	0.4035
Image	0.5955	0	0.6944	0.3553	0.3154	0.6101	0.2403
Loyalty	0	0	0	0	0	0	0
Perceived Quality	0	0	0.1759	0	0.1801	0.3485	0.3306
Complaints	0	0	0.017	0	0	0	0
Satisfaction	0	0	0.5046	0	0.5169	0	0
Perceived Value	0	0	0.0699	0	0.0716	0.1385	0

Regarding the results obtained for this study, is also worth mentioning that a comparison of them with those obtained in the last ECSI made in Portugal, in 2012 (available on the website *http://www.ecsiportugal.pt*), supports the conclusion that they are in accordance with the reality of Portugal, despite the slightly lower average value found for the satisfaction variable (Table 7).

Table 7 – Comparison of the results obtained (available on the site: http://www.ecsiportugal.pt)

Variable	ECSI Portugal 2012 (observation interval)	Store
Satisfaction	[6.75;7.81]	6.6
Loyalty	[6.24;7.5]	7.1

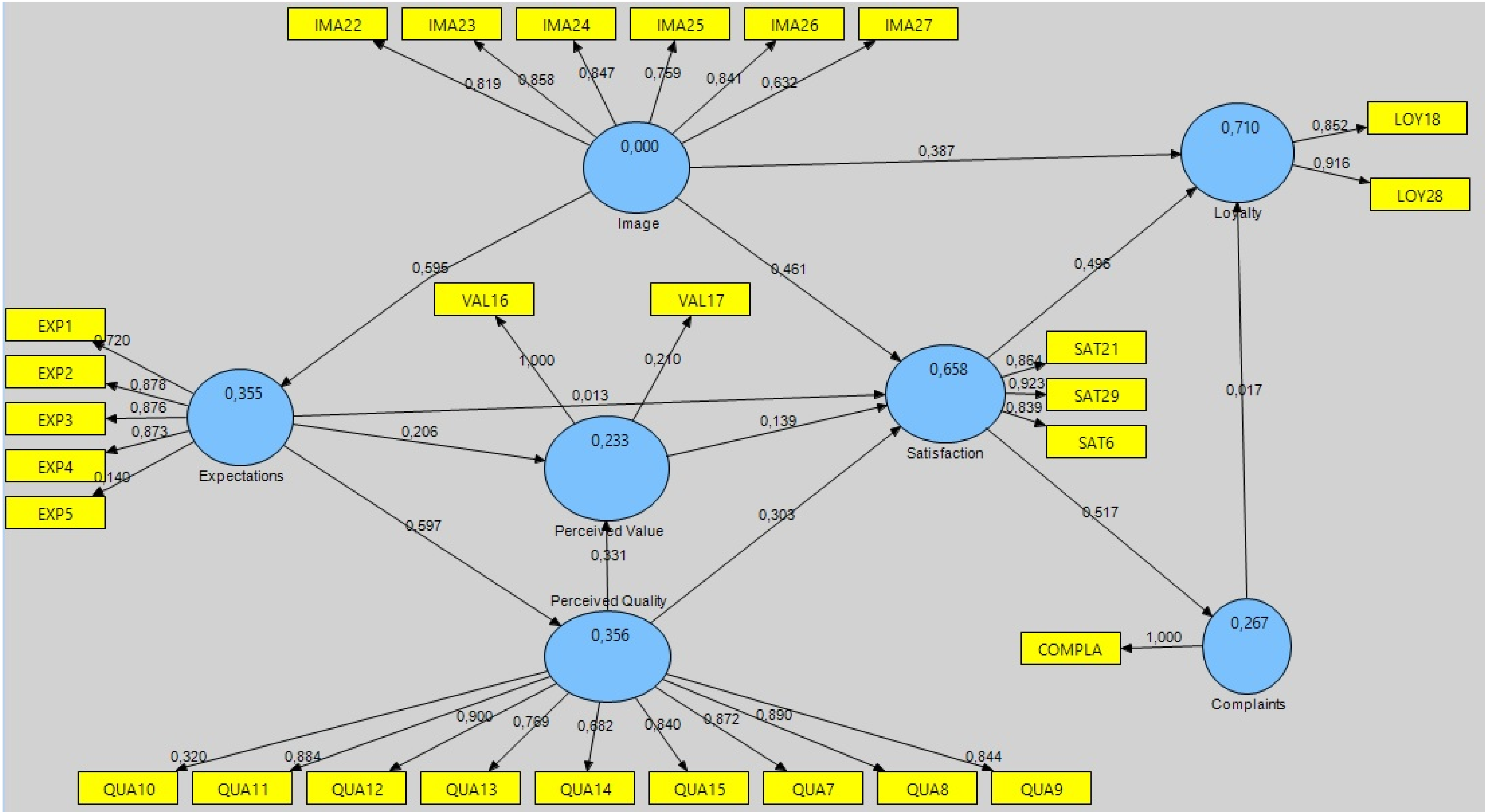

Figure 5 – The structural and measurement model

CONCLUSIONS

ECSI has been applied to various industry sectors in different countries, including Portugal. It has never been used in the context of Portuguese retail and it contributes to the discussion on the relationship between satisfaction and loyalty, which is indeed a topic of interest for researchers in quality management.

The major objective of this study was to contribute to knowledge on the impact of customer satisfaction on their loyalty. As seen in the literature review, this is a relationship that may not always exist and, when it does, it is subject to not only various theoretical interpretations such as the various constraints of an idiosyncratic and circumstantial nature, which makes it impossible to give a single answer to this problem, which is applicable to any industry.

Regarding the hypothesis to be tested, as most authors suggest, it was possible to find a positive causal relationship between satisfaction and loyalty, and that this relationship, in the case studied, is 2:1 (i.e.: if customer satisfaction increases by two units, then an increase in loyalty of one unit is forecast). It was also possible to verify the impact of the antecedents of satisfaction (value, quality, expectations, image) and of loyalty (complaints, satisfaction) that are considered in the literature, whose findings appear to be in accordance with the same. Thus, it is possible to reaffirm the importance of promoting satisfaction to achieve loyal customers in large-scale retail, or, ultimately, to ensure positive long-term results. Alongside this, it is also important to remember the role of the image of the organization in achieving this ultimate goal, in the case of the sector studied.

Despite the interesting results achieved with this study, it is important to note the limitations of the same. First of all, the study is based on the single case of a Portuguese retail company, which limits its representativeness in terms of this sector. In the future it would be interesting to roll out the study to a representative sample of the same sector. Moreover, we chose to adopt a method of a non-probability sample of convenience (each respondent is an individual voluntarily willing to participate in the study), which may raise questions regarding the representativeness of the sample; the fact that a tool was used that was self-administered and carried out online, also prevents from the outset, the participation of certain groups of individuals (particularly older and less academically qualified people), whose contribution would be important in terms of representativeness of the sample relative to the population. Regarding the size of the sample (117 observations), it would have been desirable to have had a larger one, especially as it was taken in a large retail store, where the number of weekend shoppers can reach into the thousands.

It is also suggested that other study tools be used, complementary to ECSI, especially those that measure customer satisfaction and loyalty through other methodologies, in order to have a more complete view and more precise research of the problem in question.

To conclude, the study is useful for the specific retail store where it was undertaken, to help it develop better customer service, in order to increase satisfaction and loyalty. It is also useful for the entire network of stores for that retailer and for other retail chains. Furthermore, the systematic application of a customer survey to whole sectors of the economy would improve competition and customer service, and ultimately contribute to development and economic growth.

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The mediating effect of advanced information systems between quality management practices and performance

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ABSTRACT

Although many researchers have recently studied quality management practices in enterprises, little previous research has analysed the impact of these practices on overall performance in this field for SME. Moreover, these studies have mostly focused on mega-sized companies or on industrial sectors. The main objective of this study was to examine the motivations for the adoption of quality management practices and the effects exerted by the advanced management information systems as mediating factors in a sector consisting of highly competitive companies with a high mortality rate in recent years: travel agencies. The results were based on a survey completed by 185 travel agencies with less than 50 employees, covering over 5% of the SME travel agencies in Spain. Structural equation modelling was used to analyse the links between the studied dimensions. The findings indicate that quality management practices have a positive, direct influence on the adoption of advanced management information systems and that the adoption of advanced management information systems has a positive, direct impact on financial performance. The results suggest that quality policies facilitate greater use of financial indicators but not in the use of nonfinancial indicators, where the key to better business performance lies. Therefore, the results of this paper indicate that being proactive about quality practices can provide travel agencies a great number of benefits through the implementation of advanced management information systems.

Keywords: quality management practices; advanced management information systems; firm's performance; travel agencies

Article classification: research paper (JEL code: M)

INTRODUCTION

The implementation of quality management practices (QMPs) in enterprises and the way in which their use has affected business performance have been widely studied over the last few years. Nevertheless, scarce research has linked QMPs to information systems in companies' decision making. Furthermore, within this group, few investigators have analysed this link in the tourism subsector, which essentially consists of companies with fewer than 50 employees (Eurostat, 2008). This study provides tangible results in this particular environment, focusing its analysis on travel agencies in Spain.

According to the Iberian Balance Sheet Analysis (SABI, in Spanish) application, this sector has experienced a high business mortality rate in recent years. At the time of this study, the number of travel agencies in Spain had decreased from 4,658 in 2010 to only 4,074 in 2011, of which 584 firms (12.53% of the sector) disappeared during a single financial period.

Both the economic crisis and the strengthening of online sales have forced these small enterprises to evolve with their environments or disappear (Casielles et al, 2009). In the space of a few years, companies have changed from using a local business model, based on customers' confidence, to global businesses, in which large amounts of information are available to customers to help them compare and in which price is a key variable in the final purchasing decision.

In addition to the above-mentioned reasons, other factors warrant this study. First, there has been very little research that has included in a single model accounting, non-financial variables and quality management practices to analyse financial improvement. There have been a few exceptions, mainly those studies that have focused on *lean management,* including quality variables, together with many other key factors necessary to maximise value offered to *stakeholders* (*timeliness of delivery, employee performance improvement, efficiency, flexibility, etc.*). Despite these factors, it is important to note that the vast majority of "lean studies" have focused on enterprises and manufacturing sectors, which have lean management as their bases and in which "wasted resource" cutbacks (overproduction, stocks, waiting times, defects, under-use of human capital and others) are more tangible. Second, it is necessary to conduct quantitative research into the different sectors in which small enterprises dominate (Lee, 2009) and also to focus on the services sector. Third and finally, mention must be made of the need for studies focused on small enterprises, thus facilitating the decision-making process in the tourism industry, as Hillary (2004) have suggested.

In the light of the foregoing, it has been deemed relevant to study enterprises that have managed to survive in a sector that has changed so much in recent years. In this respect, this article seeks to analyse empirically whether investing in quality can make a difference between surviving and disappearing in highly competitive and ever-evolving sectors.

Specifically, it will analyse whether the implementation of QMPs has positive effects on the use and development of advanced information systems in decision-making. Moreover, it will examine whether there is a positive link between the use of these systems and the company's finances.

This article provides evidence relevant to the research conducted in this field in different aspects. First, it highlights the main QMPs adopted by travel agencies and their impacts on these companies' performance using management information in decision-making. Second, it makes it easier to understand the effects produced on a small services enterprise by undertaking quality measures. Third, it increases understanding of the impact of QMP implementation on companies' financial performance, which is measured in terms of sales growth or earnings growth, among other indicators. Fourth, because this study focuses on a sector with a high business mortality rate, analysing enterprises that have survived could shed light on whether investing in quality is a good strategy to differentiate and survive in complex and highly competitive sectors. Fifth and finally, this study incorporates a new methodological approach, using a second-tier construct in the model for benchmarking: indeed, it adds accounting information systems to other non-financial information systems.

The remainder of this article is structured as follows. Section 2 discusses the theoretical arguments for the adoption of QMPs and their effects on the use of both financial and non-financial information in decision making, in addition to their direct or indirect links to companies' financial performance. Section 3 describes the methodology used in the empirical study. Section 4 presents the quantitative analysis. This article ends with section 5, in which the findings are analysed, and conclusions based on the research are outlined.

REVIEW OF THE LITERATURE

Impact of QMPs on information systems used in the decision-making process. In recent years, research related to QMP implementation in companies has been increasing. Most of this research has suggested that these practices have direct effects on companies' financial performance (Rubio-Andrada et al., 2011). However, views differ regarding whether the cost reduction obtained by the implementation of QMPs is offset by expenses related to monitoring compliance with these policies (Nair, 2006). Studies have argued that there is positive interaction between QMP implementation and financial performance, based on two differentiated factors.

On the one hand, there are effects on internal factors: as QMPs improve and reduce a company's internal processes, they have the impact of more efficient use of available resources (Rubio-Andrada et al., 2011 or Alonso-Almeida et al., 2012).

On the other hand, there are effects on external factors: QMPs have an impact on a company's competitiveness, which has positive effects on its sales, market share or benefits. In this respect, various studies have linked QMPs to increases in customer satisfaction (Chen and Kao, 2010), improvement in a company's brand image (Llach et al., 2013) or an improvement of employees' performance (Rodriguez-Antón and Alonso-Almeida, 2011).

Whilst QMPs are considered a key variable for companies' survival (Singh et al., 2008), few studies have analysed their effects on services companies. Their implementation has been studied in banks (Dawson and Patrickson, 1991) and educational organisations (Cruickshank, 2003). Some approaches have also examined the tourism industry (Tarí et al. 2010 y Alonso-Almeida et al. 2012), focusing mainly on hotels, by analysing the effects of quality policies on prices or analysing their links with the rating stars that they have obtained (Núñez-Serrano et al., 2014). However, the latter sector has received much greater research attention, examining its efficiency or its shareholder value creation, for instance (FitzPatrick et al., 2013). In contrast, this study focuses exclusively on the implementation of QMPs in travel agencies, the characteristics of which are very different from those examined previous studies, both for their size and for their increasing mortality in Spain.

It is therefore apparent that the impact of QMPs on a company's financial variables has been extensively studied. The same cannot be said for the impact of quality on the information systems used in decision-making processes. However, to optimise strategies based on quality, there is a consensus that more detailed and precise accounting information systems, such as Advanced Management Accounting Programs (AMAPs), are necessary because the classic information systems are insufficient (Baines and Langfield-Smith, 2003). The weaknesses in the classic accounting information systems are highlighted by their sole focus on internal variables. Globalisation also requires the use of Non-Financial Management Accounting Information (NFMAI) that can consider and investigate the changing environment in which a company operates and provide useful information for decision making (Baines and Langfield-Smith, 2003; Santini, 2013).

In their article entitled "Antecedents to management accounting change: a structural equation approach," published in 2003, Baines and Langfield-Smith positively linked changing and highly competitive environments to (both financial and non-financial) information systems and business success. However, this analysis was conducted in a manufacturing and industrial environment. The study subsequently generated prolific research, and the article has been cited more than 280 times. However, the current article emphasises the use of more detailed and complex management information (AMAPs and NFMAIs), compared with classic systems (Management Accounting Systems [MAS] and Management Accounting Information [MAI]), which have generated extensive literature.

If we focus on services enterprises and in particular on the tourism industry, the high degree of competitiveness of which makes the use of these two constructs (AMAP and NFMAI) suitable, the authors of this article are unable to find empirical studies linking QMPs to AMAP and NFMAI using the same terms with which they were defined by Baines and Langfield-Smith (2003). There are, nevertheless, many studies in the services sector directly linking quality to the degree of development and the use of accounting information systems (Patiar et al., 2012 or Weinstein, 2009, to name recent studies on different services, such as hotels, higher education or maritime transport). In terms of the use of non-financial information in decision making, there is also an extensive literature, in which Kaplan and Norton's balanced scorecard stands out as the key tool for monitoring non-financial variables (Kaplan and Norton, 1996; Kaplan and Norton, 2007).

In light of the above scholarship, the following hypothesis is proposed:

> **H1**: The adoption of QMPs has a positive, direct effect on the use of Advanced Management Information Systems (AMIS).

Impact of information systems used in decision making on companies' financial performance. It has been observed that the implementation of QMPs can be crucial for the future survival of a business (Russo and Fouts, 1997). This factor can be even more influential in a sector with high business mortality, such as the sector in question in this article, in which being competitive can mean the difference between surviving and disappearing. Competitiveness implies that the enterprise will have to manage not only internal but also external variables. It also implies studying the past (financial information from the accounting system) and planning for the future (non-financial information from indicators). Regarding accounting control, the use of advanced financial information systems is crucial to obtaining good financial performance (Baines y Langfield-Smith, 2003). However, Kaplan and Norton's research (1992) showed that non-financial control variables have become increasingly important over the years. This type of variable can facilitate integrating strategy into an organisation, based on a series of cause-effect indicators. Additionally, according to Lueg and Carvalho (2013), non-financial indicators are very versatile tools because they can apply to different industries and organisations, adapting each non-financial indicator to the business's needs. Therefore, although financial indicators provide accounting information on past activities, they do not ensure an adequate strategy to make a profit in the future (Nanni et al. 1992; Baines and Langfield-Smith, 2003). As Atkinson et al. argued (1997), any information system must incorporate non-financial information due to its predictive power. In highly competitive sectors such as travel agencies, Mia and Clarke's research (1999) must be considered because they found a link between financial performance and the use of information systems. Similarly, Davila (2000) showed that the use of non-financial information improves companies' financial performance with a high level of customer contact. Other recent studies emphasising the importance of non-financial information systems include Chari et al. (2012) and Domanović (2013), which focused on changing environments with high levels of uncertainty.

If we focus on the tourism industry, various studies, mainly focusing on the hotel sector run, have employed similar approaches (Teeratansirikool et al. 2013 or Hussain et al. 1998).

For these reasons and on the basis of the published literature, the following working hypotheses are proposed:

> **H2:** AMISs can be considered a second-tier construct, formed by financial and non-financial variables.
>
> As a result of H2, two sub-hypotheses are introduced to analyse the links between financial and non-financial factors and AMISs.
>
> **H2a**: The use of advanced financial information systems (AMAP) is directly linked to the use of AMISs.
>
> **H2b**: The use of advanced non-financial information systems (NFMAI) is directly linked to the use of AMISs.
>
> **H3**: The use of AMISs has a positive, direct effect on the companies' financial performance (FP).

To summarise, Figure 1 shows the model for benchmarking.

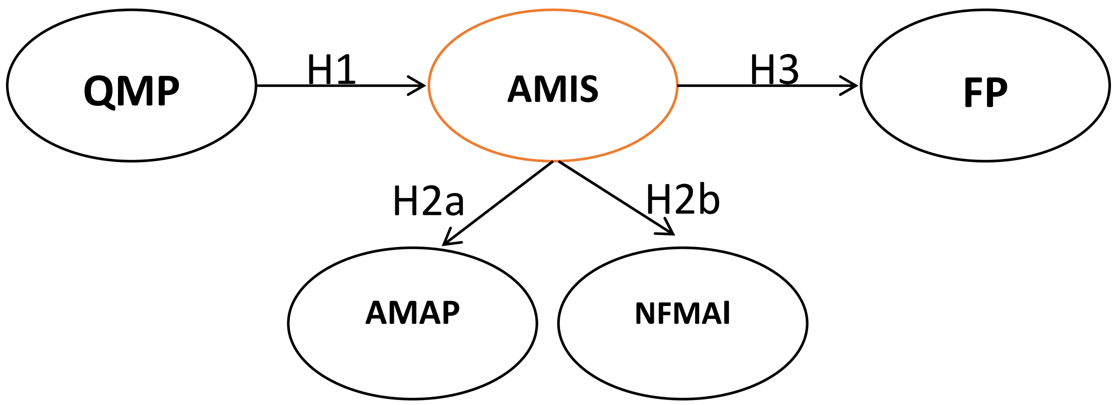


Figure 1. Model for benchmarking.

METHODOLOGY

Sample and data collection. This study was conducted by means of a survey, covering more than 5% of the travel agencies in Spain. The surveys were electronically completed by 185 Spanish travel agencies with fewer than 50 employees. All of the replies were received in the first quarter of 2013. The sample was limited to travel agencies because they represent a highly competitive sector with a high mortality rate (Lin et al., 2009). Furthermore, in this regard, we thought it would be interesting to test new business management practices. Moreover, these undertakings are mostly small or medium-sized enterprises, in keeping with this article's objectives.

The survey included in its first section the company's descriptive and financial information; three additional parts completed its content (AMAP, Non-Financial Management Information [NFMI] and quality practices). Table 1 shows the profiles of companies that completed the questionnaire.

Table 1. Profile of sampled companies

Classification		
	n	**%**
Retailers	129	69.73
Wholesalers	6	3.24
Retailers-Wholesalers	50	27.03
Total	185	100.00
Type of company		
Independent	35	18.92
Subsidiary	150	81.08
Total	185	100.00
Years since creation		
< 5 years	84	45.41
> 5 years	101	54.49
Total	185	100.00

Measurements. The four constructs forming the structure of the model were determined on the basis of previously published data.

All of the variables used in each construct can be observed in Annex 1, as well as the bibliographic references justifying their use. They are presented in a schematic manner in the following section.

- Quality Management Practices (QMP): the company's senior management commitment to the quality of the service provided; the company's cooperation with customers and/or providers to increase standards of service; the capacity to identify improvements in the provision of services; the company monitors compliance with the objectives and corrects for any possible deviations; there is a business culture based on continuous improvements

- Use of AMAPs: periodic calculation of product profitability analyses; periodic calculation of customer profitability analyses; use of target costing; analysis of the creation of shareholder value
- Non-Financial Management Information (NFMI): use of non-financial indicators in the company's management; use of benchmarking analysis; detailed and continuous study to assess market needs and to identify new business opportunities; analysis of employees' satisfaction, training and turnover
- Financial Performance (FP): profits have increased in the last two annual periods; market share has increased in the last two years; sales have increased in the last two financial years; the costs of operations have decreased in the last two financial years; supply costs have decreased in the last two financial years; non-quality costs have decreased in the last two annual periods

In the three first constructs, a 7-point Likert scale was used, with 1 indicating "totally disagree" and 7 indicating "totally agree."

In the last construct, the measurement scale developed by Camisón (1999) was used. This scale was later used by other authors, such as Pereira-Moliner et al. (2012) and Bagur-Femenías et al. (2013).

FINDINGS

The first part of our study consisted of conducting factor analysis to determine the clustered variables in the used constructs. Subsequently, links between the constructs were tested by means of structural equation modelling. Using robust statistical methods, the main indices were analysed to determine the model's goodness of fit and also to analyse the mediating effects of advanced management information systems on a company's performance.

The actions performed in the two previous phases are detailed below.

Factor analysis. Variables that are clustered into a construct can be determined by exploratory factor analysis (EFA). For the purpose of implementing the analysis, a minimum load of 0.5 was factored (Loiacono et al., 2002). These factor structures were verified by confirmatory factor analysis (CFA), thus disregarding the variables that did not exceed the threshold of 0.7 in that analysis. In contrast, the factors that exceeded 0.7 were assessed using Chronbach's alpha, proving that all of the constructs had an alpha greater than 0.7 (Carmines and Zeller, 1979).

The next stage was to conduct a consistency analysis of the indicators of reliability, exceeding in all of the cases the minimum value of 0.6 for the composite reliability coefficient (Bagozzi and Yi, 1988). Finally, the convergent validity of the model was assessed according to Fornell and Larcker's criteria (1981). The findings show that both the Average Variance Extracted (AVE) and the loading of items were greater than 0.5.

The results can be observed in Table 2.

Table 2. Factor analysis of the dimensions

Dimension	Code	Exploratory factor analysis	Confirmatory factor analysis	Internal consistency and reliability statistics
Quality Management Practices	QMP1	.784	.726	
(QMP)	QMP2	.749	-	Alpha cronbach: .878
	QMP3	.831	.800	AVE: .573
	QMP4	.763	.703	Composite Reliability: .870
	QMP5	.822	.784	
	QMP6	.801	.768	
Advanced Management	AMAP1	.846	.810	Alpha cronbach: .814
Accounting Practices	AMAP2	.789	.700	AVE: .558
(AMAP)	AMAP3	.768	-	Composite Reliability: .791
	AMAP4	.804	.728	
Non Financial Manag. Inform.	NFMI1	.880	.845	Alpha cronbach: .890
(NFMI)	NFMI2	.894	.874	AVE: .672
	NFMI3	.858	.796	Composite Reliability: .891
	NFMI4	.837	.759	
Financial Performance	FP1	.835	.890	
(FP)	FP2	.777	-	Alpha cronbach: .869
	FP3	.901	-	AVE: .699
	FP4	.779	-	Composite Reliability: .873
	FP5	.860	.887	
	FP6	.778	.719	
	FP7	.648	-	

In Table 3, the discriminant validity of constructs is confirmed. In all of the cases, it shows how each construct is more closely related to its own dimensions than to the dimensions of other constructs.

Table 3. Discriminant validity

	QMP	AMAP	NFMAI	FP
QMP	*0.757**			
AMAP	0.615	*0.748**		
NFMAI	0.180	0.135	*0.820**	
FP	0.237	0.172	0.303	*0.836**

*Square root of AVE on the diagonal

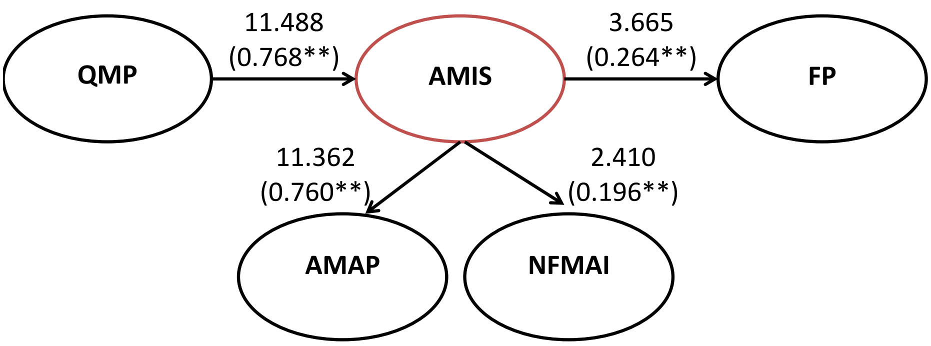
Benchmarking of the model. The established model was benchmarked through the robust method with EQS, version 6.1, which is structural equation modelling software in which the suitability of the model was proved. According to Schermelleh-Engel et al. (2003), although it would be sufficient to have three of their recommended values to determine the prosperity of the model, satisfactory results can be observed for all of the indices in Table 4. Thus, the explanatory capacity of the model is validated.

Table 4. Main indices (EQS)

Index	**Result**	**Ideal Value**
x^2 (chi-square)*	107.2502	Minimum possible
x^2 / degrees of freedom	1.2471	< 3
BB-NFI (Bentler-Bonnet normed fit index)	0.914	> 0.8
BB-NNFI (Bentler-Bonnet non-normed fit index)	0.977	> 0.9
IFI (Bollen's fit index)	0.982	> 0.9
CFI (comparative fit index)	0.981	> 0.9
RMSEA (root mean square error of approximation)	0.039	< 0.06

* Satorra-Bentler scaled chi-square

In Figure 2, the tested model is presented as a summary.



** p-value significant at the 0.05 level

Figure 2. Standardised solution for the causal model.

The final step is to assess the mediating effects of AMIS between quality and financial performance. Such mediating effects were measured using the methodology proposed by Baron and Kenny (1986), who proposed three regression series: first, regressing the mediator on the independent variable; second, regressing the dependent variable on the independent variable; and third, regressing the dependent variable on both the independent variable and the mediator. In Table 5, the regression results can be observed. The control variables included in the regressions were the following: typology and average age of employees. Typology is a dichotomous variable (0 = Independent firm; 1 = Group / others), and the employees' average age follows the following scale: 0 = younger than 30 years old; 1 = between 30 and 45 years old; 2 = between 45 and 60 years old; and 3 = older than 60 years old.

Table 5 confirms the studied mediating effects: first, the regression shows how the independent variable affects the mediator; second, the second regression confirms that the independent variable does not affect the dependent variable; and finally, the third regression validates that the effects of the mediate factor on the dependent and independent variables are insignificant when the mediate variable enters the model.

Table 5. Regressions conducted to assess the mediating effect of AMIS between QMP and FP

		Q MP- AMAP	**QMP-FP**	**QMP&AMAP - FP**
		BETA		
Control	TYPE	0.231	0.198	0.203
	AGE	-0.104	-0.194	-0.138
Independent	QMP	0.588**	0.253**	0.236**
	AMAP			0.027
r2		0.381	0.092	0.087
		QMP - NFMAI	**QMP-FP**	**QMP&NFMAI - FP**
		BETA		
Control	TYPE	-0.058	0.198	0.293
	AGE	-0.260	-0.194	0.024
Independent	QMP	0.225**	0.253**	0.175**
	NFMAI			0.235**
r2		0.064	0.092	0.149

** Significant at the $p < 0.05$ level

RESULTS, ANALYSIS AND CONCLUSIONS

The conducted analysis validates the model proposed in this article. Each hypothesis' results and their interpretation are presented below.

The first important point is that the results obtained in the research confirm the positive, direct link between QMP and AMIS. The quality policies enable having more detailed and precise financial and non-financial information systems (e.g., Patiar et al., 2012; Wenstein, 2009), especially in changing and highly competitive environments (Baines and Langfield-Smith, 2003; Santini, 2013). Concerning travel agencies in Spain, the findings of this article are in agreement with those of previous studies, and consequently, H1 is accepted.

In addition, the results show that advanced information systems in travel agencies offer both financial and non-financial indicators. A closer look at the results reveals that quality policies in travel agencies encourage the control of financial variables related to the price of the final product. Our attention is caught by both the absence of advanced techniques in the calculation of costs in the AMAP construct (such as, for instance, the cost systems-based activities, also called ABC) and the presence of other techniques, although these techniques might not be as common as target costing. This difference might be explained by the new sales channels becoming increasingly common in this sector. Operating in a global marketplace in which the customer has access to a large amount of information to compare, with lower incomes available for consumption due to the economic crisis, could explain why for the final consumer, price is a key variable in the purchasing decision. This result would force travel agencies to adopt management techniques rather than cost calculation methods, by ensuring sales with minimal profit margins (target costing or calculating the profitability of products or services). Regarding financial information, it is worth noting that its importance in AMIS is significant but inferior. As highlighted in Kaplan and Norton's multiple papers (1996), the use of non-financial information is essential to guaranteeing the long-term survival of companies. In this sense, observing the variables that compound the NFMAI construct reveals that the use of non-financial management indicators remains a current practice and that placing the emphasis on workers as the driving force of enterprises is still a key factor in the development of long-term sustainable businesses, in line with Fullerton et al. (2012). Travel agencies must be customer driven (Casielles et al., 2009). To attend to the needs of the consumer, it is essential to adapt to the demand. This adaptation can be accomplished with a complete and efficient information system that monitors not only financial variables (workers' performance, cost controlling, cost-benefit analyses) but also external variables (benchmarking or identification of new business opportunities) as many authors have previously indicated (e.g., Nanni et al., 1992; Kaplan and Norton, 1996 and 2007). In this regard, although the results of the study indicate greater importance of financial indicators in advanced information systems, the non-financial indicators are also significant in the development of the construct. Hence, H2a and H2b are accepted.

One of the initial objectives of this research was to examine the role of advanced information systems as mediators between quality policies and financial performance. Previously, many authors had already indicated a link between the use of information systems and enhanced business performance (e.g., Kaplan and Norton, 1996 and 2007; Davila, 2000; Baines and Langfield-Smith, 2003; Chari et al., 2012, Domanovic, 2013; Teeratansirikool et al., 2013). The results of this study point in a single direction, given the direct link between the use of advanced information systems and financial performance. Hence, H3 is accepted.

The detailed analysis of the mediating effects of advanced information systems between quality policies and travel agencies' financial performances implies a double analysis in this paper because the AMIS construct is formative. The use of the formative construct enables one of the primary contributions of this article: the findings show that quality policies have direct effects on the use of both non-financial information and financial information, although the results are more significant in the latter case. In contrast, if we study the effects of QMP and AMAP on FP and those of QMP and NFMAI on FP, we can observe that the link is only significant in the case of the use of non-financial indicators. These results suggest that quality policies facilitate to a greater extent the use of financial indicators, but the key to achieving better business performance lies in the use of non-financial indicators.

This study opens the door to other research, for instance, analyses of whether the results are valid in other tourism subsectors, such as bars, restaurants, hotels, etc., or attempts to validate the results for other countries. It might also be of interest to embed other management practices in the model, such as environmental management practices or practices of corporate social responsibility (in this way completing the so-called triple bottom line), and to analyse how they affect information systems and companies' performances.

Finally, this study is subject to several constraints inherent to the methodology used to collect the required data. The first constraint lies in the surveys having been conducted in a particular geographical region; therefore, it might be difficult to extrapolate the results of this study to other countries. Additionally, the sample only focuses on a subsector of the tourism sector, such as travel agencies. In this respect, the conclusions might be difficult to apply to other sectors.

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ANNEX 1

Code	Definition
Quality Management Practices: Saraph, et al. (1989); Flynn et al. (1994); Molina-Azorín et al. (2009)	
QMP1	Senior management is highly committed to the quality of marketed goods or of the service provided.
QMP2	The company works with customers and suppliers to improve quality.
QMP3	The improvements in the provision of services are identified.
QMP4	Compliance with the objectives is controlled, and possible deviations are corrected.
QMP5	There is a culture based on continuous improvement.
Advanced Accounting Information: Hussain et al. (1998); Baines and Langfield-Smith (2003); Fullerton et al. (2012)	
AMAP1	Product profitability analyses are periodically calculated.
AMAP2	Customer profitability analyses periodically calculated.
AMAP3	Target costing is a standard management tool.
AMAP4	The creation of shareholder value is analysed.
Non-financial Information Systems: Baines and Langfield-Smith (2003); Fullerton et al. (2012)	
NFMAI1	Non-financial indicators are used to complement the accounting information.
NFMAI2	The market is analysed to seek new business opportunities.
NFMAI3	Benchmarking facilitates decision-making.
NFMAI4	Employees' satisfaction, training and turnover are analysed.
Financial Performance: Das et al. (2000); Agus (2005); Molina-Azorin et al. (2009); Rubio-Andrada et al. (2011); Bagur-Femenías et al. (2013).	
FP1	Profits have increased in the last two financial years.
FP2	Market share has increased in the last two financial years.
FP3	Sales have increased in the last two financial years.
FP4	Costs of operations have decreased in the last two financial years.
FP5	Supply costs have decreased in the last two financial years.
FP6	Costs of waste have decreased in the last two financial years.

ISO 9001:2015 Revision

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ABSTRACT

Purpose. This paper aims to discuss the rationale behind the ISO 9001:2015 revision and the status of this (still ongoing) process. Key Stakeholders have (and are still working) towards a Quality Management Systems with less emphasis on documentation and new/reinforced approaches like consideration of organizational context and (relevant) Stakeholders, risk based thinking and knowledge management. The main question is how far ISO/TC 176 can go without alienating the "traditional" user and at the same time bonding Quality with Management.

Design/methodology/approach. the status of the revision process and a comparison of ISO 9001:2008 and the expected ISO 9001:2015 International Standard are presented, along with author comments on the revision processes and its expected outcomes.

Findings. The revision should assure the standard reflects the changes of an increasingly complex, demanding and dynamic environment and remains stable and adequate to provide assurance that organizations by complying with them are able to provide conformity products and services that satisfy their customers.

The core elements have been standardized by the "Annex SL" and it follows the Plan Do Check Act. Some familiar elements have been omitted (e.g., Quality Manual title is no longer a specific requirement) and some ideas should be reinforced or introduced.

Practical implications. There will be a 3 year transition process and major benefits like Quality Management Systems with less emphasis on documentation and new/reinforced approaches as consideration of organizational context and (relevant) Stakeholders, risk based thinking and knowledge management.

Originality/value. Any opinions expressed by the author are personal viewpoints and information about the revision of ISO 9001 is not yet final. The author thinks organizations will have to be clearer about what they say they are going to offer and the main question is how far ISO/TC 176 can go without alienating the "traditional" user.

Keywords: Quality Management Standards, Management Systems, ISO 9001 revision

Article Classification: General Review

INTRODUCTION

ISO 9001 standard has achieved great international visibility with more than 1 Million Organizations with ISO 9001 certified Management Systems (MS) all over the world (ISO Survey 2012, accessible at www.iso.org).

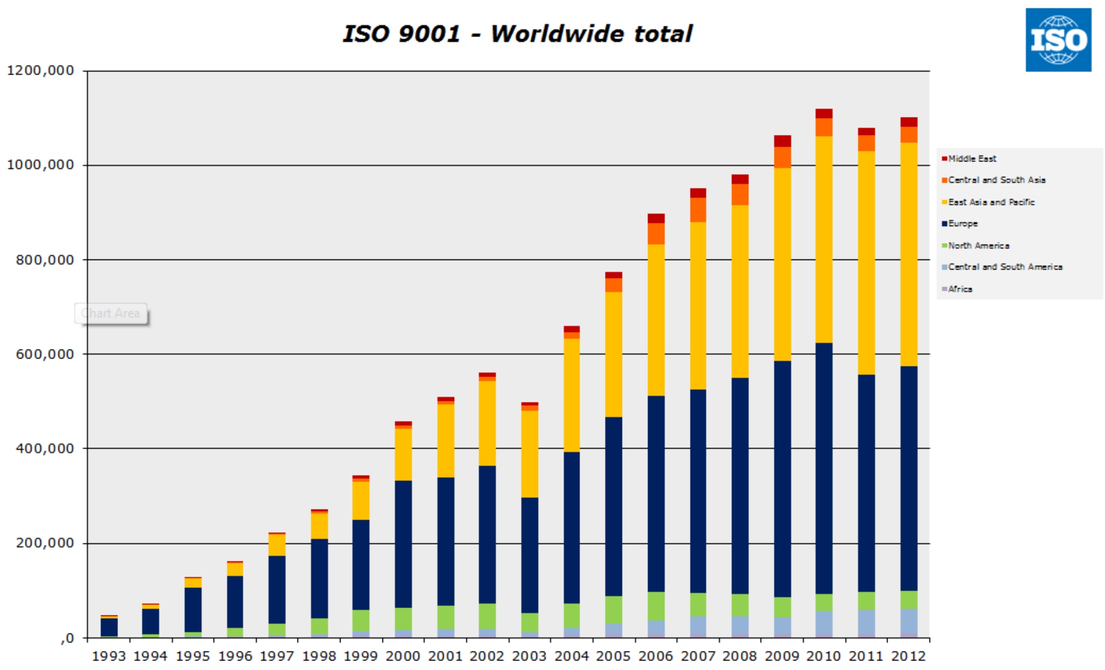

Figure 1 – ISO 9001 Certified Organizations Survey Trends

The scientific studies (Boiral, 2012), have linked the success in the implementation of QMS ISO 9001 to the Organisation's motivations (most significant results when the motivations are internal rather than external) and to the way the standard is interpreted and implemented. Also the studies of Levine and Toffel (2010, Harvard Business School) concluded, by analysing 1000 organizations of which 500 with QMS implemented and certified and 500 without QMS implemented and certified, the first presented a set of indicators significantly more favourable than the others: 9% higher sales volume and consequent additional profits; more employment (10%) and better wages (7%) due to higher sales volumes and profitability, and in combination with ISO 14001 less waste and incidents (these effects are more pronounced in small organizations).

ISO has a Directive governing the publication of standards (to be reviewed every 5 years). Sometimes the review confirms there is no change but are not the majority of the cases.

The ISO 9001:2008 revision process started by ISO/TC 176 aims to assure that the future ISO 9001:2015 standard reflects the changes of an increasingly complex, demanding and dynamic environment and remains stable for the next 10 years. The requirements should be clearly understandable and adequate to provide assurance that organizations by complying with them are able to provide conformity products and services that satisfy their customers. ISO TC 176 has the following structure: SC1 (Terms and Definitions), SC2 (Quality Systems, with WG 23 Implementation Guidance and

WG24 Revision of ISO 9001) and SC3 (Supporting Technologies). At the beginning of this process (October 2011) ISO conducted a web survey with approximately 12000 answers (of which 1000 in Portuguese language), with the following main conclusions:

- 64% of the respondents wanted enhancement (7918 responses) to ISO 9001:2008
- The Top 5 Concepts were: Resource Management, Voice of Customer, Measures, Knowledge Management and Risk Management
- In addition there were free text comments which concerned the following 5 main issues: Top management involvement, Risk assessment, Business continuity / planning, Inclusion of finance, Resources / competence / work environment.

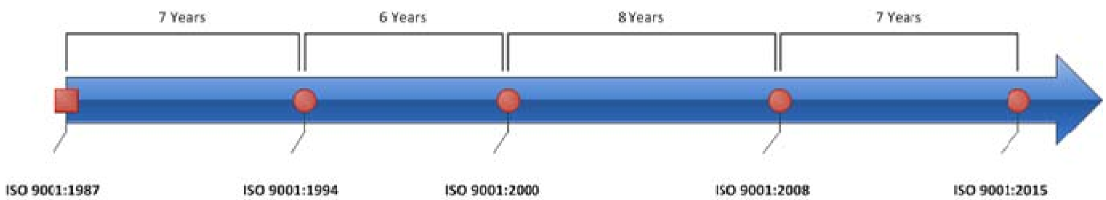

Figure 2 – ISO 9001:2015 Forecast schedules

Where are we now?

- June 2014: Publication of DIS for Ballot and Comment (changes might still happen to content and publication date)
- Nov 2014: meeting to review results of DIS Ballot
- April 2015: Publication of FDIS
- Sept 2015: Publication of ISO 9001:2015

In response to the proliferation of different MS Standards the core elements have been standardized by the "Annex SL" (or "High Level Text" as it is sometimes referred to) and it follows, the Plan Do Check Act (Clauses 6, 8, 9 and 10):

- Clause 4 = The organization's business environment and MS scope
- Clause 5 = Leadership and organizational structure
- Clause 6 = (PLAN) Planning
- Clause 7 = Support processes and capability
- Clause 8 = (DO) Operational processes
- Clause 9 = (CHECK) Performance evaluation
- Clause 10 = (ACT) Improvement

The DIS ballot is now scheduled to start on 2014-07-10 and to close on 2014-10-10. Although ISO 9001:2015 is not yet at DIS (Draft International Standard), there are some familiar elements have been omitted (e.g., Quality Manual is no longer a specific requirement, the new requirement for “documented information” gives greater freedom on how this is implemented) and some new ideas should be reinforced:

1. More emphasis on process approach and less on documentation.
2. After considerable discussion Products and Services were chosen versus Goods and Services, requiring further update of terminology.
3. Risk based thinking was introduced giving additional credibility to ISO 9001 within Business and Top Management by adding some systematic evaluation of potential and actual issues with the aim of making processes more robust and capable.
4. Organizational context should be considered and Interested Parties concept was also introduced but with the precaution we are referring to relevant parties that must have some actual or potential impact on the quality of products and services.
5. Concepts like Change Control and Strategic Direction will be reinforced on the future ISO 9001:2015 standard, trying to further approach and embed ISO 9001 and Business Management.

DETAILED COMPARISON OF ISO 9001:2008 AND ISO/DIS 9001:2015 VERSIONS

Quality Principles (SC1 (Terms and Definitions). There has been a proposal to review the Quality Management Principles accordingly to the following scheme:

Table 1 –Changes in Quality Management Principles proposed ISO/DIS 9001:2015
(source: 2014, ISO /TC 176/SC 2/WG 24/N 112)

1. Customer Focus	1. Customer Focus
2. Leadership	2. Leadership
3. Involvement of People	3. Engagement of People
4. Process Approach	4. Process Approach
5. System Approach to Management	5. Improvement
6. Continual Improvement	6. Evidence-based Decision Making
7. Factual Approach to Decision Making	7. Relationship Management
8. Mutually Beneficial Supplier Relationships	

Systems Approach: The Quality Management Principles (QMP) has been reduced from 8 to 7; the one which was omitted is “Systems Approach”. This is largely because of the failure of TC 176 to communicate clearly on the differences between Systems Approach and Process Approach, so the QMP committee decided to amalgamate “systems” and “process” under the new principle “Process Approach” which refers to “managing inter-related processes”. A system is the management of inter-related processes so, although Systems Approach” is not a principle, the new principle is more powerful as it redefines Process Approach as the processes and their inter-relationships. Systems Approach is there in the new QMP and more clearly expressed.

There are still some issues to solve (e.g. how to translate outputs, and outcomes in Portuguese and Spanish, output a result of a process, but outcome?).

Omitted elements. Many people have commented that familiar elements have been omitted. Some of these are:

- Quality Manual: No longer a title specific requirement but one can have one. The new requirement for "documented information" gives greater freedom on how this is implemented.
- Management Representative: it is no more a specific title but management are required to appoint somebody with the Management Representative's roles so the situation looks quite similar.
- Preventive Action**:** The change from "preventive action" to "risk and opportunity" (Cl. 6 Planning for the quality management system) is an example of a change to the way management think and of the issues of governance.
- Systems Approach: The Quality Management Principles (QMP) have been reduced from 8 to 7; the one which was omitted is "Systems Approach". Systems and processes have been incorporated under the new principle "Process Approach" which refers to "managing inter-related processes". A system is the management of inter-related processes so, although Systems Approach" is not a principle, the new principle is more powerful as it redefines Process Approach as the processes and their inter-relationships. Systems Approach is there in the new QMP and more clearly expressed.
- Continual Improvement: Clause 10 is titled "Improvement" but clause 10.3 is titled "continual improvement, as there are several types of improvement e.g., breakthrough and continuous improvement.

New ideas introduced on the standard. New ideas have been included such as:

- Risk based thinking: As already noted, this adds management credibility to the standard. But "risk experts" should note that this is not ISO 31000 but more a way of thinking that replaces preventive action and seeks to add some systematic evaluation of potential and actual issues with the aim of making processes more robust and capable.
- Interested Parties: this has been added to clause 4.2 but with the precaution that it is "relevant interested parties". To be relevant, the interested party must have some actual or potential impact on the quality of the goods and services.
- Change Control: This was included in the previous version of the standard but had now been highlighted as, in practice, many systems fail because of incomplete (or lack of) change management. It is now included in three places and this is another area of the standard that will need refining in the Paris meeting.
- Strategic Direction: This requirement has been added to Management Review to try to meld the business and quality systems, but will auditors be ready for this?

- Knowledge Management: Several examples of companies where their QMS scope no longer matched the expertise available, e.g. situations were der to the economic crisis older staff in organisations have taken early retirement and, in many cases, this has created a crisis of knowledge management.
- Leadership: "Top Management" is still there but Leadership doesn't quite align with the principles (where leadership is at all levels). Possibly the right wording would be "everything" and "everywhere".

Comparing ISO 9001:2008 versus proposed ISO/DIS 9001:2015. The following tables aims to compare the present ISO 9001:2008 International Standard versus the proposed ISO/DIS 9001:2015.

Table 2 – ISO 9001:2008 versus proposed ISO/DIS 9001:2015 (source: 2014, ISO /TC 176/SC 2/WG 24/N 112)

ISO 9001:2008		ISO/DIS 9001:2015
0. Introduction	=	0. Introduction
1. Scope	=	1. Scope
2. Normative References	=	2. Normative References
3. Terms and Definitions	=	3. Terms and Definitions
4. Quality Management Systems,	⇨	4. Context of the Organization
4.1 General Requirements		4.1. Understanding the organization and its context
4.2 Documentation Requirements	⇨	See section 7.5
		4.2. Understanding the needs and expectations of interested parties
		4.3. Determining the scope of the quality management system
		4.4 Quality Management System and its processes
5. Management Responsibility	⇨	5. Leadership
5.1 Management commitment		
5.2. Customer Focus		5.2. Quality Policy
5.3. Quality policy		5.3. Organizational roles, responsibilities and authorities

5.4. Planning		6. Planning for the quality management system
		6.1. Actions to address risks and opportunities
		6.2. Quality Objectives and planning to achieve them
		6.3. Planning of changes
5,5 Responsibility, authority and communication	⇨	See section 5.3 for staff responsibility and 7.4 for communication
5.6 Management review	⇨	See section 9.3 for management review
6. Resource Management	⇨	7. Support
6.1. Provision of Resources		7.1. Resources
6.2. Human resources		7.2. Competence
		7.3 Awareness
		7.4. Communication
6.3. Infrastructure	⇨	See 7.1 for infrastructure
6.4 Work Environment	⇨	See section 7.1 for workplace criteria
		7.5 Documented Information
7. Product realization	⇨	8. Operation
7.1. Planning and Product realization		8.1. Operational planning and control
7.2. Customer related processes		8.2. Determination of requirements for products and services
7.3. Design and development		8.3. Design and development of products and services
7.4. Purchasing		8.4. Control of externally provided products and services
7.5. Production and service provision		8.5. Production of products and services
7.6. Control of monitoring and measuring equipment		8.6. Release of products and services
		8.7. Control of nonconforming processes outputs, products and services

8. Measurement, analysis and improvement		9. Performance evaluation
8.1. General		9.1. Monitoring, measurement, analysis and evaluation
8.2. Monitoring and measurement		9.2. Internal audit
		9.3. Management review
8.3. Control of nonconforming product	⇨	See 8.8
8.4. Analysis of data	⇨	See 9.1
8.5. Improvement		10. Improvement
		10.1. General
		10.2 Nonconformity and corrective action
		10.3.Continual Improvement

Notes:

- This matrix is the sole responsibility of the author. An "official" matrix comparing ISO 9001:2008 versus ISO/DIS 9001:2015 should be available only after the June meeting of ISO/TC 176/SC2/WG23.
- SC2 will develop a guidance document ISO TS 9002:2015 supposed to be started on June 9 2014 and available when ISO 9001:2015 is published.
- The new clauses in Section 4 require the organization to determine the issues and requirements that can impact on the planning of the quality management system and can be used as an input for its development.

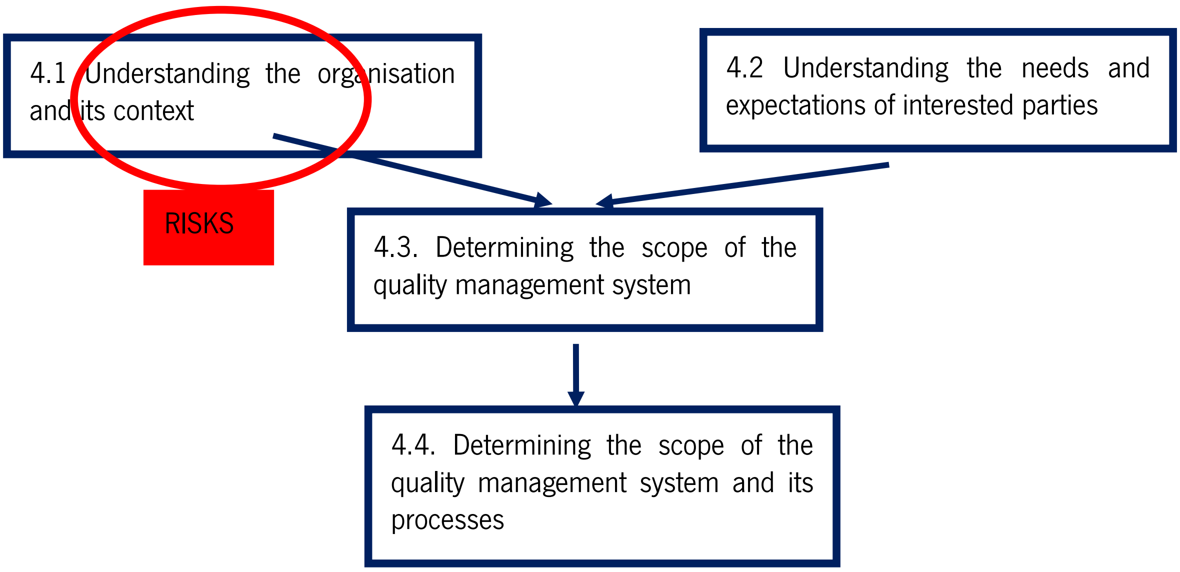

Figure 3 – Risk Based approach

ISO/DIS 9011:2015 proposes a processes model showing the links with the clauses of the international standard:

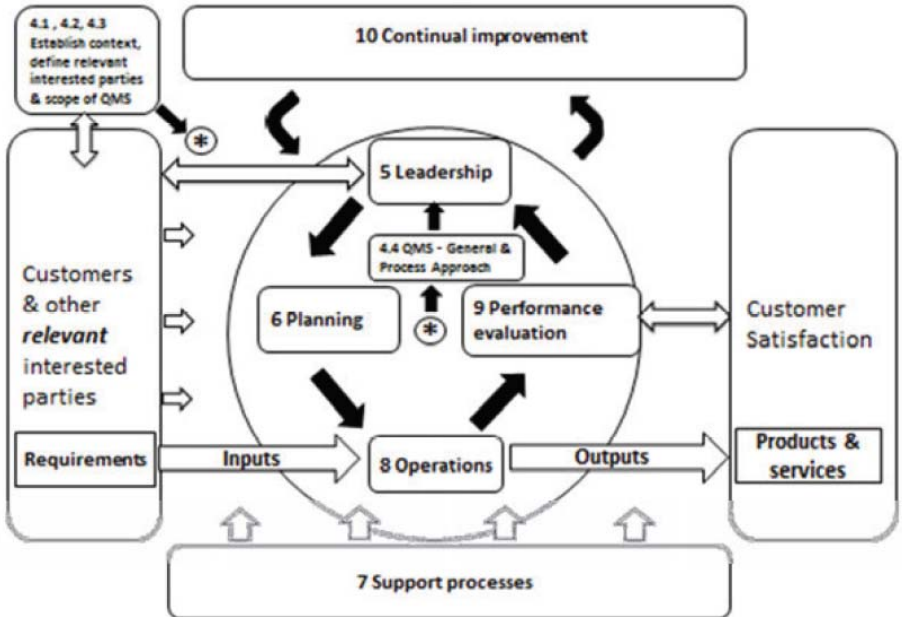

Figure 4 – ISO 9001:2015 proposed links (source: ISO)

Somme issues still open:

- Generic implementation guidance (possibly to be numbered as ISO 9002).
- Updated guidance for small businesses.
- Service sector (revive and revise the old ISO 9004-2?).
- Sector guidance (possible way to address concerns from Automotive Sector?)
- Application for “one-off” projects (updated ISO 10006).

CONCLUSIONS

Based on what we know the author believes we should relax that ISO 9001:2015 should not be a major source of concern, for the more than 1 Million certified organizations and the many Quality Professionals and Scholars that work with it. It will have major benefits for Quality Management Systems with less emphasis on documentation and new/reinforced approaches like consideration of organizational context and (relevant) Stakeholders, risk based thinking and knowledge management. The author thinks one of the major changes will be that organizations have to be clearer about what they say they are going to offer and the main question is how far ISO/TC 176 can go without alienating the "traditional" user.

According to ISO the following will be the major changes in terminology:

Table 3 – Major differences in terminology between is 9001:2008 and the proposed ISO/DIS 9001:2015 (source: 2014, ISO /TC 176/SC 2/WG 24/N 112)

ISO 9001:2008	ISO/DIS 9001:2015
Products	Products and Services
Exclusions	Not used (See Annex A4. for clarification of applicability)
Documented records	Documented information
Work environment	Environment for the operation of process
Purchased product	Externally provided products and services
Supplier	External provider

There will be time for users to make any adjustments necessary to their quality management system – a three-year transition period has already been agreed with ISO/CASCO and the IAF, after publication of the new version, during which certifications to ISO 9001:2008 will continue to be recognised.

And what about the feedback from ISO 9001 community?

- Some like very much the "Annex SL" approach, but other do not.
- Some concerns that some requirements are being soft grading (e.g., Design & Development and Calibration).
- Concerns about "auditability" of some requirements (I agree this might be a major challenge for Consultants and for Certification Bodies Auditors).
- Some want more prescriptive requirements (e.g., Automotive Sector).
- Introduction of the concept of "Relevant Interested parties" and "Risk Based Approach" is a new reality.
- Elimination of usual terminology and requirements like "Preventive action"; "Management Representative", "Quality Manual" still not liked by all.

And last but not least, what should you do now?

- Stay tuned to what's happening with the revision to ISO 9001.
- Get familiar with the concepts of "Risk-based thinking" and "Relevant interested parties".
- Look into www.iso.org. since periodic updates will be made available by ISO/TC176/SC2/WG23.

- After publication of DIS (Draft International Standards schedule for mid-2014), start working on understanding and incorporating the changes. DIS will be followed by FDIS (Final Draft Standard) and finally IS (international Standard).
- Is your organization pleased with your present Quality Management System? Is it really a lean process based system? Does it integrates and supports your business well?

Depending on you the answer, some organizations should consider the 2015 ISO 9001 revision as a great opportunity to reviews and reignite theirs systems. If the system is working well, maybe just adjust it to the new ISO 9001.2015 changes.

And as many times happens when processes changes occurs some people will say this was a lost opportunity to move to new heights of performance and provide a fresh new ISO 9001 that addresses new technology and advances in quality thinking, while others will say we have gone too far and could alienate a significant part of the more than 1 Million certified organisations.

It is true that some representative e.g. from automotive industry think the revision is too, light. It should incorporate tools like Quality Function Deployment, Failure Mode and Effects Analysis, Statistical Process Control, Measurement System Analysis, Advanced Quality Planning Process and so on. As an example of the opposition versus some of the proposed changes on ISO 9001.2015, let´s quote some of IATF comments on document ISO /TC 176/SC 2/n 1206 dated 6 May 2014: for example, IATF "he International Automotive Task Force (IATF), that is and an acts an "ad hoc" group of automotive manufacturers and their respective trade associations, formed to provide improved quality products to automotive customers worldwide and which members include IATF members include the following vehicle manufacturers: BMW Group, Chrysler Group, Daimler AG, Fiat Group Automobile, Ford Motor Company, General Motors Company), PSA Peugeot Citroen, Renault SA, Volkswagen AG and the vehicle manufacturers respective trade associations - AIAG (U.S.), ANFIA (Italy), FIEV (France), SMMT (U.K.) and VDA (Germany) (source http://www.iatfglobaloversight.org/ accessed 2014.06.29). IATF disagrees with the decision to raise the generic level of ISO 9001 where it results in the reduction of requirements.

Accordingly to IATF "ISO 9001 needs to be more prescriptive not more generic to bring value to the organization. In the effort to achieve the goal of making the standard adaptable to every type and size of industry, and to eliminate the needs for "exclusions" of specific requirements, the document has become diluted and unusable compared to what was already working". In the same line of thought IATF argues that "when the he document will be released in 2015, it will be likely be viewed as not usable by users including specifiers and regulators ".

Also some other users are concerned on how to address risks and opportunities with Top Management, for example.

As said before, the author does believe that ISO 9001:2015 will have major benefits for Quality Management Systems with less emphasis on documentation and new/reinforced approaches like consideration of organizational context and (relevant) Stakeholders, risk based thinking and knowledge management.

And let it be clearly: in the author personal opinion the main ISO 9001 revision goals have been achieved; a more Performance related standard, more Friendly to sectors like Services and Small and Medium Enterprises and not static but rather Risk Based. And has stated by Professor H. Lee from Stanford (2004), some years ago, but still very much valid today, organizations (and I had the standards assuring and supporting their performances) must be Agile (detect and respond), Adaptable (innovative and resilient) and Aligned (constancy of purposes and values, transparent, authentic, responsible and working forward long term mutual beneficial Stakeholders relationships).

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Analyzing the feedback structure of failure management in manufacturing systems

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ABSTRACT

Purpose. Despite manufacturing companies' intended zero-defects strategy, experience in dealing with complex systems shows that a comprehensive error and defect prevention is virtually impossible. Complex systems are characterized by diverse interacting components which are subject to intrinsic dynamics as well as circular, partially delayed cause-effect relationships. Due to these system properties, system performance is strongly affected by the internal emergence and external introduction of defects and disturbances. Serial production can be considered as such a complex system and, hence, requires adequate mechanisms for defect and nonconformity management.

Design/methodology/approach. The paper presents a system dynamics (SD) model for the analysis of manufacturing system's performance resulting from different defect management strategies. The model incorporates containment actions, root cause analyses, corrective actions as well as organizational learning effects resulting from the analysis of defects.

Findings. The model provides fundamental insights into how the system's feedback structure presents challenges to employees and management facing partially conflicting targets while resources are limited.

Originality/value. The optimum design of associated processes requires a systemic approach as defect management activities add even more complexity to the manufacturing system. Most existing approaches, however, neglect the strong interactions between short-term production targets and defect management activities. Both subsystems are traditionally optimized independently, provoking target conflicts.

Keywords: Defects, Nonconformity Management, Quality, Manufacturing System, Learning

Article Classification: Research paper

INTRODUCTION

In light of intense international competition organizations must excel in order to prevail. Simultaneously, manufacturing companies are obliged to decrease production and labor costs while increasing both product quality and productivity (Schmitt *et al.*, 2012). Following the recommendation of (Crosby, 1979) and (Juran, 1979), most organizations aspire to achieve "zero defects" within their production processes. However, experience in dealing with complex systems shows that a comprehensive error and defect prevention is virtually impossible (Stüttgen, 2003). As (Weick, 1987) states: „No system can completely avoid errors. Any discussion of reliability must start with that as axiomatic. Actors frequently underestimate the number of errors that can occur". Manufacturing systems are considered as such complex (socio-technical) systems and, hence, require adequate mechanisms for defect and nonconformity management (Schönsleben, 2011; Westkämper, 2009; Kletti and Schumacher, 2011; Scholz-Reiter *et al.*, 2002; Mertins and Jochem, 1997).

Quality deviations in manufacturing can be traced down to a broad range of root-causes with various underlying causal structures. Insufficient product quality is caused e.g. by design, manufacturing and assembly problems, insufficient maintenance of plant and machinery as well as hardware, software and operating errors (Schäuffele and Zurawka, 2010).

Managing nonconformities in manufacturing systems. The introduction of standardized processes for managing defects and nonconformities aims at the improvement and systematization of handling process problems with an influence on product quality (Mistele, 2007). The primary goal is the fast and reliable identification and elimination of quality problems. A thorough analysis and successful elimination of underlying root causes and causal structures can prevent identical or similar problems from (re-)occurring even across different product groups (Schmitt and Pfeifer, 2010). Yet, precondition is the realization of analyses with qualified tools and methods, the existence of adequate processes and structures as well as staff's awareness of the importance of all associated activities.

Furthermore, successful nonconformity management promotes information and knowledge exchange regarding the emergence, elimination and prevention of errors. A continuously growing knowledge base will induce learning effects on two sides – leading to both a reduced emergence of new problems as well as an increase in the efficiency and effectiveness of root cause analysis and elimination.

Both, defect production as well as additional, unplanned efforts to identify and eliminate the underlying root causes may affect production output. In most cases nonconformity management consumes limited production resources and hence negatively affects the production rate in the short run. On the other hand, the elimination of root-causes increases the yield, reduces rework and, hence, improves the effective production rate in the long run. Complex and partly counterintuitive cause and effect relations aggravate the selection of appropriate measures and strategies when facing throughput gaps which are partially caused by high defect rates.

Oftentimes, the mid-term benefit of a thorough root cause analysis and elimination is neglected vis-à-vis short-term production targets. A joint study of the WZL of RWTH Aachen University and The Boston Consulting Group reveals that rigorous root-cause analysis – even of recurrent problems – is not common practice in manufacturing industry. The main reason for this situation lies in existing time and cost pressure on the one hand and high resource requirements for a root cause analysis on the other hand, where necessary even combined with an interruption of production (e.g. line stop). (Schmitt *et al.*, 2013)

The optimum design of defect management strategies requires a systemic approach as related processes add even more complexity to manufacturing systems. Most existing approaches, however, neglect the strong interactions between short-term production targets and defect management activities. Both subsystems are traditionally optimized independently, provoking target conflicts in serial production.

The resulting research question is: *How can defect management processes be designed and evaluated under consideration of complex systems' dynamic behavior?* In order to answer that question, the paper presents a system dynamics (SD) model for the analysis of manufacturing system's performance resulting from different defect management strategies. The model incorporates containment actions, root cause analyses, corrective actions as well as organizational learning effects resulting from a thorough analysis of defects.

Learning from defects. Learning in organizations has been studied by many researchers focusing on different aspects (e.g. cost, productivity, quality). (Wright, 1936) was the first to report the learning curve phenomenon in literature. He observed that the number of direct labor hours it takes to produce an individual unit decreases at a uniform rate (i.e. the learning rate) as the quantity of units manufactured doubles. The identified learning curve follows a log-linear relationship given by the equation (Yelle, 1979; Bailey and McIntyre, 2011; Khan et al., 2011):

$$T_x = T_1 x^b \tag{1}$$

where T_x and T_1 = Time required to produce the x^{th} resp. the first unit

x = The cumulative unit number

b = $\frac{\log \phi}{\log 2}$ = The learning index

ϕ = The learning rate (often expressed as a percentage)

Different authors describe the linkage between quality and learning in their work, leading to both mathematical and empirical relationships. A comprehensive overview is given by (Khan *et al.*, 2011). Only few authors link quality improvements explicitly to experience gained from handling incidents, defects or quality problems in the past. (Marcellus and Dada, 1991) suggest that defective parts provide a significant opportunity for learning and process improvements. By gradually discovering and eliminating more and more root causes, defective parts will occur with decreasing frequency. Based on empirical data, (Li and Rajagopalan, 1997) tried to answer the question whether defective units explain learning curves better than good units. Their study resulted in the finding, that defective units are statistically more significant than good units in trying to explain learning curve effects. (Westkämper *et al.*, 1997), too, found out that defect rates and, hence, the cost of nonconformity at a small batch manufacturer decrease with increasing cumulated output. The reason for this behavior is seen in the identification and elimination of product and process problems. (Cooke, 2003) recommends the implementation of an incident learning system. According to Cooke an organization can reduce risk and minimize loss by learning from past incidents. An effective incident learning system supports a process of continuous organizational improvement helping to reduce both incident severity and risk of disaster.

The importance of "learning from mistakes" has been highlighted by many researchers without linking the effect explicitly to improvements in product quality. (Tjosvold *et al.*, 2004) found out, that a problem solving approach, where team members analyze, discuss, and plan how to correct mistakes, is an important antecedent of learning from mistakes.

System dynamics. According to (Reid and Koljonen, 1999) the dynamic behavior of a system primarily results from the interaction of three main factors:

- the structure of the system,
- the frequency and duration of time delays in feedback loops as well as
- the degree to which information and work are amplified through the system's feedback structure.

System dynamics (SD) – initially called *industrial dynamics* – was first introduced by J. W. Forrester in the late 1950s (Forrester, 1958). According to (Forrester, 1969) system dynamics "is a way of studying the behavior of industrial systems to show how policies, decisions, structures, and delays are interrelated to influence growth and stability". System dynamics modelling focusses on feedback structures and delays as feedback causes the majority of a system's dynamic behavior.

In this paper, a system dynamics approach is applied in order to analyze the dynamic behavior of defect management in manufacturing systems as such processes are characterized by distinct feedback structures with significant delays in the processing of information.

MODEL OF DEFECT MANAGEMENT IN MANUFACTURING SYSTEMS

In this section we present an integrated model of defect management and quality based learning for a serial production. At first an appropriate target system for defect management in manufacturing systems needs to be defined. Subsequently the developed

SD model will be described, focusing on the feedback structure of the system causing its dynamic behavior. The model is derived from detailed insights into defect management processes and strategies at different German manufacturing companies. It incorporates the introduction of new root causes, rework, root cause analyses, corrective actions, as well as organizational learning effects based on the understanding of root cause emergence. Figure 1 shows the feedback structure of defect management in manufacturing systems. The different parts of the model will be discussed in detail within the following sections of the paper.

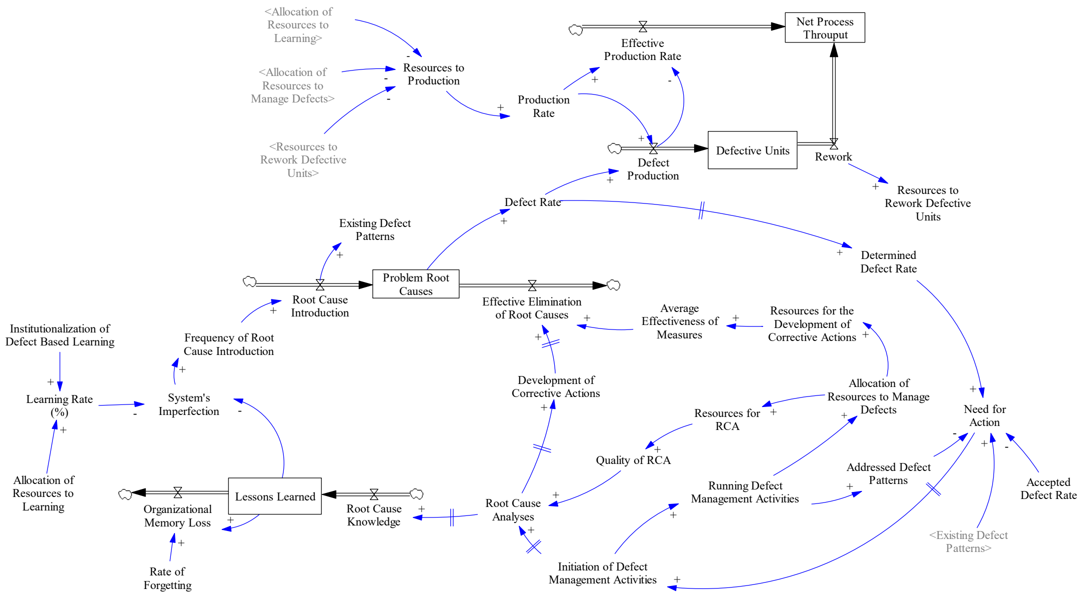

Figure 1 – Model structure

Target system for defect management in manufacturing systems. The target system for defect management in manufacturing system is developed based on the existing state of the art within the triangle of quality, cost and time. The primary target of defect management is the fast identification and effective elimination of problem root causes as well as the implementation of adequate measures in order to prevent the reoccurrence of identical or similar defects. Considering only reactive process improvements in our model (based on identified defects) prevention and appraisal costs are not within the focus of interest. Hence, total quality costs are considered as being primarily influenced by internal and external failure costs. Furthermore, resources in our model are considered as being strictly limited and shared between production and defect management.

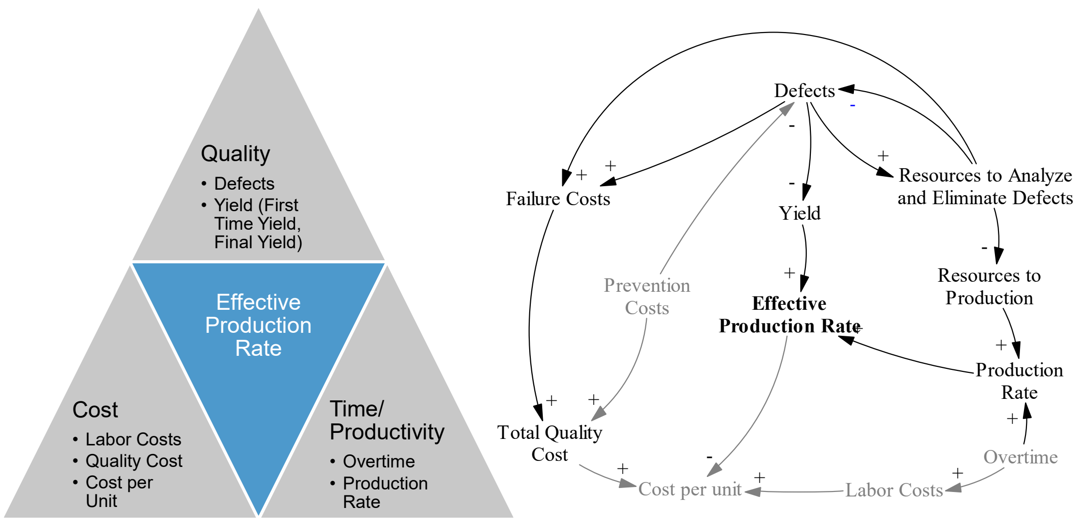

Figure 2 – Defect management target system

As Figure 2 depicts, defect management activities may, as a result of shared resources, negatively affect the average total production rate (P_{Tot}). Consequently, a performance measure needs to be found, that reflects both the production output and the corresponding quality level. In accordance with (Colledani and Tolio, 2012) the maximization of the effective production rate (P_{Eff}) is considered the superior target of production defect management. The main system performance measures of interest are consequently:

- The average total production rate of the system (P_{Tot})
- The first time yield (FTY), that is the percentage of conforming products without requiring any rework
- The average effective production rate ($P_{Eff} = P_{Tot} x FTY$)

Defect introduction. Based on the assumption that no system can completely avoid errors, new root causes are continuously introduced into the manufacturing system (Figure 3). The frequency at which new root causes emerge, depends upon the system's imperfection. The stock of existing problem root causes is continuously growing unless existing root causes are effectively eliminated by adequate measures. A high stock of root causes within an organization leads to a high defect rate. In our model all root causes are assumed to have the same (average) impact on the defect rate.

The imperfection of a system is supposed to be 1 (on an interval from 0 to 1) in the beginning of an analyzed time span – it can only be reduced by applying learning effects resulting from analyzed defects (compare section 2.4 of this paper).

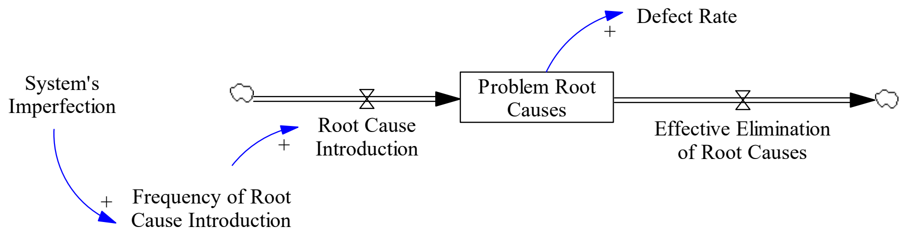

Figure 3 – Defect introduction

Managing defects. A high defect rate negatively influences the average effective production rate of the manufacturing system. This again leads to a reduced net process throughput causing a throughput gap. A strategy to reduce this throughput gap is to rework defective parts, if possible. On the one hand this seems to reduce the throughput gap but on the other hand reduces the total production rate as well, as resources from production are shifted to rework. Consequently, rework might be an adequate containment action in order to assure the ability to supply in the short-run but should never be considered a long-term solution.

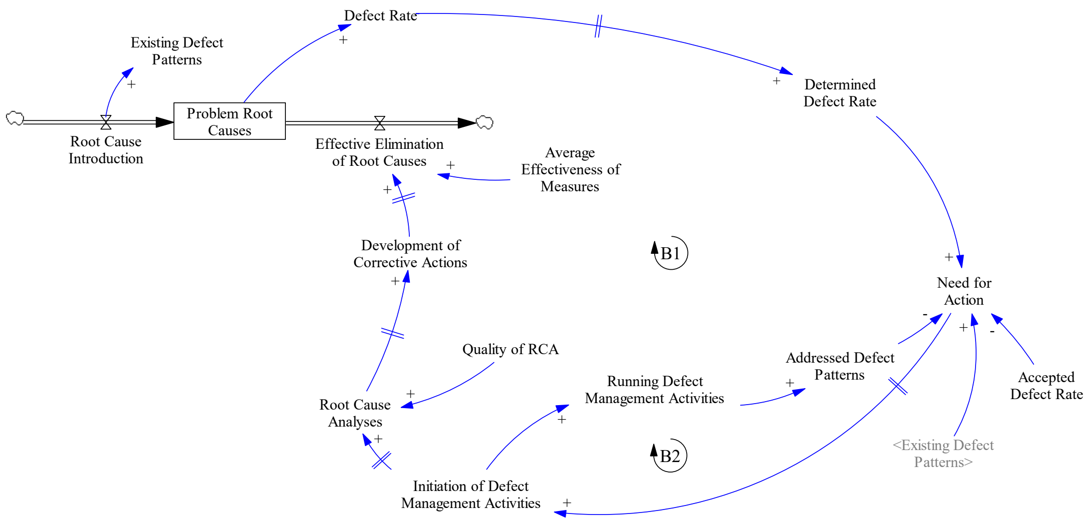

Figure 4 – Root cause elimination

In order to reduce defect rates, root causes need to be analyzed and eliminated effectively. Figure 4 shows a standard process for defect management creating a balancing loop of root cause elimination (B1). Based on the outcome of quality inspections, an explicit need for action results from a determined defect rate which is higher than the accepted defect rate of the system. To reduce the model's complexity we apply a 100 % inspection and assume that all defects will be revealed. In order to avoid redundant efforts, new defect management activities will only be initiated if existing defect patterns are not yet addressed by other running activities (B2). Starting with an analysis of the defect, the root cause needs to be identified. Once the problem has been understood, suitable corrective action must be developed in order to eliminate the root cause and to prevent the defect from reoccurring. The quality of the root cause analysis (RCA) as well as the average effectiveness of implemented measures is significantly influenced by the amount of resources allocated to defect management.

Defect based learning. As mentioned earlier in this paper, system's imperfection leads to a continuous emergence of new root causes. The frequency of root cause introduction can be lowered by reducing the system's imperfection. We propose that organizations reduce system's imperfection by institutionalizing defect based learning.

Figure 5 shows how lessons learned can result in a reduced frequency of the emergence of new root causes. Lessons learned accumulate from the knowledge gained from root cause analyses. According to (Cooke, 2003) *organizational memory loss* is assumed to be a fraction of the *lessons learned*. In our model system's imperfection is modelled using the mathematical expression:

$$System's\ Imperfection\ = \quad (2)$$

$$IF\ THEN\ ELSE(Lessons\ Learned\ <=\ 1, 1,$$

$$1 * Lessons\ Learned\text{^}(LOG(\text{"}Learning\ Rate\ (\%)\text{"}, 10)/LOG(2, 10)))$$

This equation represents the log-linear relationship of a learning curve which was introduced earlier in this paper. As Figure 5 shows, defect based learning builds up an additional balancing loop (B3), depending on intermediate results of the root cause elimination loop (B1).

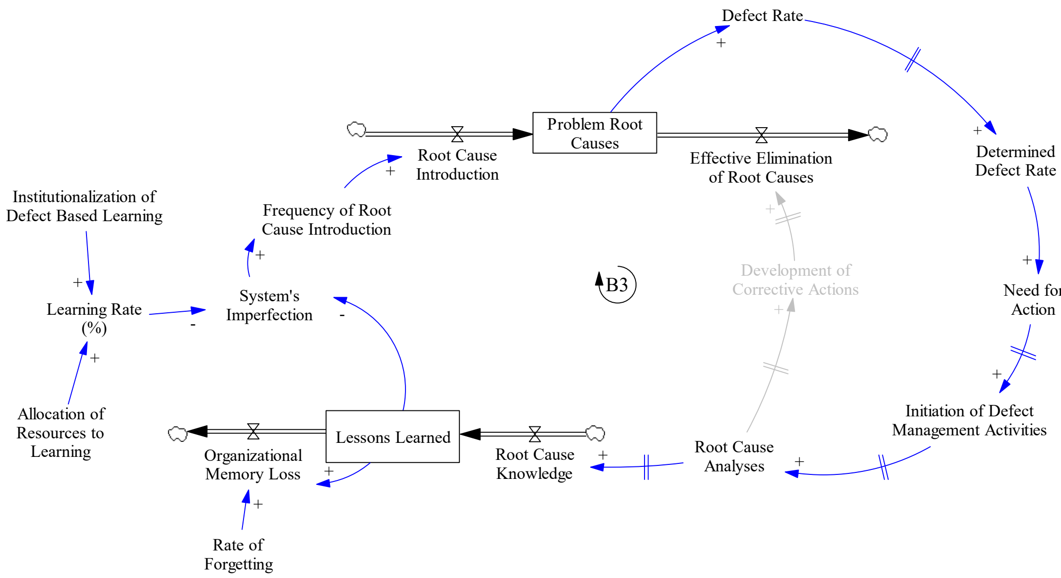

Figure 5 – Defect based learning

Conflict of shared resources. Looking at the model structure it is quite obvious, that the effective production rate and hence the system output could be increased by adding more resources to production. The predominant conflict in practice, however, is the adequate allocation of *limited resources* to production, defect management and defect based learning activities. In our model resources are considered as being strictly limited. A possible way to increase the effective production rate is to reduce the number of defects. Yet, in order to reach this goal, scarce production resources need to be shifted to defect management. By implication, this will further reduce the feasible production rate as less resources are available for production. On the other hand, if no defect management activities are initiated at all, the effective production rate will continuously deteriorate.

Dynamic behavior of the system. A possible strategy in defect management is to allow a certain defect rate in manufacturing processes in order to spare resources for production. However this may lead to a rather unstable behavior of the system, caused by the presence of significant time delays within the negative feedback loop of root cause elimination.

The dynamic behavior of the system is shown exemplarily as a result of varying the *accepted defect rate*. The results of the sensitivity simulation are shown in Figure 6. Varying the accepted defect rate from 0 to 0.5 shows that the behavior of the system changes from a stable goal seeking behavior (accepted defect rate = 0) to an oscillating behavior.

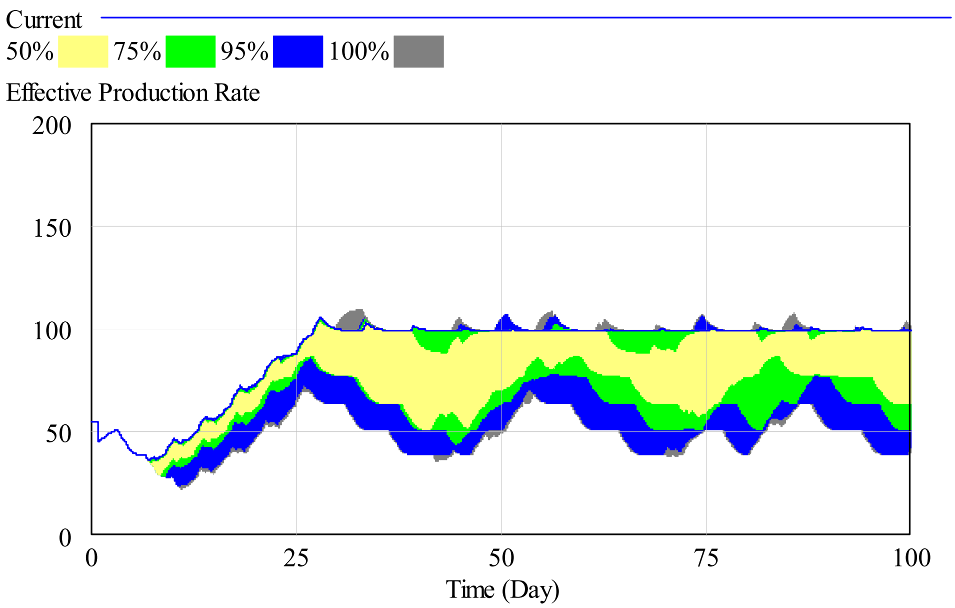

Figure 6 – Sensitivity of a system's response to changes in the accepted defect rate

CONCLUSION

Due to the complexity of manufacturing systems zero defects are virtually impossible. This situation forces companies to set up appropriate strategies and corresponding processes for handling defects and nonconformities. One of the major challenges when facing throughput gaps in production is the adequate allocation of resources to production and rework on one side and defect management activities on the other side. Even though the potential of "learning from mistakes" is scientifically recognized and generally accepted, most companies leave this potential untapped. A central hypothesis of our research is that learning curves exist not only for production efficiency but also for root cause emergence – leading to a reduced frequency of root cause introduction if properly exploited. We suggest, that organizations should develop and encourage learning behavior based on defects, the analysis of root causes and their elimination.

In our paper we presented a system dynamics model of defect management in manufacturing systems. In the first place, an appropriate target system was derived from the generic triangle of cost, time and quality. The structure of the system was than described by focusing on the introduction of defects and possible feedback loops. Subsequently, the dynamic behavior of the system was shown by taking the example of varying the accepted defect rate for a manufacturing process. The sensitivity analysis showed, that an accepted defect rate other than zero leads to an unstable, oscillating performance. Derived from the awareness of the system's behavior, we suggest that organizations should apply a zero defects mentality to defect management even though this goal can hardly be achieved in complex systems.

In future research the developed model should be applied to different real case scenarios in order to predict future performance when planning system and process adaptations. The fact that there is only little empirical evidence in the literature showing the effect of the proposed defect based learning on the frequency of new root cause introduction provides additional scope for future research. In particular, more industry studies should be conducted in order to test the hypothesis of this paper.

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Quality Management and Integrated Management System of Consultancy Company in Energy Sector

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ABSTRACT

The recently issued International Atomic Energy Agency (IAEA) publications (GS-R-3, GS-G-3.1 and GS-G-3.5) regarding Management Systems for Facilities and Activities define requirements for creation, introduction, evaluation and continuously improvement of the Management System, which unifies the safety, health, environment, security, quality and economic elements.

At implementation of their activities, the organizations often apply other standards in their interrelations with suppliers and the parties concerned - ISO 9001:2008, ISO 14001:2004 and OHSAS 18001:2007, regarding quality, environment and occupational health and safety management.

GS-R-3 is intended to help an organization to establish, implement, assess and continually improve a management system that integrates safety, health, environmental, security, quality and economic elements, to foster a strong safety culture and improve safety performance, in all the activities of the organization.

Both IAEA GS-R-3 and ISO 9001:2008 are based on the common management principles that reflect good management practices: Customer focus, Leadership, Involvement of people, Process approach, System approach to management, continual improvement, Factual approach to decision making and mutually beneficial supplier relationships.

The requirements in both standards are structured in terms of the following main categories: Management system, Management responsibility, Resource management, Process implementation or Product realization and Measurement, Assessment or Analysis, and Improvement.

Establishing Integrated Management System each organization needs to take into consideration its corporate culture and the nature of its business when deciding how far it wants to take the integration.

The purpose of this report is to present the incorporation of the quality management within the framework of Integrated Management System of a consultancy company working in nuclear energy sector.

Keywords: Quality Management, Integrated Management System

Article Classification: Case study

INTRODUCTION

The Integrated Management System (IMS) unifies all applicable requirements to the activity of an organization, allows their coordinated implementation and this way ensure both the effective management of the organization and the avoidance of conflicts at its management.

The Integrated Management System is a guarantee that the safety is not exposed to risk, by consideration of all actions regarding their connection with the safety as a whole, not as separate management systems; for increase of the safety, by effective management of all defined processes having an effect on the quality, environment and occupational health and safety. In this sense, IMS require maintenance and development of high safety culture.

The establishment and implementation of IMS in a consultancy company operating in energy sector will guarantee that the requirements for quality, environmental protection and operational health and safety, are not considered separately from the safety requirements, and the possibility for potential negative influence of all these factors on the safety will be avoided.

Basis for Integrated Management System in the field of energy sector development are the requirements of GS-R-3 regarding Management Systems for Facilities and Activities. This is the standard that defines the framework of the system, where the requirements of the standards: ISO 14001:2004 Environmental management systems – Requirements with guidance for use, BS OHSAS 18001:2007 Operational health and safety management systems – Requirements and ISO 9001:2008 Quality management systems – Requirements, are integrated.

Standards in different areas are tools for implementation of sustainable development concept in the enterprise. If the QMS is implemented first, then the implementation of EMS, OHSAS is easier, because standards ISO 9001, ISO 14001, OHSAS 18001 are based on common principles, PDSA cycle and concept of continuous improvement. ISO annual survey of certification confirms, that despite of decrease of number of certificates in several countries, total number of QMS, EMS, industry specific QMS certificates is still growing, thus development of IMS is a way to increase efficiency of enterprise's operations and management, simultaneously addressing different areas – quality, environment, occupational health and safety and giving a contribution to implementation of sustainable development concept (Mezinska, 2011), (ISO, 2009).

An example of Integrated Management System that is implemented in a Company operating in energy sector is presented in this paper.

The purpose of the paper is to encourage the use of integrated quality, environment, health and safety management systems by companies inside and outside the energy business.

STANDARDS OVERVIEW

The objective of the IAEA GS-R-3 is to define requirements for establishing, implementing, assessing and continually improving a management system that integrates safety, health, environmental, security, quality and economic elements to ensure that safety is properly taken into account in all the activities of an organization. The main objective of the requirements for the management system is to ensure, by considering the implications of all actions not within separate management systems but with regard to safety as a whole, that safety is not compromised (IAEA GS-R-3, 2006).

The objective of the IAEA GS-G-3.1 (IAEA GS-G-3.1, 2006) is to provide generic guidance for establishing, implementing, assessing and continually improving a management system that integrates safety, health, environmental, security, quality and economic elements in order to meet the requirements established in IAEA GS-R-3. It also provides illustrative examples of the application of the management system requirements. It is applicable throughout the lifetime of facilities and for the entire duration of activities in normal, transient and emergency situations.

The objective of GS-G-3.5 (IAEA GS-G-3.5, 2009) is to provide recommendations and guidance supplementary to those provided in GS-G-3.1 for establishing, implementing, assessing and continually improving a management system that integrates safety, health, environmental, security, quality and economics. All the topics covered correspond to requirements established in GS-R-3.

The objective of IAEA SF-1 is to establish the fundamental safety objective, safety principles and concepts that provide the bases for the IAEA's safety standards and its safety related program. Related requirements and guidance on meeting these requirements are provided in other safety publications (IAEA SF, 2006).

Safety is concerned with both radiation risks under normal circumstances and radiation risks as a consequence of incidents, as well as with other possible direct consequences of a loss of control over a nuclear core, nuclear chain reaction, radioactive source or any other source of radiation.

Safety measures include actions to prevent incidents and arrangements put in place to mitigate their consequences if they were to occur.

The Safety principles are applicable, as relevant, throughout the entire lifetime of all facilities and activities – existing and new – utilized for peaceful purposes, and to protective actions to reduce existing radiation risks. They provide the basis for requirements and measures for the protection of people and the environment against radiation risks and for the safety of facilities and activities that give rise to radiation risks, including, in particular, nuclear installations and uses of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

The ultimate focus of ISO 9001:2008 is to improve customer satisfaction (ISO 9001:2008). It promotes the adoption of a process approach when developing, implementing and improving the effectiveness of a quality management system, to enhance customer satisfaction by meeting customer requirements. This standard is based on the plan-do-check-act (PDCA) model.

Customer requirements form the input to the product realization process, with the output being a product or service that will affect customer satisfaction. An organization must measure customer satisfaction and use this information when determining the need to improve the process.

ISO 14001:2004 is also based on the PDCA cycle (ISO 14001:2004). Top management sets the vision for an organization in its environmental policy; the Environmental Management System (EMS) is then designed to support the policy. An organization must develop procedures to identify the ways it affects the environment, identify relevant legal and other requirements, and set objectives and targets that will continually improve the management system and prevent pollution.

An organization uses the planning information to develop operations that manage the environmental impact of its activities, products or services. Then top management reviews the performance of the EMS to determine the need to change the system to ensure it supports the organization's environmental policy.

BS OHSAS 18001:2007 was developed by registrars and organizations to fill a market demand to manage occupational health and safety (OHS) issues (BS OHSAS 18001:2007). While it is not officially an international or national consensus standard, it is being adopted by many organizations as a logical and complementary approach. This specification recognizes the similarities between environmental and OHS issues and is patterned after ISO 14001.

Though it is organized like ISO 14001, it has been modified to reflect the different parties associated with OHS issues.

RISK ENGINEERING LTD CASE STUDY

A model of management system integrating the requirements of the standards ISO 9001:2008 [7], ISO 14001:2004 [8] and OHSAS 18001:2007 [9] described in (Vorobev, 2011), is used and adapted for the needs of Risk Engineering Ltd. Below is described the algorithm of the model:

- Consistent analysis of the standards aim at finding requirements regarding the processes that have to present in the management system of the organization;
- Analysis of the connections among the processes (determination of the documentation flows, information, resources) unifying the processes in a system;
- Finding of common requirements of the three standards to the processes, the documentation and the resources with the purpose of excluding of the duplication of the IMS components;
- Consecutive decomposition of the IMS processes, necessary for inclusion in the model of all necessary processes;
- Analysis and construction of a system of interrelations of the IMS processes;
- Verification for the conformity of the constructed model of the initial established requirements of the standards and elimination of the nonconformities found.

The root of the processes model tree is the process **“A0 Activity of the Company”**. It may be decomposed on four sub-processes. For every process are defined key managing effects, mechanisms, inputs and outputs:

- Company activity management;
- Provision of resources;
- Production and after sale services provision;
- Measurement, analysis and improvement.

The process **“A1 Company activity management”** is decomposed on five sub-processes:

- Development of the policy, objectives and tasks of the IMS;
- Risk management;
- Planning and development of the IMS;
- Distribution of the responsibilities and interrelations of the employers;
- Analysis of the effectiveness and efficiency of the IMS.

The process **“A2 Provision of resources”** consists of five sub-processes:

- Management of the material and information resources;
- Management of the staff;
- Management of the infrastructure;
- Management of the production environment;
- Management of the finances.

The process “A3 Production and after sale services provision” is decomposed on six sub-processes:

- Planning of the life cycle of the product;
- Determination of the interested parties requirements;
- Design and development;
- Purchasing;
- Production;
- Control of documents

The process “A4 Measurement, analysis and improvement” consists of five sub-processes:

- Control of records;
- Monitoring and measurement;
- Control of nonconformities;
- Analysis of data;
- Improvement.

Risk Engineering Ltd is a Bulgarian private company in the field of scientific and technical consultancy and engineering services, founded by a team of Bulgarian engineers and initially registered in 1990.

The activity of Risk Engineering Ltd. covers the following:

- Project management and engineering services – design, construction, installation, commissioning, repair and maintenance of industrial and technical infrastructure sites and energy facilities;
- Operation and maintenance of facilities for production of electrical and thermal energy – solar, cogeneration and hydroelectric;
- Investigations of energy efficiency of buildings and industrial systems, certification of buildings and implementation of energy efficiency technologies;
- Support activities for development of information systems and configuration management in industry and energy sector;
- Commercial activities, including import of raw materials, processed products, equipment, facilities and spare parts related to the company main activities;

- Consultancy services in the field of industry and energy sector as well as consultant under the provisions of Law for spatial planning;
- Implementation of environmental management and waste management projects.
- Provision of consulting and engineering services according to FIDIC contracts.

In Risk Engineering Ltd work specialists with experience of many years in the energy sector, as well as possibility is given for creation and progress of young specialists with a view to the future of this branch. At implementation of the activities, depending on their specific, the services of contractors and specialized organizations are widely used, and permanent contacts with experts of scientific institutions, state organizations and free experts are also maintained. This approach provides flexibility and guarantees high professionalism at implementation of the specific tasks in changeable economic situation.

Risk Engineering Ltd took into consideration its corporate culture and the nature of its business when decided to develop and introduce integration of different management systems. Choosing to integrate Risk Engineering Ltd benefited from:

- Simplified systems resulting in less confusion, redundancy or conflicts in documentation.
- Optimized resources in maintaining a single system with a single goal vs. multiple systems with the same goals.
- Integrating qualify, environmental and OHS objectives into the overall business strategy.

Upgrading the Quality Management System, (approved by Lloyds Register Quality Assurance (LRQA) for conformity with ISO 9001:2008 on 30 January 2009) with the requirements of ISO 14001:2004 (regarding the environment) and BS OHSAS 18001:2007 (regarding the occupational health and safety), Risk Engineering Ltd aim at reaching and demonstrating good effectiveness towards environment, as well as at reaching and proving the implementation of activities, connected with the occupational health and safety. The Environmental Management System and the Occupational Health & Safety Management System were approved on 30 January 2012 for conformity with requirements of ISO 14001:2004 and BS OHSAS 18001:2007 (IMS Risk Engineering, 2012).

The management and employees of Risk Engineering Ltd ensure the constant supervision, respectively measuring and analysis the processes, with a purpose of applying of activities, necessary for obtaining the planned results and provision of their permanent improvement.

The **Integrated Management System Manual** presents the Integrated Management System of quality, environment and health and operational safety in conformity with the requirements of ISO 9001:2008, ISO 14001:2004 and BS OHSAS 18001:2007.

The documented **IMS procedures** ensure the control of the whole documentation and data connected with the requirements of ISO 9001:2008, ISO 14001:2004 and BS OHSAS 18001:2007 and the documents of external origin.

The **Schemes** of the processes give the order for implementation of the corresponding activities typical for the process, the documentation and the responsible staff. The scheme of the specific process determines the stages of the process, the review, check and validation of the stages and the responsible persons for their implementation and gives guarantee for high quality of the works performance.

Forms are developed for regulation and control of different activities of Risk Engineering Ltd regarding the quality, environment and occupational health and safety management. They are directed to monitoring of the environmental aspects identification and assessment, program for significant aspects management; monitoring plan for environment and for OHS, check-list for environment and OHS monitoring, objectives and a program for environment and OHS management.

The **IMS instructions** contain regulations regarding environment protection and assurance of occupational health and safety of the employees of Risk Engineering Ltd and companies and persons working at the sites as subcontractors performing construction and installation works (CIW).

Records on quality, environment and occupational health and safety, maintained by Risk Engineering Ltd include: correspondence; contracts' documents; quality, environment and occupational health and safety records; filled-in forms for non-conformities and undertaken corrective and preventive actions and responses at extraordinary situations; assessments of the environment aspects and risks for the occupational health and safety; documents for training and qualification of the staff; documents for suppliers, protocols and other records containing evidence for conformity with the requirements and for effective functioning of IMS; records on projects in elaboration; archive documents including final reports.

Identification and evaluation of significant environmental aspects. The Company, by the established for this purpose Commission for environmental management performs identification and evaluation of the environmental aspects and defines the methods for their operative management aim at prevention of the negative effects on the environment. The procedure for implementation of the environmental significant aspects assessment is described in a procedure REL-QM-PR-005 "Environmental Management".

The identification of the environmental aspects in the framework of IMS scope is done on the basis of evaluation of the input and output elements (including planned and unplanned), connected with:

- Present, future and suitable past activities, products or services;
- Planned or new elaborations;
- Modified or new activities, products and services;
- Usual and unusual working conditions;
- Conditions at starting and stopping of activities;
- Expectable extraordinary situations.

The Commission creates criteria and methods for evaluation of the identified aspects of the environment, so that to be determined these of them, which are significant for the company.

As sources of information at determining and updating of the aspects the Commission uses data from previous assessments and reviews, available data from monitoring carried out, statements of interested parties and records from incidents arising, if there are any. On the basis of the corresponding client requirements for environment protection, if necessary, the Commission defines specific measures for environment protection at implementation of the respective project.

The planning of Risk Engineering Ltd activity, connected with the environmental management is performed annually by the Commission for management of the environment.

The Commission plans the activities on the basis of definite significant aspects of the environment, the effect of the actions carried out according to the previous planning, the results of the control, stipulations by the authorized state bodies and extraordinary situations arising, if there are such, as well as the adequacy of the following responses for prevention of harmful consequences for the environment.

The Commission especially assesses the effect of the actions carried out for permanent improvement, reflecting in decrease and prevention of the harmful impacts on the environment.

The arising during the period changes in the company activity are considered at the activities planning, the used technologies and materials, the normative and other requirements and their application and the results of it.

The members of the Commission conduct periodical meetings – at starting of new project/contract and at necessity, but minimum once in three months, where they consider the assessment of the conformity with the requirements, the necessity of changes in the aspects assessment and the measures for control of the environment management and various other matters, connected with the state of the activities related to the environment.

The members of the Commission perform periodical assessment of the conformity with the applicable normative and other requirements adopted by Risk Engineering Ltd, concerning the environment. The assessment is performed on the basis of the identified normative requirements, the internal requirements of Risk Engineering Ltd, review of the requirements of contracts with clients, etc. The assessment of conformity is done at every change in the requirements or the circumstances (e.g. at new project/contract, change in the normative document concerning the activity, etc.), but minimum once per year, at implementation of the Management review.

Classification of the aspects is performed on the basis of the assessment of degree of the environmental impact and presented in Table 1.

Table 1 – Classification of the aspects on the basis of the assessment of degree of the environmental impact

Aspect	**Impact (OB=E*B)**	**Description of the action**
Unessential	Admissible ([illegible]≤5)	Further activities are not necessary
Essential	Area of attention (6 ≤ [illegible] ≤ 12)	Control measures to be defined, necessary for decrease of the impact up to the admissible level
Significant	Immediate action ([illegible]>12)	Measures and actions are undertaken, so that the impact to be decreased or restricted, including stopping of the process (when it is possible)
	Aspects, having positive effectiveness towards the environment	Measures are planned for maintenance and continuously improvement of the positive impacts

Note: The aspects having positive environmental impact are not subject of assessment according to the specified criteria, but are classified as significant.

Identification of the dangers, risk assessment and specification of measures. The main stages of the activity on management of occupational health and safety (OHS) are: planning, preparation connected with identification of the dangers and risk assessment, implementation of the activity, control, reporting and improvement.

The planning of the activity on management of OHS is done annually by the Committee on labor conditions (CLC), members of which include:

- Representative(s) of the management, appointed by order of the Executive director, and
- Representative(s) of the employees, selected according to the Labor code.

Executing the requirements of the Law for Occupational Health and Safety (LOHS) and standard BS OHSAS 18001:2007 an evaluation of the risk for health and safety of the employees has been made.

The processes for identification of the dangers, risk assessment and getting the risk under control are managed jointly with licensed office for labor medicine. The processes are realized according to the developed by the Service on labor medicine (SLM) and accepted by the company methodology for assessment of the working places, assessment and management of the professional risk. The Service on labor medicine, the Committee on labor conditions and specialists of the company participate in the risk assessment. External experts may also participate at necessity.

The methodology used in order to evaluate the working places and the professional health and safety risks defines the amount of the risk by multiplying its three components (probability for damage, exposition of the risk factor and weight of the damage). Based on these parameters the risk is ranged in 5 categories: *low, average, high, very high* and *intolerable*. The identified risks for the employees' health and safety are classified with ranks from one to three (low, average and high risk). The established in the company organization following LOHS has been investigated. A list with the dangers identified for the health and safety of the workers has been prepared. Based on the collected information are prepared charts for evaluation of risk according to working places and charts of the defence requirements needed (Galabova and Nenkova, 2011).

The risk assessment is performed according to the Management decision at:

- Starting of new activity or modification of the existing;
- Changes in the organizational structure (new positions);
- New equipment, technologies;
- New buildings, premises, reconstruction of existing;
- Changes in the normative documents;
- Results of investigations, accidents, damages, professional cases, incidents without accidents;
- Findings from internal checks, external interested parties, clients;

The risk assessment is performed including the following stages:

- Determination of the working places (in some cases activities), for which risk assessment will be performed;
- Identification of the dangers and the persons permanently exposed to them;
- Cost evaluation of the risk elements – probability for damage, frequency of exposition of the risk factor and weight of the damage. The product is the digital expression of the risk – basis for determination of its degree, according to which measures are undertaken for reduction and restriction.

At preparation of the risk assessment CLC take into consideration the following input elements:

- The normative documents connected with health and operational safety for the branch;
- Actual implemented own observations;
- Control observations and measurements by the authorized state bodies and performed by them assessments and recommendations;
- Analyses of processes and professional activities related to the health and operational safety;
- Statements and claims by the employees and/or their representatives and results of inquiries with them;
- Data submitted by manufacturers and suppliers of raw materials, materials and equipment;
- Data from carried out observations and measurements of the working surroundings factors and of the specific indicators for safety of working processes, working equipment and working places;
- Data for accidents and for the common and professional sick rate of the employees;
- Data by medical observations and check-ups.

On the basis of the given information for the risk assessment according to projects, including the requirements of the corresponding client for the occupational health and safety assurance, CLC determines specific measures for assurance of health and safe labor conditions at implementation of the respective project.

The equipment used in the Risk Engineering Ltd activity is maintained in good technical condition, and all failures which may affect the safety and the health of the working people are eliminated in the possible shortest period.

At work with risk for the health and safety, which cannot be eliminated in other way, personal and collective protective means are used.

Every employee is instructed to take care for his health and safety, as well as for the health and safety of the other persons, directly affected by his activity, in conformity with his qualification and the instructions given by his manager.

The instruction of the employees is performed according to the sequence of the requirements included in the legislation.

The employees, in conformity with their qualification and instructions, are obliged to:

- Use properly the equipment, transport means and other working facilities;

- Use properly personal protective means and special working cloths;
- Use properly the means for collective protection without their removal and modification;
- Inform immediately the direct manager for every arising working situation, which may cause immediate danger for their health, as well as for all faults in the protective means;
- Co-operate with the management and the corresponding officials at implementation of the measures for assurance of health and safe labor conditions and of the recommendations given by the control bodies.

The necessary organization is established. Persons, who are not suitable trained, instructed and equipped for the places where serious or specific danger for their health and life exists, are not allowed to be there. Authorized state bodies also exercise control over the health and safety at work.

RISK ENGINEERING LTD CASE STUDY FINDINGS

Risk Engineering Ltd. defines and documents the way by which the requirements for quality, environment and occupational health and safety are observed, taking into account the following activities:

- Using of quality plans for realization of the product/service;
- Providing all the resources, processes and control necessary for achievement of the required quality, by ensuring occupational health and safety and environmental protection;
- Compatibility among all processes and the corresponding documentation;
- Determination of all requirements to the external organizations for implementation of tests, when such are necessary;
- Determination of appropriate inspections at the relevant stages of the process of implementation of the tasks, when this is required by the Customer's Terms of Reference or by normative acts;
- Determination and elaboration of records on quality, environment and occupational health and safety;
- Use of appropriately trained and qualified personnel and, if necessary, conducting additional training.

The Management performs a review and evaluation of the Integrated Management System in order to ensure its continuous fitness and efficiency in satisfying the requirements of ISO 9001:2008, ISO 14001:2004 and BS OHSAS 18001:2007 Standards, as well as the Company's policy on Quality, Environmental and Occupational Health and Safety Management. The review is performed at least once per year. Intermediate reviews are also performed, if necessary.

The reviews are performed with a purpose of evaluating the possibilities for improvements and the necessity of changes in the system, including the policy and objectives of quality, environment and occupational health and safety. The results are documented in the Minutes of Meeting of the Management.

The input data for the Management Review includes the following (Nenkova et al., 2013):

- Results of internal and external audits of the system;

- Results of assessments of compliance with the normative and other requirements, which the Company has agreed to fulfil in connection with the environment and occupational health and safety;
- Feedback information from customers and interested parties (internal and external), as well as analysis of this information by the Management and the Company's personnel concerned;
- Results of the implementation of processes and the compliance of the products and services with the specified requirements;
- The degree of achievement of the Company's general and specific objectives;
- The efficiency in relation to the environment and occupational health and safety;
- Changes in the circumstances, including the normative and other requirements related to the environment and occupational health and safety;
- Current state of the investigation of incidents, as well as of the corrective and preventive actions;
- Actions followed the previous Management Reviews;
- Changes that could impact on the IMS;
- Recommendations for improvement of the processes and activities, as well as of the IMS as a whole.

The outputs from the Management Review include any decisions and actions related to the following:

- The improvement of the IMS, and of its processes;
- The adequacy of the quality, environmental and occupational health and safety policy;
- Improvements of the quality of services related to the Customers' requirements, and to the efficiency in relation to the environment and occupational health and safety;
- Resource needs (their determination and provision).

CONCLUSION

There is no panacea for integrated management system developing; each organization has to take into consideration its corporate culture and the nature of its business, when take a decision about integration of the management systems.

The implementation of an Integrated Quality, Environment, Health and Safety Management Systems in an organization is a rational and efficient manner of increasing performance and optimizing resources in the management of these functions. In Bulgaria, the subject is relatively new and not so many enterprises are adopting Integrated Management Systems.

The application of IMS in a company Risk Engineering Ltd leaded to:

- Unification of all requirements in one system; integrated and systematically planning the activities for assurance that all requirements may be satisfied;

- Determination of the priority areas for improvement, leading to optimization of the company activities implementation;
- Detection, elimination and non-admission of duplicated responsibilities at the activities implementation, guaranteeing transparency where and from whom the decisions are made in the framework of the company;
- Avoidance of conflicts and decrease of the risk at setting and implementation of the goals;
- Optimization of the existing documents and increased control over development of new ones;
- Continuous improvement of the company activity results at high level of safety and trend towards satisfaction of all interested parties;
- Creation of confidence that the safety is of the first significance in the Management system and has priority before the production schedules and schedules for implementation of projects.

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A comprehensive Internal Quality Assurance System at University of Minho

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ABSTRACT

Purpose. The European Standards and Guidelines for Quality Assurance (ESG) adopted at the Bergen Ministerial Meeting in 2005 in the scope of the Bologna Process call upon higher education institutions to take up a systematic approach to internal quality assurance. Standard 1.1 of the ESG establishes that institutions should have a policy and associated procedures for the assurance of the quality and standards of their programmes and awards.

University of Minho (UMinho) has a longstanding experience on innovative methods for the coordination and management of the teaching and learning processes, including, since 1991, systematic mechanisms for the evaluation of teaching. However, to fulfil the new demands raised by the ESG UMinho felt the need to define a formal institutional quality policy, building upon the existing procedures and mechanisms in order to set up a comprehensive internal quality assurance system (SIGAQ-UM) fully compatible with the ESG.

The article presents the distinctive features of SIGAQ-UM, the procedures involved in its certification by A3ES, as well as on the perceived impact on the University's activities, including some comments on the difficulties to develop and consolidate a quality culture embedded in all the academic community.

Findings. SIGAQ-UM is a fully operational comprehensive internal QA system certified by the Portuguese Agency A3ES in January 2013, with considerable impact on the University's operation.

Value. Disclosure of best practices on QA in higher education.

Keywords: Quality assurance in higher education, internal quality assurance systems, quality culture.

Article classification: Case Study.

INTRODUCTION

Quality assurance (QA) in higher education stays high in the agenda of the European Higher Education Area, as it plays a key role in the Bologna Process. A fundamental principle of QA, emphasised in the EUA Graz Declaration 2003 and endorsed by the Berlin Ministerial Communiqué, is that "consistent with the principle of institutional autonomy, the primary responsibility for quality assurance in higher education lies with each institution itself". This is also an underlying principle of the European Standards and Guidelines (ESG) adopted in Bergen, which call upon higher education institutions to take up a systematic approach to internal quality assurance. However, the follow-up reports on the Bologna Process show that, in many cases, there is still no holistic approach to quality enhancement within institutions.

Portuguese higher education institutions are since 2007 required by law to develop their own internal quality assurance systems since 2007 and data from the Portuguese Agency for Assessment and Accreditation of Higher Education (A3ES) shows that significant progress was already made by many institutions (Fonseca, 2011). Indeed, as a result of the former national evaluation system (1995-2005) several institutions had already started to implement some QA mechanisms as a way to embed a quality culture in their activities.

University of Minho, which was a pioneer in this field in Portugal, has a longstanding experience on innovative methods for the coordination and management of the teaching and learning processes, including, since 1991, systematic mechanisms for assessing the quality of teaching in all its graduation programmes on a yearly basis. The internal quality assurance system of UMinho (SIGAQ-UM) can thus be seen as a case study of continuous development from the initial mechanisms of tracking and feedback from students to a comprehensive system covering all activities and services, certified by A3ES under its Institutional Audit Process.

THE EARLY STAGES OF QA AT UNIVERSITY OF MINHO

Since its beginning, in 1975, the University of Minho has in place an innovative process for the coordination and management of teaching that considers each degree programme as an "educational project" with its own coordination structures, which include the Degree Committee and the Degree Director. The Degree Committee includes a student (delegate) for each curricular year and an equal number of professors. A Degrees Council (presently, a Pedagogical Council) was also created for each scientific area, to coordinate common aspects of different programmes (for example, the Engineering Degrees Council, for the whole set of Engineering programmes). This was quite a novelty, since the coordination of teaching in Portugal, at the time, was mainly performed in a fragmented way, at subject level (the Chairs or Cathedras), by the Chair holders, and students had no participation in it. This structure proved to be useful to keep track on the quality of teaching and promote improvement.

In June 1991 a formal system for the evaluation of teaching was established by an Rector's Resolution, after extensive consultation with the University Academic Council, containing three main elements (a more detailed description of this early system is available at Montenegro et al. (2010):

- A procedure for the application of a survey to students, covering all course units of all undergraduate programmes, on a semi-annual basis, whose outcomes included individual and aggregate results, as well as percentiles. Individual results concerning the quality of teaching were only sent to the corresponding teacher. Overall results, aggregated by degree programme (global and for each curricular year), Department, School and the whole University, were widely publicised and published as a book.

- The systematic monitoring of the students' success in every course unit including data on the number of students registered in the unit, students that attended classes regularly, students assessed, pass and failure rates and part time students.
- An internal reflection system, in two complementary dimensions:
  - Degree Directors, Departments and Schools were called upon to analyse the results from the surveys and take remedial/improvement actions as deemed necessary;
  - in the case of pass rates bellow predefined standards, the course unit coordinator was asked to analyse, as deeply as possible, the reasons for the abnormal non-success and propose measures to improve the efficacy of teaching; a second lower critical value was defined for pass rates, below which the Degree Committee had necessarily to analyse the suggestions from the course unit coordinator and prepare formal recommendations aiming at overcoming the detected problems.

This system went on quite smoothly for over one decade, with small adjustments in the questionnaires. It proved to be very useful for the self-evaluation of degree programmes in relation to the external evaluations rounds 1995-2000 and 2000-2005, because a lot of data collection and analysis on students and teachers' performance and students' satisfaction was already available.

In 2004 the system was reinforced with the establishment of a QA administrative structure, under the coordination of the Pro-Rector for the assessment and quality of teaching, with the objective to plan and coordinate the evaluation procedures and interact with the national evaluation agency. With the support of this new structure, existing questionnaires were updated and new ones were devised, aiming at more comprehensive procedures to collect and interpret data on students and teachers' performance and satisfaction.

This system run up to 2009/10, making use of an extensive set of mechanisms and procedures for the quality assurance of teaching, including:

- Internal feedback mechanisms for systematic collection of data from students, teachers and services (particularly, students supporting services), through the application of a wide set of surveys covering, inter alias, social-demographic context and expectations of freshman students, assessment of learning/teaching processes at course unit level by students and teachers, assessment of organisational and curricular aspects at degree programme level by students, teachers' satisfaction with the working conditions and learning environments, enquires to incoming and outgoing ERASMUS students on the special support facilities concerning students in mobility schemes, and the satisfaction of the main users of the different University Services. The results from the surveys are made available to key decision makers in the different levels within the University.
- External feedback, mainly collected by means of the AlumniUM site, set up with the objective to follow-up the professional careers of the alumni and to provide them with information about on-site and distance educational offers, access to an employment pool and other services favouring a permanent relation with the University. Systematic feedback is collected annually from alumni

and employers. Additional ways include formal consultation of professional associations, enterprises and public services, as deemed relevant, when a new degree programme is designed and developed, and reports from external advisory committees set up in connection with some Schools or degree programmes.

- Internal reflection on the data collected from monitoring the operation of the degree programme and from internal and external feedback, leading to the preparation of a report on the progress of learning/teaching processes, to be discussed and analysed in the Degree Committee and Pedagogical Council. Issues needing correction are identified and some measures for improvement are taken as a result of the assessment.

This system has been helpful in the promotion of quality of teaching, but two handicaps could be identified. On one hand, although the Degree Council issued recommendations on some corrective or improvement measures, a proper action plan was not consistently drawn up and subjected to the approval of the relevant bodies at School and/or University level, which led to somewhat heterogeneous results. Secondly, no follow-up procedure concerning the implementation of the actions for improvement was in place in a comprehensive way.

- External reviews at programme and institutional level:
    - Every degree programme went through two external evaluation processes, conducted by the former National Evaluation Council in the context of the evaluation rounds 1995-2000 and 2000-2005. These exercises, especially in the preparation of the self-evaluation reports, were very useful to promote participation and internal reflection.
    - At institutional level, UMinho has been reviewed for three times by the European University Association, on a voluntary basis, under the Institutional Evaluation Programme (EUA/IEP). The first review took place in 1997 and the second one ten years later, with a follow-up in 2009.

It is interesting to compare the comments of the two external review teams, since they help to understand the sometimes difficult and casuistic way that has been followed in the implementation of internal quality assurance mechanisms, as well as the progresses achieved. In the 1997 report it can be read (CRE, 1997):

"The review team has the impression that there is a real interest for the exercise of self-evaluation and external quality assurance, and that 'quality' is a permanent concern for all UMinho actors. During the visit, the team was told that five years ago the scientific staff was very sceptical about evaluation exercises and even refused them. Now, on the basis of previous, discipline based self-evaluations the process is well embedded even in the teaching exercise. At the level of Departments or Schools, we feel that there is no clear policy yet for quality assurance, the Schools are not yet ready for the idea of continuous self-evaluation. (...) However, we must mention that people are better prepared for and conscious about it and to carry out such an exercise is much easier now than it was 5 years ago."

In the 2007 review, the external report stresses the different processes for quality assurance in place, namely the large scale monitoring of results of academic activities and the annual surveys of student and teacher satisfaction about teaching and learning processes, as well as the Degree Council system, through which the quality of teaching can be assessed, and concludes (EUA, 2007):

"The Team found that there is a good quality culture prevailing at UM. The Team especially appreciates the way educational programmes are managed through the matrix system by degree-based committees and degree leaders; this structure makes it possible to develop, manage and assess these programmes in co-operation with teachers and students. Such a system may be better than traditional student satisfaction surveys, since it provides an opportunity for immediate reactions."

MOVING TOWARDS A COMPREHENSIVE INTERNAL QUALITY ASSURANCE SYSTEM

As confirmed by the external reviews, in 2009 the University of Minho had already in place most of the usual instruments to monitor the quality of teaching and take appropriate action towards its improvement. The same was true for research activities, as the University applied the criteria used by the Foundation for Science and Technology to monitor the performance of its research units.

As mentioned above, the ESG appeal to higher education institutions to adopt a systematic approach to internal quality assurance. The first standard of the ESG establishes that institutions should have a policy and associated procedures for the assurance of the quality and standards of their programmes and awards, and consequently should develop and implement a strategy for the continuous enhancement of quality, adding that "the strategy, policy and procedures should have a formal status and be publicly available" (ENQA, 2009).

UMinho felt that, to comply with this standard, it needed to develop further three main elements of its QA system:

- The definition of explicit quality standards for its activities, a matter that at the time had no tradition in the Portuguese Universities;
- The organisation of its QA instruments as a well documented system, applied in a consistent and holistic way;
- The definition of procedures for the monitoring and continuous improvement of the QA system itself.

Aiming at full compliance with the ESG, UMinho has therefore adopted a formal institutional quality policy, building upon former QA procedures and mechanisms while addressing the questions raised above, in order to set up an internal quality assurance system (SIGAQ-UM) certifiable by the national agency A3ES. This system, presented in the next sections, was tested, on a trial basis, in the academic year 2010/2011 and has been running regularly since then.

The institutional quality policy. UMinho assumes an unambiguous commitment towards quality and quality assurance, explicitly mentioned in its Statutes as a fundamental vector for its activities and accomplishment.

The institutional strategy for quality assumes, as a nuclear underlying principle, the shared vision of the University's mission and objectives by all the academic community, translated into a strategic institutional development plan and its furtherance throughout the whole University, and developed and implemented through the following key elements:

- The Strategic Programme of UMinho adopted by the Board of Trustees (Conselho Geral) under proposal from the Rector;

- An operational plan (Quality Plan) that translates the strategic programme into concrete action plans, both at institutional level and at the level of organisational units and services;
- The definition of formal methodologies and procedures for monitoring, assessment and feedback action for quality enhancement (Plan-Do-Check-Act approach), implemented at the various levels of management, all suitably documented in a Quality Manual.
- In practice, based on the detailed description of the objectives and actions defined in the Quality Plan, as well as on the elements collected by means of monitoring, each unit, service or pedagogical entity, through appropriate bodies and in accordance with properly institutionalised methodologies, promotes an analysis of the results achieved and the level of conformity with the objectives and targets fixed. The purpose of this analysis is to produce annual self-assessment reports which reflect on the processes and results and propose amendments to be introduced, expressed in improvement plans and the possible reformulation of objectives or goals.

The quality policy encompasses, furthermore, the consolidation of a quality culture embedded in all the academic community and University's activities, where continuous assessment is to be seen as a natural element of the institutional life, in a double perspective of quality enhancement and of providing relevant and updated information on the degree of fulfilment of the University's mission.

The internal quality assurance system (SIGAQ-UM). The institutional quality policy is developed and embodied in a formal QA system – the SIGAQ-UM – whose object are the different dimensions of the institutional mission, covering systematically the quality assurance of all activities within the University.

The objectives of SIGAQ-UM are to promote the definition and documentation of the structuring elements for the implementation of the quality policy, namely:

- The institutional strategy and the standards for quality;
- The responsibilities of the different bodies and management levels in the quality assurance processes;
- The processes for monitoring, control, reflection and subsequent intervention for quality improvement;
- The ways for the participation of students, teachers, researchers and other staff, as well as external stakeholders;
- The production and dissemination of information, including the publication of information that is relevant to external stakeholders;
- The organisation and continuous improvement of the system itself and the methods for the monitoring and revision of the quality policy.

The two main documents for the definition of SIGAQ-UM are:

- The Quality Plan, grounded on the Strategic Programme;
- The Quality Manual, as a normative document that describes the system's organisation and implementation.

The Quality Plan

The Quality Plan addresses, in a comprehensive and dynamic way, the question of the quality standards for the University. In reality, by fixing strategic objectives, hierarchic operational objectives, the actions to be developed and the corresponding schedule and goals, the Quality Plan establishes the quality standards to be pursued.

As mentioned earlier, the strategic document that underpins the Quality Plan is the Strategic Programme for the 4-year Rector's mandate. It develops around strategic development vectors relating to the key areas of the University's mission (mission vectors) and to activities which support a harmonious and sustainable development of the University (support vectors).

Vectors are developed into action plans, which include the definition of the strategies, methodologies and performance indicators involved in the prosecution and monitoring of the foreseen actions, the goals to be met and the schedule and the levels of responsibility for their implementation.

Additionally, the Quality Plan includes a set of action plans concerning transversal measures associated to the learning, working and living environments in campus. Monitoring the development of actions plans, as well as the level of achievement of the expected outcomes, is the responsibility of bodies or entities identified in the plans, and requires the systematic collection of appropriate performance indicators, which can be of two different types:

- Quantitative indicators, associated to concrete goals that can be quantitatively assessed;
- Products, to be developed within a predefined timetable– in this case, a 4-level scale is used to assess the stage of development of a product, in order to monitor the progress of its implementation in an objective way.

The Quality Manual

The Quality Manual, formally approved by a Rector's Resolution, defines the overall conception of the institutional quality policy and its translation into an internal quality assurance system. The following aspects, central to the ESG, are addressed and developed in the Manual:

- The statutory mission, vision and objectives of UMinho, as well as its strategy for quality;
- A brief presentation of the University's organic model;
- The macro-organisation of SIGAQ-UM, in terms of its ambit, objectives, coordination structures and levels of responsibility in the scope of quality and QA;
- The methodologies for the monitoring, assessment and action for quality enhancement, discriminated for each of the different dimensions of the institutional mission (research, teaching and learning, and interaction with society) and also the transversal dimensions of human and material resources and services;
- The interface of SIGAQ-UM with the strategic management of the University;
- The participation of internal and external stakeholders in the QA system;
- The production and dissemination of information (mechanisms to collect, analyse and use information, and to publicise information relevant to external stakeholders);

- The ways in which the QA system is monitored and revised.

The Manual also establishes a set of performance indicators covering the main dimensions of the University activities, which, in its evolution over time (as time series), constitute an Institutional Progress Chart that will allow for a dynamic view of the development of the University.

Having in mind the complexity of the teaching and learning processes, the Manual pays special attention to the methodologies for the quality assurance of teaching. It includes, therefore, a particularly detailed specification concerning the strategy for the assessment of teaching, the hierarchic structure used for monitoring, assessment and preparation of improvement action plans, the identification of best practices, the flagging and treatment of (quantitative or qualitative) results bellow predefined goals, and the follow-up of adopted action plans for correction and improvement.

QA supporting structures

The main structures for the coordination and support of SIGAQ-UM are:

- The QA Follow-up Committee (Comissão de Acompanhamento), acting as a coordination and advisory body chaired by the Vice-Rector with the QA portfolio and integrating the QA Manager, representatives from Schools, cultural units and services, and from students. It may also include an external consultant. The Committee is responsible for the meta-evaluation of SIGAQ-UM, including the approval of an annual report on the system's operation and enhancement.
- An important feature of the Committee is that the Schools' representatives are required to act as "quality promoters" in their organic units, liaising with the QA Office and assisting the Dean in regard to the local coordination of teaching and learning QA processes, thus contributing to a proper vertical articulation of SIGAQ-UM.
- The QA Office (SGAQ – Serviços para a Garantia da Qualidade), responsible for the functional coordination of the QA system, acting as a logistics support centre for the Committee and the SIGAQ-UM. The Quality Manager acts as Head Officer of SGAQ.
- A specific information system, properly integrated into the University information system, which provides support for data gathering and analysis (including on-line surveys), monitoring of action plans in the Quality Plan and on-line preparation of reports, allowing for a paperless environment in the whole system.

Strategy for QA of teaching and learning. As mentioned above, the methodologies for the quality assurance of teaching are particularly detailed in the Quality Manual. Indeed, the complexity of teaching and learning processes, the lower experience with regard to the assessment of teaching and the level of detail which characterises the external QA standards in this particular dimension of the institutional mission justify a substantially increased degree of explicitness to ensure the quality of teaching.

The strategy for monitoring, assessing and improving teaching is essentially developed at successive levels of intervention which are gradually aggregated and consists mainly in the preparation of annual self-assessment reports, in accordance with previously defined specifications and format. The starting point for this analysis is the subject level (Course Unit), which constitutes the foundation for the organisation, planning and operation of teaching, and is hence located at the core of the processes of teaching and learning as well as of the interaction among its main actors (students and teachers). The mechanisms of quality assurance for teaching are thus developed in progressive "quality cycles", from the level closest to the learning environments upwards to the following levels of analysis – the Degree Programme, the Organic Unit (UOEI) and UMinho as a whole.

Detailed specifications have been devised for the structure of the self-assessment reports, aiming at the development of forms that facilitate their on-line preparation. A model structure has been adopted for the different reports (initially for teaching, but extended later to self-evaluation of Research Units, Cultural Units and Services), which establishes a distinction between the background information that underlies the self-assessment process and the self-assessment exercise per se:

- The background information is imported from sources and databases in UMinho' information system, including the aggregated appraisals submitted at the previous levels of analysis. It becomes automatically available upon opening of the report. An agile access to information is thus provided through selective viewing interfaces, which allow for an easy and interactive navigation among a highly significant volume of information.
- The electronic form for the elaboration of the report is pre-formatted, including a self-reflection on nuclear aspects of the organisation, functioning and results of teaching at the level of analysis in question, the identification of strengths and weaknesses (or SWOT analysis), and specific fields to suggest improvement measures and identify best practices liable to be included in a best practices portfolio.

Since the background information is treated separately and in advance, the preparation of the self-assessment reports (either for teaching, research or Services) corresponds to a predominantly analytic process, devoid of bureaucratic load and relatively light on the academic community. However, although light, the process ensures the systematic identification of potential situations of poor quality thanks to a process of automatic identification of results that require further examination, in accordance with flagging criteria defined in the Quality Manual. In case a course unit is flagged with results in need of further examination (i.e. results that stray significantly, by default, from the goals and targets set out in the Quality Plan and remaining criteria stipulated by the Pedagogical Councils), the self-assessment report must include a reflection from the course unit coordinator on the reasons that may have been at the root of those results, as well as a suggestion for an action plan to overcome or minimise the problems detected. Such reflections and suggestions are resumed at the next level of analysis – the degree programme self-assessment report – which shall explicitly include a proposal for an action plan aimed at the resolution of the problems encountered, or a proper rationalisation for the non-necessity of a formal action plan to tackle the situation in question. It is for the Pedagogical Council to analyse and validate the action plans for improvement proposed by the Degree Programme Directors. Consequently, there are appropriate safety measures to ensure that the situations under reference are necessarily analysed and treated.

The recommendations for improvement are not limited to those situations in which there is evidence of results in need of further examination. The structure of the reports ensures that, even in course units and degree programmes without instances of flagging, there is the possibility to suggest recommendations for improvement, particularly in terms of pedagogical innovation, as part of an unremitting contribution towards continuous improvement.

Follow-up on the implementation of the action plans for improvement is guaranteed as well. The software application for the management of the action plans allows for the recording of the improvement actions comprised in the plan, the respective coordinators and of those responsible for their implementation and schedule, as well as the monitoring of plan implementation. It should be further noted that the self-assessment reports always require an appreciation of the answer given to the recommendations and improvement plans included in the previous assessment.

Constraints on the implementation of SIGAQ-UM. In the setting up of the system the main constraints were related not so much with the design of the QA system itself, since a clear quality policy and strategy for quality assurance had been previously defined, but rather with some problems of pedagogical organisation and timely availability of reliable information on the teaching/learning processes. Indeed, the comprehensiveness of the QA system and the on-line application of its main instruments, such as surveys and the preparation of self-evaluation reports, implied the need for a better integration of sometimes autonomous information systems into a single institutional information system, which, in turn, required well defined procedures for the pedagogical management of programmes and course units. The tackling of these "upstream" constraints had, in practice, a very positive impact on the organisation of the teaching and learning processes.

A key element for the success in the design and implementation of SIGAQ-UM was the participative way in which it was developed, in permanent contact with the academic community through many direct contacts and meetings whenever possible, the dissemination of information and personal support from the SGAQ to answer questions and difficulties in the application of the QA instruments. However, it is not easy to reach all the intended recipients, particularly students and some academics. So, especial attention has been paid to internal communication mechanisms, namely in the upgrading and proper use of institutional mail boxes. A comprehensive institutional communication policy under preparation in the Rectors Office may contribute to the adoption of better procedures for a dynamic dissemination of information.

Clarity of language in the definition of concepts, drafting of procedures and preparation of forms for self-evaluation reports also raised some problems and required permanent attention. Along the development of SIGAQ-UM several clarifications and simplifications were introduced to improve the understanding of the QA instruments by part all those involved in their use. A paradigmatic example was the revision of the section of the Quality Manual dealing with the flagging of course units. In reality, in many sectors of the academic community the flagging of a course unit was initially seen as a penalisation of the teaching team and not as a mechanism for systematic signalisation of potential problems (whatever their possible causes) for the purpose of a thorough analysis of the situation and, if necessary, the proposal of improvement action plans, thus as an opportunity for quality enhancement. The straightforward change of the expression "unsatisfactory results" into "results to reflect upon" in the Quality Manual helped to somehow mitigate the problem and provide a better understanding of the flagging mechanism.

As said earlier, the composition of the QA Follow-up Committee favours the vertical articulation of SIGAQ-UM both upwards and downwards throughout the University. However, the role of the "quality promoters" in the local coordination and support of QA mechanisms is still heterogeneous in the different organic units, contributing to a larger than desirable centralisation in the operation of the system. The added-value of the Committee's composition is therefore still liable to a better exploiting.

PERCEPTIONS ON IMPACT

The impact of SIGAQ-UM on the pedagogical component of the institutional mission is particularly visible in aspects related to the organisation and coordination of teaching, as mentioned before. In effect, the integrated approach of all the dimensions and aspects connected with teaching, including the integration of the different areas of UMinho' information system, has brought to light the existing problems of articulation between sectors, as well as issues of information organisation, allowing for the respective characterisation and treatment, with several visible improvements. Likewise, a significant number of action plans for improvement of teaching and learning are laid out every year as a result of the reflections contained in the self-evaluation reports.

As regards research, an important added value of the strategy defined for its quality assurance lies in the fact that the Schools and the University now rely on a systematic collection of performance indicators on research and development activities. The Scientific Councils have systematic access to the self-assessment reports of the research units, which is bound to facilitate the definition and development of research policies at School level. Similarly, the hierarchical structure adopted for the preparation and appraisal of self-assessment reports of Services may bring gains in coordination and inter-service articulation.

SIGAQ-UM has gained an important external visibility which impacts positively on the University's image. All the structural documents of the system are publically available in the website, as part of the open-access policy adopted by UMinho. It is interesting to notice that the structure of the Quality Manual has been used as a reference model by several other higher education institutions.

The annual meta-evaluation report on SIGAQ-UM always includes a section on the system impact, including for example concrete information on the main problems encountered, the improvement actions planed and undertaken and, wherever possible, the perceptions of academic staff and students on impact (SGAQ, 2014).

THE CERTIFICATION OF SIGAQ-UM

After an extensive consultation process and the consequent adoption of a set of reference points for internal quality assurance systems presented as "non prescriptive proposals, which describe the main characteristics of a well designed and properly implemented quality assurance system", the Portuguese Agency A3ES set up an institutional audit process with the objective to "assess and certify the internal quality assurance systems developed by the institutions" (A3ES, 2013a). In late 2011 the Agency invited higher education institutions to express their interest in participating in the first experimental exercise of applying the audit model. Fourteen institutions responded to the request, but only five met the requirements, namely the existence of a quality manual formally approved and with a minimum of one year's effective application.

UMinho had the privilege of being one of the five selected institutions to integrate the experimental audit process, which proved to be very useful for the enhancement and consolidation of SIGAQ-UM, due in particular to the following aspects:

- The exercise comprised an intensive and interactive preparation phase, including a national Workshop with the participating institutions and a local Seminar which counted with the participation of a large number of members of the University, allowing for the clarification of external and internal QA processes;

- The preparation of the self-evaluation report on SIGAQ-UM, in particular, showed to be a good opportunity to involve the academic community and increase its awareness on quality assurance matters;
- The developmental approach of the audit process, which assesses the degree of development of the different QA processes (including the system as a whole) rather than their full conformity with rigid externally defined standards, stimulates the adoption of flexible QA procedures more suitable to the complexities of the teaching/learning and research processes and their acceptance and appropriation by the academic community;
- The discussions in the meetings with the External Assessment Team (EAT) during the on-site visit contributed also to the involvement and awareness of many academic and non-academic staff members and students, particularly those engaged in teaching and research coordination bodies;
- The very positive assessment from the EAT, as well as its recommendations supporting the improvement measures identified by UMinho in the self-evaluation report, strengthened the motivation for the continuous enhancement of the QA system and its permanent focusing on quality improvement while keeping the bureaucratic burden on UMinho as low as possible.

The audit report (A3ES, 2013b) highlights "the existence of a well-defined and documented institutional policy for quality, which covers the different aspects of the institutional mission" and considers that the system "has all the conditions to contribute to the continuous quality improvement of UMinho activities". In January 2013, following this positive assessment from the EAT, the Agency issued a full certification of SIGAQ-UM for a period of six years.

CONCLUSION

The ultimate goal of an internal QA system should be the embedment of a quality culture in all the academic community, "in the understanding that quality assurance activities are not activities which run parallel to the life of the institution, as the responsibility of only one or several specific people, but rather the responsibility of each and every member of the community, in a concern with quality which should be present in all the activities of the institution". Key success factors for the development and consolidation of such a quality culture, as identified in the EUA Quality Culture project, are "appropriate strategic planning, the creation of organizational structures appropriate for quality assurance, the commitment of institutional leaders at the highest level, the involvement of staff and students of the institution, the involvement of external stakeholders, and a well-structured system of data collection and analysis" (Santos, 2011).

SIGAQ-UM encompasses all these elements for fostering an internal quality culture. Its certification by A3ES validates UMinho's institutional quality policy, demonstrates the system's substantial stage of development and endorses it as an example of best practice.

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Acceptance Sampling for Non-Gaussian Variables with Robust Methods – Part II

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ABSTRACT

In the quality control of a production process (of goods or services), from a statistical point of view, the focus is either on the process itself with application of Statistical Process Control or on its frontiers, with application of Acceptance Sampling (AS) and Experimental Design. AS is used to inspect either the process output (final product) or the process input (raw material). The purpose of the design of a sampling plan is to determine a course of action that, if applied to a series of lots of a given quality, and based on sampling information, leads to a specified risk of accepting/rejecting them. Thus AS yields quality assurance. The classic AS by variables is based on the hypothesis that the observed quality characteristics follow the Gaussian distribution (treated in classical standards). This is sometimes an abusive assumption that leads to wrong decisions. AS for non-Gaussian variables, mainly for variables with asymmetric and/or heavy tailed distributions, is a relevant topic. When we have a known non-Gaussian distribution we can build specific AS plans associated with that distribution. Alternatively, we can use the Gaussian classical plans with robust estimators of location and scale — for example, the total median and the sample median as location estimates, and the full range, the sample range and the interquartile range, as scale estimates. In this work we will address the problem of determining AS plans by variables for Extreme Value distributions (Weibull and Fréchet) with unknown shape parameter. Classical plans, specific plans and plans using the robust estimates for location and scale are determined and compared.

Keywords: quality control; acceptance sampling; acceptance sampling by variables; robust methods

Article Classification: Research paper

INTRODUCTION

Acceptance Sampling (AS) is used to inspect either the output process – final product – or the input – initial product. On a lot-by-lot basis, a random sample is taken from the lot and based on the information given by the sample a decision is taken: to accept or to reject the lot. The purpose of AS is to determine a course of action, not to estimate lot quality. It prescribes a procedure that, if applied to a series of lots, will give a specified risk of accepting lots of given quality. An AS plan indicates the rules for accepting or rejecting a lot that is being inspected. There are two approaches to AS in the literature. The first approach is AS by attributes, in which the product is specified as conforming or non-conforming (defective) based on a certain criteria and the number of non-conforming units is counted. The other approach is AS by variables, if the item inspection leads to a continuous measurement. In comparison to sampling plans by attributes, sampling plans by variables have the advantage of usually resulting in considerable savings in sample size for comparable assurance. The main disadvantage of the classical case of the acceptance sampling by variables is that it is based on the hypothesis that the observed quality characteristic follows a Gaussian distribution.

References to this section are Duncan (1986), Guenther (1977), Montgomery (2004) and Schilling and Neubauer (2009).

In AS, the aim is to determine the sample size, *n*, and the acceptability constant, *k*, that satisfy the conditions referred to as the producer's risk and the consumer's risk, where:

- The producer's risk is the probability of rejection of one lot, that is acceptable (with a "good" quality), also designated as probability of type I error (α);
- The consumer's risk is the probability of accepting one lot, that is not acceptable (with a "bad" quality), also designated as probability of type II error (β).

The producer wishes the acceptance of "good" lots with high probability (1-α) and the consumer wishes the acceptance of "bad" lots with small probability (β) (Montgomery (2004) and Schilling and Neubauer (2009)).

There are two quality values that we need to define (Montgomery (2004) and Schilling and Neubauer (2009)):

- *AQL* - *Acceptable Quality Level* - the worst quality level that is still considered acceptable. The *AQL* is a percent defective that is the base line requirement for the quality of the producer's product.
- *LTPD* - *Lot Tolerance Percent Defective* – the poorest quality in an individual lot that should be accepted, the level of quality where it is desirable to reject most lots. The *LTPD* is a designated high defect level that would be unacceptable to the consumer.

To prevent "good" lots from being rejected and "bad" lots from being accepted, we calculate the values of *n* and *k* by solving the system

Equation 1

$$\begin{cases} P_{ac}(AQL) = 1 - \alpha \\ P_{ac}(LTPD) = \beta \end{cases},$$

where $P_{ac}(\omega) = P(\text{accept the lot} | \omega)$ designates the acceptance probability (function of *n* and *k*) and ω the non-conforming proportion. If we let ω vary in [0, 1], we can establish the operating characteristic curve, *OC-curve*, $P_{ac}(\omega)$. This curve shows the lot acceptance probability in accordance with its quality, given by the non-conforming proportion ω. This is the most used way of determining an AS plan: to specify two points on the OC-curve and solve for the (*n,k*) that uniquely determines the OC-curve going through these points $(AQL, 1-\alpha)$ and $(LTPD, \beta)$ (Gomes, Figueiredo and Barão (2010)).

In AS plans we can be built up with a single specification limit (the upper or lower) or with two specification limits (the upper and the lower). This latter situation is theoretically more complex since the two previous procedures have to be added into one. For more details see Carolino (2012).

Let X denotes the random variable that represents the quality characteristic inspected. For simplicity, in the next sections we will assume that there is a single specification limit, the upper limit U, so the non-conforming proportion is given by $\omega=P(X\geq U)$. In section 2 we will review the classical case where X is assumed to follow a Gaussian distribution. In section 3 we will derive AS plans when X follows an Extreme Value distribution (Weibull and Fréchet). As a particular case of Weibull distribution we obtain the results for the exponential distribution studied in Carolino, Casquilho and Barão (2007) and Levinson (1997). In the section 4 robust estimators for location and scale are presented (Figueiredo and Gomes (2004), Figueiredo and Gomes (2009) and Figueiredo (2003)). In section 5, quality index with robust estimators are proposed. In section 6 classical plans, specific plans and plans using the robust estimates for location and scale are compared by means of the k and *LTPD*, and OC-curve. The main conclusions are driven in section 7.

ACCEPTANCE SAMPLING FOR GAUSSIAN VARIABLES

The acceptance sampling by variables in the Gaussian case was solved in theory and for application in American Standard, MIL-STD 414 (updated several times in details). The most recent international version is ANSI/ASQC Z1.9-2013 (2013).

Consider that the quality characteristic of interest, X, follows a Gaussian distribution, with mean μ and standard deviation σ, $X \sim N(\mu, \sigma)$ and that a sample of size n is taken from the lot for AS purposes. The non-conforming proportion is given by $\omega = P(X \geq U) = 1 - \Phi\left(\frac{U-\mu}{\sigma}\right)$. The lot is accepted if the estimated non-conforming proportion based on the sample is "small" or an associated quality index Q is "big". The definition of Q depends on the standard deviation of X being known or unknown, as follws.

σ known. If σ is known the quality index Q is defined as $Q = \frac{U-\bar{X}}{\sigma}$ and the criterion of acceptance is $Q = \frac{U-\bar{X}}{\sigma} \geq k$. The values of n and k are the solution of the system $\begin{cases} P_{ac}(Q \geq k | \omega = AQL) = 1-\alpha \\ P_{ac}(Q \geq k | \omega = LTPD) = \beta \end{cases}$, and are given by $\begin{cases} k = \frac{z_{1-\alpha} z_{LTPD} - z_{\beta} z_{AQL}}{z_{\beta} - z_{1-\alpha}} \\ n = \left(\frac{z_{1-\alpha} - z_{\beta}}{z_{LTPD} - z_{AQL}}\right)^2 \end{cases}$, where z_p denotes the p-probability quantile of the standard Gaussian distribution. For details see Duncan (1986) and Montgomery (2004).

σ unknown. If σ is unknown the criterion of acceptance is $Q = \frac{U-\bar{X}}{S} \geq k$, with $S^2 = \frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{n-1}$ the unbiased estimator of σ^2. The values of n and k result from the resolution of the system

$$\begin{cases} P_{ac}(Q \geq k | \omega = AQL) = 1 - \alpha \\ P_{ac}(Q \geq k | \omega = LTPD) = \beta \end{cases}$$, or from the equivalent

$$\begin{cases} 1 - F_{t,v=n-1,\delta=\sqrt{n}\Phi^{-1}(1-AQL)}\left(k\sqrt{n}\right) = 1 - \alpha \\ 1 - F_{t,v=n-1,\delta=\sqrt{n}\Phi^{-1}(1-LTPD)}\left(k\sqrt{n}\right) = \beta \end{cases}$$, where $F_{t,v,\delta}(.)$ represents the distribution function of the non-central t variable with v degrees of freedom and non-centrality parameter δ (Duncan (1986) and Montgomery (2004)).

ACCEPTANCE SAMPLING FOR NON-GAUSSIAN VARIABLES

At this point, we will take a closer look at two specific distributions that are widely used in Statistical Quality Control, namely the Weibull and Fréchet distributions.

The procedure to be used for non-Gaussian variables is analogous to that used for the Gaussian case. We start by defining the quality index for each case and compare its observed value with the constant k of acceptance, considering the situations of known and unknown parameters. To define the AS plan for each case, we must solve system in Equation 1.

Let us consider the Weibull distribution, Weibull(θ,δ), with probability density function (*pdf*) $f_X(x) = \frac{\theta}{\delta}\left(\frac{x}{\delta}\right)^{\theta-1} e^{-\left(\frac{x}{\delta}\right)^{\theta}}, x > 0, \delta > 0, \theta > 0$, and the Fréchet distribution, Fréchet(θ,δ), with *pdf* $f_X(x) = \frac{\theta}{\delta}\left(\frac{x}{\delta}\right)^{-\theta-1} e^{-\left(\frac{x}{\delta}\right)^{-\theta}}, x > 0, \theta > 0, \delta > 0$, and let $\hat{\theta}$ and $\hat{\delta}$ represent the maximum likelihood estimators of their respective shape and scale parameters based on a random sample of size *n*. Considering that $Y = \frac{2n\hat{\delta}^{\theta}}{\delta^{\theta}} \sim \chi^2_{2n}$, in the Weibull case, and that $Y = \frac{2n\hat{\delta}^{-\theta}}{\delta^{-\theta}} \sim \chi^2_{2n}$, in the Fréchet case, the results of Table 1 are obtained (for details see Carolino (2012)).

Table 1: Non-conforming proportion, Criterion of acceptance and Acceptance Sampling plans for the Weibull and Fréchet cases.

Distribution	Non-conforming proportion $\omega = P(X > U)$	Criterion of acceptance		Acceptance Sampling Plan: Values of k and n	
		θ known	θ unknown	θ known	θ unknown
Weibull (θ,δ)	$e^{-\left(\frac{U}{\delta}\right)^{\theta}}$	$Q_U = \left(\frac{U}{\hat{\delta}}\right)^{\theta} \geq k$	$Q_U = \left(\frac{U}{\hat{\delta}}\right)^{\hat{\theta}} \geq k$	$\begin{cases} n = \frac{k\chi^2_{2n;\beta}}{2\ln(LTPD)} \\ k = -\frac{2n\ln(AQL)}{\chi^2_{2n;1-\alpha}} \end{cases}$ *	**
Fréchet (θ,δ)	$1 - e^{-\left(\frac{U}{\delta}\right)^{-\theta}}$	$Q_U = \left(\frac{U}{\hat{\delta}}\right)^{-\theta} \leq k$	$Q_U = \left(\frac{U}{\hat{\delta}}\right)^{-\hat{\theta}} \leq k$	$\begin{cases} n = -\frac{k\chi^2_{2n;1-\beta}}{2\ln(1-LTPD)} \\ k = -\frac{2n\ln(1-AQL)}{\chi^2_{2n;\alpha}} \end{cases}$	**

* Note that, this system its equal to the exponential case, Carolino, Casquilho. and Barão (2007), Carolino (2012). ** Since the exact distribution of Q_U is unknown analytically, to determine the values of n and k that satisfy the system (1) we have to proceed with simulation methods.

ROBUST ESTIMATORS FOR LOCATION AND SCALE

As we referred previously, when we have a non-Gaussian distribution we can build specific AS plans associated with that distributions. If the real distribution of data is very asymmetric and/or has heavy tails, but we are able to adequately model the data and estimate its parameters, which usually is not easy, we can use those specific AS plans.

As also mentioned, the classical plans (Gaussian case) assume normality of the data and they use $\bar{X}$ as an estimator of μ and S as an estimator of σ. However, when data is Non-Gaussian, $\bar{X}$ and S may not be the best estimators, mainly when the distribution is asymmetric and/or has heavy tails.

Thus, alternatively, as robust estimators for μ, we suggest the sample median ($\tilde{X}$) and total median ($\tilde{X}_T$), respectively, given by:

$$\tilde{X} = \begin{cases} X_{(m)}, & if\ n = 2m-1 \\ \frac{X_{(m)}+X_{(m+1)}}{2}, & if\ n = 2m \end{cases}, \quad m \geq 1 \qquad \text{and} \qquad \tilde{X}_T = \sum_{i=1}^{n} a_i X_{(i)}, \quad \text{such that}$$

$a_i = a_{n-i+1}, \forall i = 1, \dots, n,\ 0 < a_1 \leq \cdots \leq a_{\lfloor \frac{n}{2} \rfloor},\ \sum_{i=1}^{n} a_i = 1.$

As robust estimators for σ, we suggest a modified version of the sample standard deviation (S*), MAD - *median (Md) of absolute deviation of the observations in relation to the sample median* – and TR - *Total Range*, given by, respectively:

$S^* = \sqrt{\sum_{i=1}^{n} a_i \left(X_{(i)} - \bar{X}\right)^2}$, such that $a_i = a_{n-i+1},\ \forall i = 1, \dots, n,\ 0 < a_1 \leq \cdots \leq a_{\lfloor \frac{n}{2} \rfloor},\ \sum_{i=1}^{n} a_i = 1$, $MAD = Md|X_i - Md|$, and $TR = \sum_{i=1}^{n} b_i X_{(i)}$, such that $b_i = -b_{n-i+1},\ \forall i = 1, \dots, n$, $b_1 \leq b_2 \leq \cdots \leq b_{\lfloor \frac{n}{2} \rfloor} \leq 0$, $\sum_{i=1}^{n} b_i = 0$.

Since these estimators are not centered to the standard deviation, and in order to reduce bias, we consider normalized versions, obtained by dividing the estimators by its mean value in normal model (normalizing constant, C_n).

The choice of the estimators presented above was based on the work of Figueiredo (2003), where it was concluded that each of these estimators is the best according to the degree of asymmetry and the tail weight index. For more details see (Figueiredo and Gomes (2004), Figueiredo and Gomes (2009) and Figueiredo (2003)).

To assess the degree of asymmetry, Fisher's asymmetry coefficient was used, given by $c_1(F) = \frac{\mu_3}{\sigma^3}$, where F represents the distribution of the data, μ_3 represents the third order central moment of the distribution F and σ represents the standard deviation of the distribution F.

For calculating the weight of the tails, we used the index (Hoaglin, Mosteller, and Tuckey (2000)):

$$\tau(F) = \frac{1}{2}\left(\frac{F^{-1}(0.99)-F^{-1}(0.5)}{F^{-1}(0.75)-F^{-1}(0.5)} + \frac{F^{-1}(0.50)-F^{-1}(0.01)}{F^{-1}(0.50)-F^{-1}(0.25)}\right) \Big/ \left(\frac{z_{0.99}-z_{0.5}}{z_{0.75}-z_{0.5}}\right),$$

where $F^{-1}(p)$ represents the p-quantile of the distribution F and z_p represents de the p-quantile of the standard Gaussian distribution.

QUALITY INDEX FOR OF CLASSICAL PLANS CONSIDERING ROBUST ESTIMATORS

This section proposes the use of classical plans using the robust estimators for location and scale.

Scale known. Considering these estimators for the mean value, the quality index of classical plans is, respectively $Q'_N = \frac{U-\tilde{X}}{\sigma}$ and $Q''_N = \frac{U-\tilde{X}_T}{\sigma}$, and the criterion of acceptance, for each case is $Q'_N = \frac{U-\tilde{X}}{\sigma} \geq k'_N$ and $Q''_N = \frac{U-\tilde{X}_T}{\sigma} \geq k''_N$. When we work with Q'_N, we use the distribution of $\tilde{X}$. When we work with Q''_N, we need to use simulation methods, since its distribution is unknown.

This case has been discussed in Carolino (2013), which were worked the same distributions (Weibull and Fréchet) and within these distributions with different degrees of asymmetry and tail weight indexes. It was found that for distributions with a degree of asymmetry close to zero and an tail weight index close to 1, the statistic which produced the best results was $Q = \frac{U-\bar{X}}{\sigma}$. For distributions with marked asymmetry and a high tail weight, the statistic that produced the best results was $Q''_N = \frac{U-\tilde{X}_T}{\sigma}$.

Scale unknown. When the scale parameter is unknown, the problem is somewhat more complex, because the aim is to find out what the best combination of estimators of location and scale according to the degree of asymmetry a tail weight index. Thus, we face 3 situations for the quality index:

Situation 1

$Q_n = \frac{U-\bar{X}}{S}$, $Q_{n_{11}} = \frac{U-\bar{X}}{\frac{S^*}{c_n}}$, $Q_{n_{12}} = \frac{U-\bar{X}}{\frac{MAD}{c_n}}$, and $Q_{n_{13}} = \frac{U-\bar{X}}{\frac{TR}{c_n}}$

Situation 2

$Q_n = \frac{U-\bar{X}}{S}$, $Q_{n_{21}} = \frac{U-\tilde{X}}{\frac{S^*}{c_n}}$, $Q_{n_{22}} = \frac{U-\tilde{X}}{\frac{MAD}{c_n}}$, and $Q_{n_{23}} = \frac{U-\tilde{X}}{\frac{TR}{c_n}}$

Situation 3

$Q_n = \frac{U-\bar{X}}{S}$, $Q_{n_{31}} = \frac{U-\tilde{X}_T}{\frac{S^*}{c_n}}$, $Q_{n_{32}} = \frac{U-\tilde{X}_T}{\frac{MAD}{c_n}}$, and $Q_{n_{33}} = \frac{U-\tilde{X}_T}{\frac{TR}{c_n}}$

In either situation, the criterion of acceptance is: Quality index ≥ acceptability constant (k) and when we work with Qn_{i1}, Q_{ni2} and Qn_{i3} (i=1, 2, 3) we need to use simulation methods, since their distributions are unknown.

SOME RESULTS

If the quality characteristic is a non-Gaussian variable and if we use the values of the standard (apply the classical plans), the risk of the producer (5%) is miscalculated and misleading. So, our main questions are: what miscalculations occur if X is Weibull or Fréchet and we use a standard AS plan for Gaussian X instead? What alternatives can we use? Can we use robust estimators for the location and scale in the Gaussian case?

As we said before, the determination of the specific sampling plan is based on the solution of the System (1). Usually α, β, AQL and $LTPD$ are fixed and the system is solved for n and k. For comparison of the plans it is more convenient to fix n (taken from the standard) and solve the system to calculate k and $LTPD$. The comparison of the results will, essentially, be based on $LTPD$ or/and OC-curve. We have, therefore, carrying out the adjustment of the alphas for the OC curves which pass in the point (AQL, 1-α), and so we can compare the sampling plans. For more details, see Carolino (2012).

To exemplify what we propose, we consider distributions with different degrees of asymmetry and tail weight index. So we are going to compare the classical AS case (Gaussian case) with the Weibull (θ=7, δ=10) and Fréchet (θ=5, δ=10) cases. We will consider:

α=5%; β=10%;

AQL=1%;

several values of n, taken from the standard.

Comparisons of Gaussian and specific plans. Consider that the quality characteristic is a random variable that follows a Weibull distribution with parameters θ=7 and δ=10. We consider that the shape parameter (θ) is unknown.

To illustrate the dangers of misusing the classic plans instead of using the specific plans we compare the classical case with σ unknown with the specific case with θ unknown. Table 2 shows the results for comparisons of the α's.

Regarding the Table 2, it should be noted that the confidence intervals for α, have higher amplitudes, verifying that the amplitude decreases with increasing sample size, which was expected to occur.

Table 2: Results of simulations: estimated α for Gaussian case (σ unknown) – α_N – when α of the Weibull case (θ unknown) – α_W – is 0.05, estimated α_W for the Weibull case (θ unknown) when α_N of the Gaussian case (σ unknown) is 0.05 and 95% confidence interval for α_N and α_W, with AQL=1%.

Sample dimension, n	α_N (σ unknown) if α_W (θ=7,δ=10)=0.05			α_W (θ=7,δ=10) if α_N (σ unknown) = 0.05		
	$\hat{\alpha}_N$	95% Confidence Interval for α_N		$\hat{\alpha}_W$	95% Confidence Interval for α_W	
		Lower limit	Upper limit		Lower limit	Upper limit
10	0,082	0,068	0,099	0,025	0,016	0,035
15	0,080	0,064	0,096	0,026	0,017	0,036

20	0,079	0,063	0,095	0,027	0,017	0,038
30	0,078	0,063	0,094	0,027	0,017	0,039
35	0,078	0,062	0,095	0,028	0,018	0,038
50	0,077	0,061	0,093	0,028	0,018	0,039
100	0,076	0,060	0,092	0,029	0,019	0,040

Table 3 shows the comparison results of the Gaussian case with σ unknown (given by the standard) versus the Weibull case with θ unknown, based on *LTPD* and *k*.

Table 3: Simulation results: comparison of *LTPD* and *k*, between the Gaussian case (σ unknown) and the Weibull case with θ unknown (simulated data with (θ=7, δ= 10))

Sample dimension, n	Gaussian data Gaussian fit (σ unknown) (α is not 5%!)		Weibull data with θ=7, δ=10				
			Weibull data (θ unknown) Gaussian fit (σ unknown)		Weibull data (θ unkown) Weibull fit		
	$LTPD_N$ %	k_N	$LTPD_{WN}$ %	k_{WN}	$LTPD_W$ %	k_W	95% Confidence Interval for k_W
10	18,2	1,56	23,0	1,67	18,0	2,91	(2,88; 2,96)
15	12,9	1,68	17,5	1,76	15,5	3,1	(3,05; 3,12)
20	10,2	1,75	16,0	1,82	8,5	3,23	(3,19; 3,25)
30	7,5	1,84	9,5	1,90	7,0	3,38	(3,36; 3,41)
35	6,7	1,87	7,8	1,93	5,7	3,47	(3,42; 3,47)
50	5,2	1,94	5,2	1,98	4,9	3,58	(3,56; 3,60)
100	3,5	2,04	4,5	2,08	3,7	3,82	(3,80; 3,84)

Analyzing the results shown in Tables 2 and 3, it can be seen that if the quality characteristic is a Weibull variable with θ unknown and if we use the values of the standard (classic case with σ unknown), the producer's risk (as well as the consumer's) is miscalculated. For example, given *AQL*=1%, *n*=10 and if we want a producer's risk of 5%, standards give the values of *k* and *LTPD*, respectively, 1.56 and 18.2%. But in fact, with this k the real risk of the producer is 2.5% (the risk of 5% is illusory and misleading) and the real consumer's non-conforming fraction is 18%. Thus, to ensure a risk of 5%, the standard shall be calculated with an estimated risk of 8.2%, giving a *k*=1.67. However, with this *k*, the non-conforming fraction assumed by the consumer is 23%, which for him is detrimental since it would assume a non-conforming fraction higher than it would take if the specific plan was considered (18%).

Comparing the values of $LTPD_{WN}$ corresponding to the Gaussian plan and $LTPD_W$ corresponding to the specific plan, in Table 3, the latter are smaller than the former. This means that the specific plans are better than Gaussian plans since they protect the consumers against the acceptance of lots with lower quality.

The same kind of precautions has to be taken in the Fréchet distribution for the calculation of the risks α and β, and the constants *k* and *LTPD*.

Comparisons of robust AS plans. At this point we compare the proposed robust plans to determine which one or ones lead to the best results. Specific plans are not considered, since, according to the results presented in 6.1., they produce better results. As mentioned earlier, if the real distribution of data is very asymmetric and/or has heavy tails, but we are able to adequately model the data and estimate its parameters, which usually is not easy, we can use those specific AS plans. When we can not adequately model the data and estimate its parameters, we can use alternative plans, particularly when we work with small size samples.

The plots in Figures 1 to 6 consider the plans with quality indexes defined in the situations 1 to 3, in section 5.2, namely *Qn* is the Gaussian quality index and Qn_{ij} (i=1, 2, 3 and j=1, 2, 3) are the robust quality indexes that use the location estimators $\bar{X}$ for i=1, $\tilde{X}$ for i=2, $\bar{X}_T$ for i=3 and scale estimators $\frac{S^*}{c_n}$ for j=1, $\frac{MAD}{c_n}$ for j=2 and $\frac{TR}{c_n}$ for j=3.

Situation 1

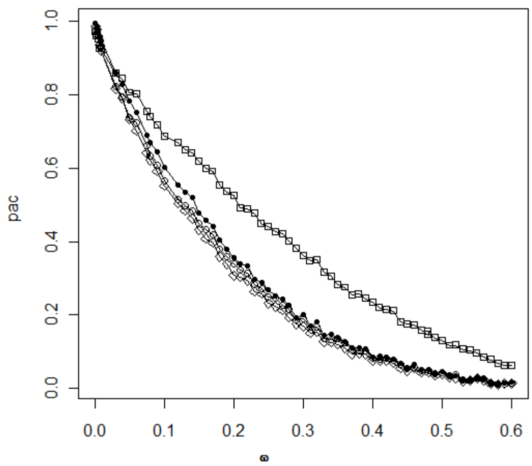

Figure 1: Comparison of Operating characteristic curves, OC, Pac(p), p∈[0; 1] – range of non-conforming proportion – in Weibull case (simulated values, θ unknown), n=5:

-●- *Qn* with estimators ($\bar{X}, S$), -○- Qn_{11} with estimators ($\bar{X}, S^*/C_n$),

-□- Qn_{12} with estimators ($\bar{X}, MAD/C_n$), -◊- Qn_{13} with estimators ($\bar{X}, TR/C_n$)

Situation 2

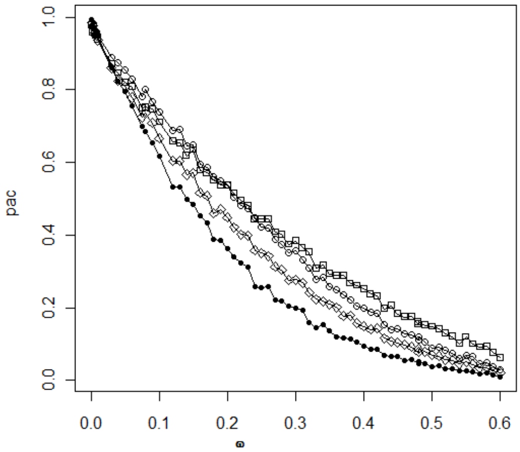

Figure 2: Comparison of Operating characteristic curves, OC, Pac(p), p∈[0; 1] – range of non-conforming proportion – in Weibull case (simulated values, θ unknown), n=5:

-●- Qn with estimators ($\bar{X}, S$), -○- Qn_{21} with estimators ($\bar{X}, S^*/C_n$),

-□- Qn_{22} with estimators ($\bar{X}, MAD/C_n$), -◇- Qn_{23} with estimators ($\bar{\bar{X}}, TR/C_n$)

Situation 3

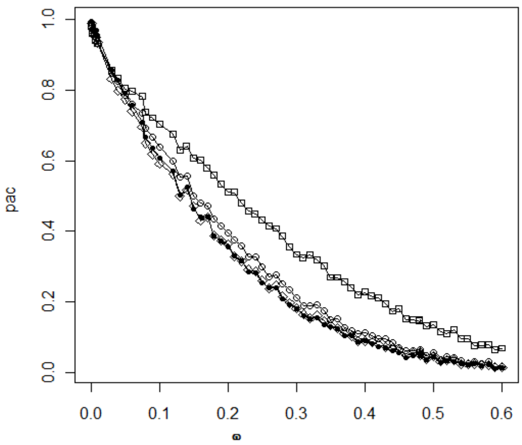

Figure 3: Comparison of Operating characteristic curves, OC, P_{ac}(p), p∈[0; 1] – range of non-conforming proportion – in Weibull (simulated values, θ unknown), n=5:

-●- Qn with estimators ($\bar{\bar{X}}, S$), -○- Qn_{31} with estimators ($\bar{\bar{X}}_T, S^*/C_n$),

-□- Qn_{32} with estimators ($\bar{\bar{X}}_T, MAD/C_n$), -◇- Qn_{33} with estimators ($\bar{\bar{X}}_T, TR/C_n$)

The plots in Figures 1, 2 and 3 show, for n = 5, the operating characteristic curves, OC – curves, Pac(ω) for the three situations presented section 5.2., when the quality characteristic follows a Weibull distribution with θ=7 and δ=7. This distribution has c_1=-0,463 and τ=0,990.

Analyzing the plots in Figures 1, 2 and 3 it is found that in situation 1 the statistics Qn_{11} and Qn_{13} lead to better results. In situation 2, the statistic Qn is better. Finally, in situation 3 the best results are produced by the statistics Qn and Qn_{33}.

The plots in Figures 4, 5 and 6 show, for n=5, the operating characteristic curves, OC – curves, Pac(ω) for the three situations presented section 5.2., when the quality characteristic follows a Fréchet distribution with θ=5, δ=10. This distribution has c_1=3.535 and τ=1.357.

Situation 1

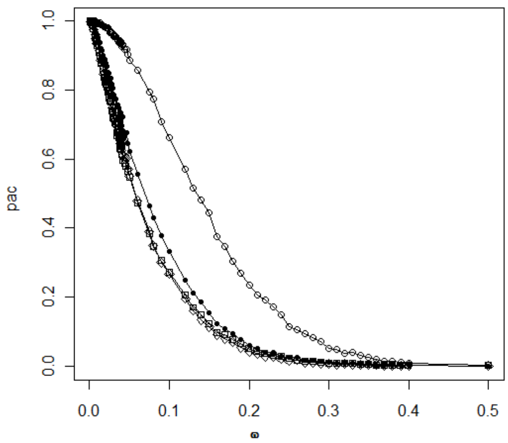

Figure 4: Comparison of Operating characteristic curves, OC, Pac(p), p∈[0; 1] – range of non-conforming proportion – in Fréchet (simulated values, θ unknown), n=5:

-•- Qn with estimators ($\bar{X}$, S), -○- Qn_{11} with estimators ($\bar{X}$, S^*/C_n),

-□- Qn_{12} with estimators ($\bar{X}$, MAD/C_n), -◇- Qn_{13} with estimators ($\bar{X}$, TR/C_n)

Situation 2

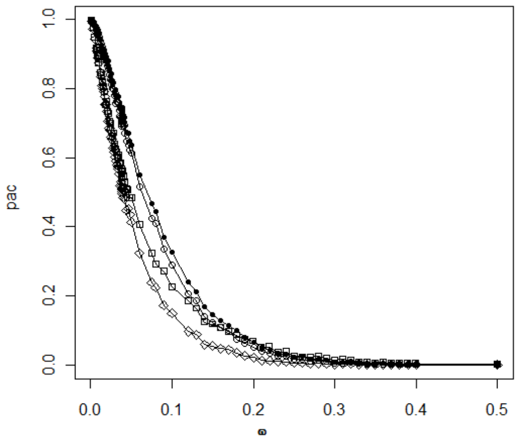

Figure 5: Comparison of Operating characteristic curves, OC, Pac(p), p∈[0; 1] – range of non-conforming proportion – in Fréchet (simulated values, θ unknown), n=5:

-●- Qn with estimators $(\bar{X}, S)$, -○- Qn_{21} with estimators $(\bar{X}, S^*/C_n)$,

-□- Qn_{22} with estimators $(\bar{X}, MAD/C_n)$, -◇- Qn_{23} with estimators $(\bar{X}, TR/C_n)$

Situation 3

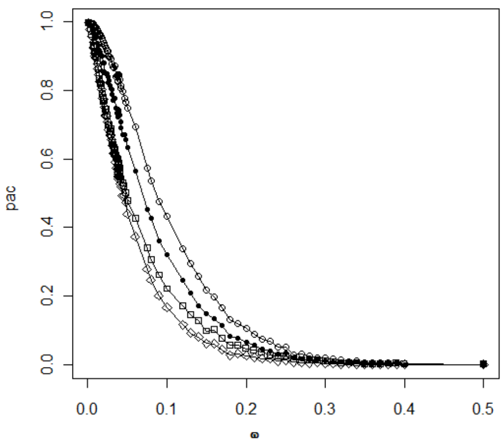

Figure 6: Comparison of operating characteristic curves, OC, Pac(p), p∈[0; 1] – range of non-conforming proportion – in Fréchet (simulated values, θ unknown), n=5:

-●- Qn with estimators $(\bar{X}, S)$, -○- Qn_{31} with estimators $(\bar{X}_T, S^*/C_n)$,

-□- with estimators Qn_{32} $(\bar{X}_T, MAD/C_n)$, -◇- Qn_{33} with estimators $(\bar{X}_T, TR/C_n)$.

Analyzing the plots in Figures 4, 5 and 6, the best results for the situations 1, 2 and 3, are obtained with the statistics Qn_{12} and Qn_{13}, Qn_{23}, Qn_{33}, respectively.

CONCLUSIONS

Considering the previous results, we conclude that if we "wrongly" use the Gaussian case when the quality characteristic is a random variable with other distribution, namely an asymmetric distribution and/or with heavy tails, the producer's risk (α) is different (it increases or decreases according to the distribution of the quality characteristic). So, it is important to note that sampling plans by variables are not to be used indiscriminately, when the normality assumption may be questioned. The application of an incorrect sampling plan can cause damage to the producer or consumer.

The results presented in Section 6.2 show that for distributions with moderate asymmetry and moderate tail weight (Weibull(θ=7, δ=7)), the best combination of location and scale estimators is ($\bar{X}, S^*/C_n$) or ($\bar{X}, TR/C_n$). For distributions with high asymmetry and high tail weight (Fréchet(θ=5, δ=10)), the best combination of location and scale estimators is ($\tilde{X}, TR/C_n$) or ($\tilde{X}_T, TR/C_n$).

The results are in agreement with those obtained by Figueiredo (2003) regarding the efficiency of the estimators depending on the asymmetry and the tail weight.

Robust AS plans are to be considered as a good alternative to the classical plans, when we can not adequately model the data and estimate its parameters, particularly when we work with small size samples and mainly for variables with asymmetric and/or heavy tailed distributions.

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The impact of the field of study on students' perceived quality in a Higher Education Institution certified by ISO 9001

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ABSTRACT

Purpose. The main objective of this paper is to investigate the students' perceived quality in a Higher Education Institution certified by ISO 9001, using six dimensions: Teachers performance; Top management performance; Staff performance; Structures and physical resources; Information and communication; and Support services. Additionally, this research intends to verify if the field of study (Engineering and Social Sciences) has a significant impact on students' perceived quality.

Design/methodology/approach. The research used a quantitative approach. The data were collected through a survey to 109 higher education students: 76 students from social sciences courses and 33 students from engineering courses.

Findings. The results show that the students evaluate the quality of the Higher Education Institution certified by ISO 9001 positively, in the six dimensions considered in this research. Through the operationalization of a multivariate analysis of variance, we find that the field of study does not influence the students' perceived quality. Students of engineering courses have levels of satisfaction similar to those of social sciences courses.

Research limitations/implications. This research was applied to a specific context of the Higher Education: polytechnic education and two fields of study (engineering and social sciences).

Originality/value. This paper explores new dimensions to evaluate the quality of Higher Education Institutions in the student's perception. Additionally, this paper uses the field of study as a predictor variable of students' perceived quality.

Keywords: Students' perceived quality, Field of study, Engineering, Social Sciences, Higher Education.

Article Classification: Research paper

INTRODUCTION

Quality evaluation in Higher Education Institutions (HEI), based on the students' perceived quality, has been highlighted in international research (e.g., Sumaedi and Bakti, 2011), as well as on national research (e.g., Cid et al., 2010; Saraiva, 2008)

However, many of the existing studies evaluate the quality of HEI based on instruments which focus essentially on the same dimensions as, for example, the famous SERVQUAL (Arokiasamy, 2012; Khodayari and Khodayari, 2011; Owlia and Aspinwall, 1996; Sumaedi and Bakti, 2011)

In order to achieve a quality culture, it is necessary to evaluate the quality control policies of HEI by the implementation of standards and guidelines, as well as the evaluation of the influence of this quality culture in students (Mourad, 2013)

The quality management models, as those established by ISO 9001, help the implementation of a quality culture (Sá et al., 2011) once that this standard assure the conformity with most of the European guidelines related to quality assurance in education (Señal et al., 2008).

As already mentioned, there are many studies on this issue. However, their perspectives and goals are rather diverse, and we do not have record of a study which examines the students' perceived quality based on the field of study here in evaluation. It was possible, however, to find some similarities in studies such as those developed by (Bonito et al., 2009a, 2009b), which aimed at studying the quality of HIE based on the students 'academic level (primary, secondary and higher education). And it is also significant to highlight the study of Cid et al. (2009) focused on student satisfaction versus quality of teaching in different schools.

This paper aims at addressing this gap, by investigating the students' perceived quality in an HEI certified by ISO 9001, using the following dimensions:

- Teachers performance (seven indicators);
- Top management performance (four indicators);
- Staff performance (three indicators);
- Structures and physical resources (thirteen indicators);
- Information and communication (five indicators);
- Support Services (four indicators).

Additionally, this research intends to verify if the students' field of study (engineering and social sciences) has a significant impact on students' perceived quality.

This paper is structured as follows: the next section reviews the literature about quality in higher education institutions; the third section presents the context of study; the fourth section describes the method used in the empirical study; then, the fifth section discusses the results of the study; and, finally, we summarise the main conclusions.

QUALITY IN HIGHER EDUCATIONAL INSTITUTIONS

Recently, in most developed countries, there have been major developments on the quality of education from the scientific and technological point of view. As stated by Rezeanu (2011), national and international experts point to an approach based on the quality of higher education.

The Portuguese education system has faced a strong growth, diversification and massification which increased competition between HEI. Therefore, the quality of education and quality certification may also represent a marketing strategy of the HEI to attract more students (Sultan and Wong, 2010). According to literature of service marketing, quality is one of the empirical determinant factors for the satisfaction of the customer (e.g., Kwek et al., 2010; Sumaedi et al., 2011).

Changes over the recent decades have enhanced the awareness of HEI to the quality theme, once it helps attract the best teachers and students, and the topic has become even more prominent with the creation of the Agency for Assessment and Accreditation of Higher Education (A3ES).

Moreover, and as a direct effect of the Agency, the government has regulated the obligation of HEI to, first, certify their courses and then to implement internal systems of quality assurance.

Students' perceived quality. According to literature, the competitiveness in academic environment is growing and, for that reason, many researchers have been arguing that HEI must reconfigure their strategies in order to ensure the required efficiency and effectiveness levels. In this regard, they should focus on their customers, on fulfilling their needs and expectations, since the sustainability of HEI depends on them (e.g., Ferreira et al., 2009; Kwek et al., 2010).

In fact, monitoring the satisfaction/perception of students about the quality of education is becoming a common practice, (e.g. this has been the target of several proposals in the literature about this matter: Cid et al., 2010, 2009; Encabo, 2011; Morais et al., 2006; Rebelo et al., 2010; Sumaedi et al., 2011). However, the key research points have been focused on teaching staff, infrastructure, teaching strategies, administrative staff, extracurricular activities, among others (e.g., Bonito et al., 2009b; Candeias et al., 2010; Cid et al., 2010; Encabo, 2011; Rebelo et al., 2010; Ribeiro and Fernandes, 2002).

The table below (table 1) presents the main results of some of the studies conducted about students' perceived quality.

Table 1 – Studies about students' perceived quality

Author/ Year	Variables/ Results
Martins et al. (2009)	The variables most closely related to the concept of quality are: - Teaching methods; - Skills of teachers.
Bonito et al. (2009a)	Academic level could be an influence (High school or College) of student's perception. Differ regarding the following variables: - Motivation; - Commitment of faculty members; - Teaching materials;

	- Teaching methods; - Evaluation methods; - Programs of courses; - Organization of the teaching and learning process; - Adjustment of infrastructure and resources; - Adjustment of the profile and structure of the course; - Degree of satisfaction; - Academic performance.
Bonito et al. (2009b)	Quality of teaching is mainly associated with the variables: - Operation; - Infrastructures; - Conditions of the classroom; (Point out that this study contents, beyond the vision of higher education, the students' view of junior and high school).
Kwek et al. (2010)	Quality of education is related to the quality of service perceived by students.
Sumaedi and Bakti (2011)	For industrial engineering students, perceived service quality is: - Academic content and knowledge center; - Supporting facilities; - Lecture responsibilities; - Social activities; - Class programs and facilities.
Peng and Samah (2006)	Affect students' satisfaction: - Facilities; - Instructions medium; - Course content; - Lecture and faculty.
Encabo (2011)	Students' satisfaction depends on their perception about: - Adequacy; - Usefulness; - Accessibility; - Safety and convenience of the learning facilities; - Faculty teaching strategies and subject matter knowledge.

CONTEXT OF STUDY

Portuguese Polytechnic higher education system. The Portuguese higher education system consists on both a public and private education system (private and cooperative), which include the universities and polytechnics subsystems. The main difference between these two subsystems is mainly related with its focus. While the university aims to more scientific and cultural aspects, polytechnic subsystem aims to a more vocational strand of theoretical and practical, focusing on the professional aspect (Lei 49/2005).

The origins of polytechnic education system in Portugal date back to the 60s, with the report "*Le Project Regional Mediterraneen*" made in cooperation with OECD, which reflected on *"the need to develop training, through the education system of middle and senior management to respond to the needs and complexities of economic and social development, beyond to traditional graduates, graduates with a general qualification lower than this, above all for the exercise of certain technical professions*" (Simão and Costa, 2000, p. 11).

Therefore, as a result of this report, in 1973 the polytechnic subsystem was established in the Portuguese Legislation (Lei n. ° 5/73 and Decreto-lei n.° 402/73). This education subsystem has gained an impressive presence over the years, and as a result the number of existing establishments in Portugal is higher than the number of universities.

There are approximately two hundred polytechnic institutions, which are divided into private (94) and public (66) schools (DGES, 2014).

Despite the wide range of Polytechnic higher education institutions in Portugal, less than two dozens have ISO 9001 certification, and the vast majority of these belong to the public education system (IPAC, 2014).

The present study was carried out in a public school that integrates one of the largest Portuguese polytechnic institutes, with a quality management system certified according to ISO 9001.

RESEARCH METHOD

Sample and data. The empirical analysis took place in a HEI, certified by ISO 9001. This HEI has been established since 1999 and at the present has approximately 1330 students. The institution offers courses mainly in two scientific areas, engineering and social sciences. In the area of engineering, there are three bachelors and two master's degrees and in the area of social sciences, two bachelors and two master's degrees.

In what concerns ISO 9001 certification, the HEI has obtained the first certification in the year 2006, which was later renewed in 2009, and more recently in January 2012. The scope of the QMS is “Polytechnic higher education ".

The data were collected through a questionnaire, made available online using a digital tool (*Surveygizmo*). The questionnaire was divulged by e-mail to students of this polytechnic HEI. The data collection took place between 8 May and 25 July 2012.

The sample of this study was composed of almost 10% of the student population of this HEI, provided by a total of 109 participants. Students of social sciences courses represent 79.7% (n = 76) of the sample, while the students of engineering courses represent only 30.3% (n = 33).

Variables and data analysis. The questionnaire was adapted from the one developed by Cid et al. (2010). The added questions are directly related to the requirements of ISO 9001, in particular in what concerns the following issues: satisfaction with the quality of information and communication and the support services provided; and satisfaction with the performance of non-teaching staff, in particular, of the top management.

The dimensions considered for this research, the specific objectives of each dimension, as well as the number of indicators corresponding to each dimension can be found in table 2.

Table 2 – Dimensions, objectives and indicators of the data collection

Dimensions	Objectives *Evaluate students' satisfaction about:*	Indicators
Teachers performance	Teachers performance in and outside the classroom	Engagement for teaching Adequacy of relationships with students Encouragement of students participation Availability to clarify doubts Respect for the students' attendance hours Teachers' attendance Teachers' punctuality
Top management performance	Top management performance	Educational establishment policy Availability of human, physical and material resources Celerity in the response to students' requirements Good performance of top management
Staff performance	Staff performance	Courtesy in attendance appropriate knowledge to the tasks they undertake Ability to resolve individual situations
Structures and physical resources	Existing structures and physical resources, as well as its conditions, availability, accessibility, etc.	Adequacy of the bibliographic collection Physical conditions of classrooms Environmental conditions of classrooms Adequacy of didactic resources supporting informatics infrastructure Appropriateness of study rooms and computer rooms Adequacy of infrastructure for socializing Offering of relevant extracurricular activities appropriate road and pedestrian accesses Proximity of alternative transport facilities Access for persons with reduced mobility Parking size appropriate to needs Internet accessibility
Information and communication	Information provided to students and the communication mode	Sufficiency and clarity of information provided on the site Sufficiency and clarity of information provided for the services Ease of communication with the different structures Effectiveness in responding to complaints Concern about collecting and analysing the views of students

Support services	Quality of support services	Adequacy of the working schedules of the different services Effectiveness, speed and courtesy in service delivery Availability of support to students with special needs Availability of health services Concern of the educational establishment in guiding new students Availability to purchase relevant bibliographic materials

These dimensions were evaluated by means of closed questions, according to a Likert-style rating scale of 4 points (1 "totally disagree", 2 "disagree," 3 "agree" and 4 "totally agree").

In terms of data analysis, firstly we analyse the sample, using descriptive measures and subsequently we use a multivariate analysis of variance (MANOVA), to examine if the quality perception of different students (students of social sciences courses versus students of engineering courses) differ among themselves in what concerns the six dimensions mentioned above.

EMPIRICAL RESULTS

Descriptive analysis. The six dimensions (Teachers performance; Top management performance; Staff performance; Structures and physical resources; Information and communication; and Support services) were operationalized by a set of questions measured by a Likert Scale. As such, we used the Cronbach Alfa in order to validate the aggregation of these questions. The value of the Cronbach Alfa for all variables is above 0,8. In particular, these values are as follow: 0.862 for Teachers performance, 0,933 for top management performance, 0,924 for staff performance, 0,901 for structures and physical performance, 0,934 for information and communication and 0,911 for support services. They provide evidence of admissible internal consistence (Hair et al., 2010) of the variables. Table 3 shows a set of descriptive statistics.

Table 3 – Descriptive statistics (whole sample)

Dimensions	N	Minimum	Maximum	Mean	Standard Deviation
Teachers performance	109	1,29	4,00	3,096	,504
Top management performance	99	1,00	4,00	2,922	,576
Staff performance	105	1,00	4,00	2,987	,525
Structures and physical resources	109	1,00	3,92	2,646	,515
Information and communication	109	1,00	4,00	2,869	,575
Support services	109	1,00	4,00	2,522	,604

The six dimensions have the averages close to 3 (the positive part of the scale used). The dimension Teachers performance presents the highest average value (3.096) while the dimension support services have the lowest value (2.522).

One must emphasize the fact that, generally, the dimensions have minimum values of 1 (lowest value of scale) and maximum of 4 (higher scale value).

Table 4 – Descriptive statistics break by field of study

Dimensions	Field of study	N	Mean	Standard Deviation
Teachers performance	Social Sciences	76	3,078	,463
	Engineering	33	3,260	,506
Top management performance	Social Sciences	70	2,942	,584
	Engineering	29	2,866	,583
Staff performance	Social Sciences	73	2,986	,476
	Engineering	32	2,988	,517
Structures and physical resources	Social Sciences	76	2,702	,454
	Engineering	33	2,629	,571
Information and communication	Social Sciences	75	2,926	,517
	Engineering	33	2,929	,548
Support services	Social Sciences	76	2,567	,527
	Engineering	33	2,589	,663

Regarding the descriptive analysis by field of study (see table 5), we perceive that the averages verified for the two groups are very similar in the six dimensions. The teachers performance is the dimension where there is the greatest difference between the averages of the two groups: students of social sciences courses and students of engineering courses.

MANOVA. On data analysis, we use a multivariate analysis of variance (MANOVA) to identify if the different students/clients of certified HEI (students of social sciences courses versus students on courses of engineering area) differ on a set of six variables that assess the quality of the institution, namely: Teachers performance; Top management performance; Staff performance; Structures and physical resources; Information and communication; and Support services.

The relationship between the independent variable and the dependent variables can be specified by the following equation:

Equation (1):

$$Y1 + Y2 + Y3 + Y4 + Y5 + Y6 = X1$$

With X1 representing the non-metric variable "predominant scientific area of the course" and Y1 to Y6 metric variables "Teachers performance"; "top management performance"; "staff performance"; "structures and physical resources"; "information and communication"; and "support services", respectively.

Before calculating the MANOVA, we tested the assumptions, specifically: normality of data distributions; univariate and multivariate homocedasticity and the correlation between the dependent variables.

In general, it is possible to verify that the variables do not follow normal distributions (see table 4). However, according to Maroco (2010, p.197) the "multivariate methods are robust to the violation of normality assumption".

Table 5 – Tests of normality

Dimensions	Field of study	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Teachers performance	Engineering	,109	28	,200	,947	28	,163
	Social Sciences	,147	69	,001	,959	69	,024
Top management performance	Engineering	,412	28	,000	,615	28	,000
	Social Sciences	,308	69	,000	,754	69	,000
Staff performance	Engineering	,366	28	,000	,660	28	,000
	Social Sciences	,372	69	,000	,679	69	,000
Structures and physical resources	Engineering	,169	28	,040	,893	28	,008
	Social Sciences	,126	69	,009	,971	69	,112
Information and communication	Engineering	,305	28	,000	,778	28	,000
	Social Sciences	,310	69	,000	,764	69	,000
Support services	Engineering	,196	28	,007	,887	28	,006
	Social Sciences	,119	69	,017	,948	69	,006

Table 6 – Box's Test

Box's M	30,258
F	1,312
df1	21
df2	10361,548
Sig.	,154

We validate the assumption of multivariate homocedasticity (see table 6), after analysing the Box's M test (p value greater than 0.05). With regard to the univariate homocedasticity (see table 7), and after having into consideration the Levene test, we also validate this assumption for the six dependent variables.

Table 7 – Levene's Test

Dimensions	F	df1	df2	Sig.
Teachers' performance	,591	1	95	,444
Top management performance	,013	1	95	,910
Staff performance	,005	1	95	,942
Structures and physical resources	1,235	1	95	,269
Information and communication	,011	1	95	,918
Support services	1,568	1	95	,214

Lastly, we can confirm, by the Bartlett's test of Sphericity (see table 8), that the dependent variables are correlated, justifying the use of MANOVA.

Table 8 – Bartlett's test of Sphericity

Likelihood ratio	,000
Approx. Chi-Square	262,632
Df	20
Sig.	,000

After calculating the MANOVA, we realised that, regardless of the statistics used, the independent variable "predominant scientific area of the course" does not have a significant effect on the dependent variables, i.e. students' perceptions on the six dimensions evaluated do not differ regardless of the predominant area of the course they attend.

Table 9 – Multivariate tests

Statistics	Value	F	Sig.
Pillai's Trace	,059	,941	,470
Wilks' Lambda	0,941	,941	,470
Hotelling's Trace	,063	,941	,470
Roy's Largest Root	,063	,941	,470

In conclusion, the students' perceived quality does not differ among the different fields of studies.

CONCLUSION

This paper explores six dimensions to evaluate quality of HIE in the students' perception, in particular: Teachers performance; Top management performance; Staff performance; Structures and physical resources; Information and communication; and Support services. Compared to the studies already carried out, in this paper were explored new dimensions to evaluate the performance of top management and staff. These new dimensions allow a more comprehensive and complete assessment of the students' perceived quality.

The results obtained through the data analysis show that, on average, the students are satisfied with the performance of the certified HEI in the six dimensions considered in this research. Additionally, it is noted that the dimension "Teachers performance" is the one that presents the highest average values, possibly because it is a dimension with direct impact on the quality of service provided by the educational institution.

The results of a multivariate analysis of variance, show that the field of study does not influence the students' perceived quality. Students of engineering courses have levels of satisfaction similar to those of social sciences courses.

These conclusions are relevant to HEI that have courses in different fields of study and, by this fact, are usually organized into departments that work with some level of autonomy. Despite this organizational division , students have similar satisfaction levels.

The main limitations of this research, and that prevent the generalization of the results, are: the reduced sample size, the selection of a specific context - Portuguese Polytechnic higher education system - and the selection of only two scientific areas. For future work, one should suggest the implementation of the data collection instrument to other contexts and students.

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The influence of supplier partnership in the new product development process: a literature review

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ABSTRACT

From the literature review of studies addressing issues related to the participation and influence of suppliers in the new product development process, several key themes which affect the issue under study are identified and detailed, highlighting the factors that contribute to the better or worse performance of these partnerships. The intention is to clarify the main problems and the main issues that have guided research concerning this specific and important form of collaboration. This study is, as such, a synthesis of the literature. The main research themes that were identified related to supplier involvement in NPD are the choice of the supplier, the quality of the partnership and the issue of integration. This study also presents the main proposals, extracted from the literature, for lines of future research.

Keywords: new product development; supplier involvement; relationship with the supplier; supply chain.

Article Classification: Literature review

INTRODUCTION

The supplier involvement and influence in the development of new products have brought benefits that are recognised as an important source of innovation (Smals and Smits, 2012). In this context, efforts have been made to show how companies can incorporate the perspective of a vendor in new product technology decisions, and consequent development of more successful products (He et al, 2014). Supplier involvement can happen at several stages or in several activities of the enterprise. The collaboration of suppliers that begins at the stage of product conceptualization, and which implies an higher degree of involvement, in terms of product development is known as the "early involvement of suppliers" (ESI) (LaBahn and Krapfel, 2000).

The literature reports various ways in which companies can improve their competitive advantage, by working with suppliers to identify the impact of their involvement in the development process and in production improvement (Feng et al, 2010). Generating competitive advantage through collaboration and supplier involvement in new product development (NPD) requires that the company will build and maintain appropriate procedures and routines, and that it will work with suppliers who have complementary expertise and capabilities in product development projects (Wagner and Hoegl, 2006).

A total of 38 studies that addressed aspects of supplier performance in new product development and its influence on these results are analysed. The studies were previously selected amongst a larger number, and they were the result of a selection based on a number of criteria of relevance and quality. The main objective of the paper and the underlying research, is, on the one hand, the description of the main issues/problems related to the collaboration process, and, on the other hand, the identification of generalisations concerning the participation of suppliers in the new product development process and their contributions, showing the favourable points and the difficulties encountered by the companies involved in this process. The main contribution of this article to the knowledge of this subject focuses on compiling a synthesis that identifies the most important factors concerning the involvement of suppliers.

The paper is structured as follows: section 2, which is the following section, presents the basic setting and rationale, including advantages and disadvantages, for the supplier involvement in NPD. Section 3 identifies in detail the major research themes that this phenomena triggers. The final section presents a list of selected papers that provide a very concise overview of the concerns and points of view of the researchers in this area, and a concise list of future lines of research proposed by the literature.

THE RATIONALE FOR SUPPLIER INVOLVEMENT

The influence of the supplier in the new product development. Supplier involvement and its influence on the development of new products have brought benefits that are recognised as an important source of innovation. This relationship can reduce overall costs and create synergies based on resources developed collaboratively, and a particular form of collaboration is the involvement of suppliers in the new product development (Smals and Smits, 2012).

Developing new products is one of the critical processes by which firms maintain or even increase their competitive advantage. And, in this context, a considerable effort has been made on showing how companies can incorporate the perspective of a vendor in new product technology decisions, and involve or integrate the supplier in the supply chain. The integration of the supplier has received significant attention in efforts to develop new products (He et al, 2014).

As shown in Figure 1 (Petersen et al, 2005) there are at least five stages in which the supplier may be involved in the development of new products.

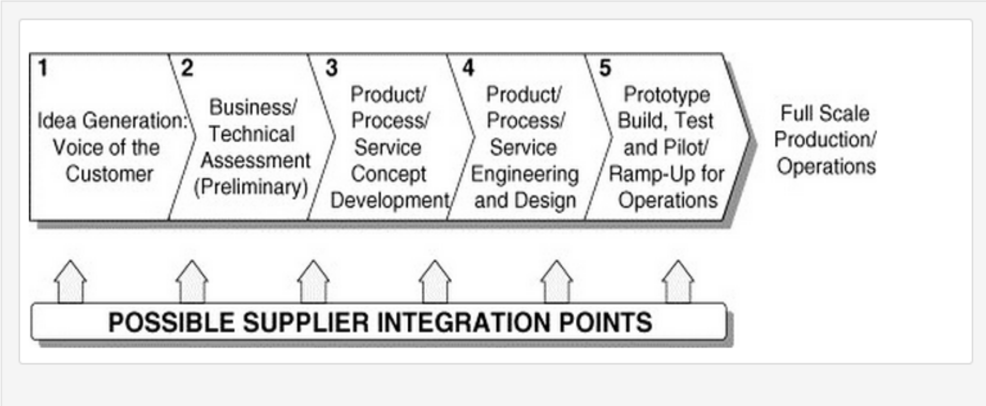

Figure 1: Possible supplier integration points (Source: Petersen et al, 2005)

Supplier collaboration can start at an early stage of product conceptualization, and this case is known as the Early Supplier Involvement (ESI). Early involvement of a supplier is a major strategic decision, because it requires a significant commitment of resources, opportunity costs of care and foreshadows the future of the business relationship (LaBahn and Krapfel, 2000).

A supplier involvement in the new product introduction can reduce the complexity of the development processes and avoids the problems that arise by ignoring restrictions related to the supplier manufacturing technologies (Walter, 2003). Besides this advantage, the participation of the supplier allows both parties to communicate more effectively resulting in shorter product development cycles and reduced acquisition costs (Humphreys et al, 2004).

The knowledge required by the products and services provided by a company is not fully available from within the company, and studies suggest that the company should integrate and use the additional knowledge, added to the skills that suppliers have, to increase their competitive advantage. The literature also mentions several ways in which companies can improve their competitive advantage by working with suppliers, where we can examine impacts of supplier involvement in the development and improvement of production processes (Feng et al, 2010).

Thus, generating competitive advantage through collaboration and supplier involvement in NPD, at whatever stage it is, requires that the company will build and maintain appropriate procedures and routines, and that it will work with suppliers who have complementary expertise and capabilities in product development projects (Wagner and Hoegl, 2006).

The collaborations should be supported with substantial investments by both parties. Financial and non-financial investments are necessary, including time, money, training, technology updates, among other resources. The time and effort required to achieve mutual collaborative relationships should not be underestimated. In this perspective, the needs, capacities and development of suppliers should be considered and incorporated into the strategic planning of the company (Cao et al, 2010), with a view to establishing a strategic and lasting interaction between company and the supplier.

Partnerships in new product development: advantages and disadvantages. In general, the literature points to the success of partnerships between suppliers in the new product introduction process. However, despite positive results in respect to the supplier involvement in new product development (LaBahn and Krapfel, 2000; Walter, 2003; Humphreys et al, 2004), some authors show unfavourable points to this early involvement, and empirical studies have found no positive relationships, or even showed negative effects of supplier involvement on performance results.

Advantages of supplier involvement in the new product development process. Companies face highly competitive environments where technological changes are pushing quality improvements and cost optimization processes, but also increase the dependence of companies on the providers in terms of technology, leading to the involvement of suppliers as sources of innovation in product development processes (Wagner and Hoegl, 2006).

In short, we may say that the benefits of involving suppliers in NPD include: reducing development costs, resulting from the initial availability of prototypes, the consistency between the design and capabilities of the supplier, and consequent optimization in engineering design; possible improvements in product quality; reduction of the overall development time due to the early identification of technical problems of the supplier; valuation of the innovation process, improving the transfer of knowledge among supplier's engineers and technical personnel; improvement in the financial performance of the manufacturer (Najafi Tavani et al, 2013).

Overall, a positive assessment is made of supplier involvement in the new product development process, as well as the need to develop the supplier relationship. The adaptation process identifies the critical role of trust in the formation of co-participation, risk and reward sharing, agreement on performance measurement, top management commitment and confidence in the ability of the supplier (Johnsen, 2009).

With a vision based on strategic resources, it is argued that involving suppliers in NPD involves the combination of buyer and supplier resources in R&D and the operation of joint capabilities through strategic integration of buyer-seller relationship. This relationship of involvement can be beneficial when the supplier is involved early in the development process, instead of working independently when it comes to the time to put new products on the market, and also on the product quality, on development cost and on product cost (Wagner and Hoegl, 2006).

Collaborating with suppliers helps companies expand their organizational boundaries, which creates competitive advantage that is realised by reducing the life cycle of the product, by the increase in the number of new product launches and by the introduction of the most up to date or more suitable technology for new products (Najafi Tavani et al, 2013).

The collaboration between partners in the supply chain are not merely transactions; it seizes on the sharing of information and on knowledge creation for sustainable competitive advantage (Cao et al, 2010).

Limitations to the supplier integration and partnership in the new product development process

A body of research based on marketing investigated the involvement of suppliers from a vendor perspective, where these have revealed a number of concerns, such as the exploitation by the power of the customer and the unwillingness of the supplier as a partner of the customer during the NPD. There is also evidence that suggests that the powerful customers abuse their power and advantages and behave opportunistically, which can ruin the trust that is an essential ingredient in the design of supplier involvement (Johnsen, 2009).

Despite the importance of this relationship, many managers, as well as other researchers, view the procedures for integrating suppliers into NPD projects as a "black box". Research suggests that participation of these external constituents is important, but that many processes associated with the integration of third parties (suppliers) are still poorly defined (Petersen et al, 2005).

Another limiting factor is the form of collaboration between companies, which can be defined as a relational system in which two or more parties gather resources, in order to meet the goals that they could not answer individually. In relations between companies that adopt horizontal collaboration, and where the supplier adopts horizontal collaboration, he does not have the freedom to make decisions on bids, and only the manufacturer can decide to send order requests to another provider (Chan and Prakash, 2012).

Some studies suggest that the practice of establishing a connection with vendor-supplier (i.e., encouraging suppliers to communicate, coordinate and mutually adjust) has no effect on the efficiency of product development (Wagner, 2012). They also report negative effects of supplier integration and conclude that "assigning more responsibilities to suppliers in product development can have a negative effect on the organisation's ability to offer new products and features, and can lead to deterioration of innovativeness of products" (Wagner, 2012). More intensive involvement of suppliers in product development can have the opposite effect of what is intended, or may result in increased product and development costs, worsen the performance of the product and increased development time (Wagner and Hoegl, 2006).

THE MAJOR RESEARCH THEMES IDENTIFIED IN THE REVIEW

This section presents the main themes and results extracted from the literature review that was performed. The main research themes are identified and detailed.

The main schools that address the issue of supplier involvement in NPD are related to the field of organizational behaviour, the management area, particularly in industrial management, the marketing area and the area of technology management.

In very concise terms we can say that the main themes related to supplier involvement in NPD are the choice of the supplier, the quality of the partnership and the issue of integration. The criteria for choosing the supplier emerge as a concern that gives rise to various evaluation models. The quality of the partnership seems to be closely associated with two parameters: trust and mutual learning. The integration is seen as an aspect that contributes to the effectiveness of the partnership. Other topics addressed include the issues of supplier development and supplier contribution to the overall competitiveness of the partnership. Below, each of these themes will be referred to.

The choice of the supplier. The question of the choice of the supplier is a widely discussed issue (Ma and Yu, 2013) and the choice of the supplier seems to be linked mainly to the cost structure. Some authors (Kuei et al, 2011) suggest that the company should demonstrate concern for their workforce throughout the global supply chain and with its immediate environment. Johnsen (2009) suggests that the involvement of the provider requires customers to qualify and evaluate the supplier's capabilities.

The supplier involvement by trust. The trust factor arises recurrently as paramount to obtain a commitment and involvement of the supplier (Walter, 2003; Humphreys et al, 2004; Lai and Yang, 2009), and acquiring and providing significant value through better management of supplier relationships (Lawson et al, 2009). Trust can contribute positively but also negatively to enhance the power of incidental learning through the modification of organizational attributes (Knoppen et al, 2010), in order to improve the fit with the trading partner. Fawcett et al (2012) argue that trust can be used to improve collaboration capabilities, proposing a maturity framework that provides the basis for the evaluation of projects and relationship risk.

Within the structure of the concept of trust Su et al (2008) identified organizational behaviour as a factor that can interfere with the proper development of the partnership between the parties. Jap (2001) suggests that competitive advantages can also be corroded over time by suspicions of opportunistic behaviour that arise in the course of the relationship.

Mutual learning. Cheung et al (2010) conceptualize in their results the learning relationship as a joint activity in which buyers and suppliers strive to create more value together than they would individually. The results achieved by Lin and Hsia (2011) show that the development of basic skills is an iterative, repeating cycle, and that these resources should be improved through continuous learning.

The relationship and integration with supplier. Srinivasan et al (2011) confirm that unified partnerships can lead to better coordination and information sharing between partners and can mitigate some of the risks and uncertainty of demand and lead the Supply Chain Purchasing (SCP) to superior results. Zhao et al (2011) provide some guidelines for managers to direct their actions to achieve a better external integration because, according to Shi and Liao (2012) the capitalization of resources requires the integration of business process and team work.

According to Walter (2003), managers act as promoters of the business relationship and have a positive influence on supplier involvement in NPD. Devaraj et al (2007) argue that the integration of the client by itself does not directly affect the operating performance and should be implemented along with the integration of vendor, so that its full potential can be realized. Other authors (Zhao and Shi, 2011) indicate that for the sake of comparison of the total profit, the supply chain integration overcomes outsourcing for most cases, especially when the number of suppliers is complementary. Based on previous studies, Flynn et al (2010) suggest that the best approach to Supply Chain Integration is to begin to develop internal capabilities integration and then to build capacity for external integration with customers and suppliers.

Technological resources and support partnerships. The use of technological resources is found to support the partnership of suppliers and purchasing department in new product development. This characteristic tends to be evidenced (Spralls et al, 2011) and it is important to develop the ability to effectively implement the technologies of e-business in supply chain. Companies should realise the benefits of new technologies for e-Business (Devaraj et al, 2007) and their potential for the integration of the supplier. Studies by Lai and Chen (2009) provide several implications for the management of e-business, so that the results can be used as an indicator of the e-business/success future effectiveness.

Performance and Partnership. Humphreys et al (2004) conclude that the development of suppliers can be positively associated with performance improvement between buyer and supplier. Fynes et al (2004) suggest that, building upon the relations of the supply chain, suppliers can improve the performance of the supply chain itself, and that effort should be considered as an investment that generates future revenue potential. Su et al (2008) show that the existing partnership influences the decision concerning the development of the commercial relationship, and that the quality of the relationship can be used to predict the behaviour of suppliers and manufacturers.

Srinivasan et al (2011) conclude that the ideal situation would be that partners in the supply chain evolve from a formal contractual relationship to a more relational form of governance, where trust in relational governance creates value and superior performance. Yusuf et al (2004) discussed the nature of a supply chain where some attributes and capabilities are explored, such as cost and quality. The prevailing conclusion is that the involvement of suppliers in the new product development can lead to numerous benefits (Schoenherr et al, 2012; Smals and Smits, 2012; Najafi Tavani et al, 2013), such as a reduction in costs and development times, improvements in quality and delivery of innovative technologies.

Supplier Development. Initiatives of Supplier Development are usually necessary in the management of relationships pertaining to important suppliers. It is defined as a long-term effort of cooperation on a company to improve the technical ability of its suppliers, to generate increases in quality and cost reductions, with a view to continuous improvement. The success of supplier development depends on both: the buyer and seller (Nagati and Rebolledo, 2013).

The literature generally supports the notion that supplier development plays a key role in driving performance improvement in purchasing, and strategically contributes to the overall effectiveness of the organization. Therefore, there is a growing interest in supplier development and in the relationship between supplier and company, which is mainly driven by the expectation of the purchaser to improve supplier performance and, thus, enhance competitive advantage (Li et al, 2012).

The nature of business relationships between vendor and company are often established at the beginning of a new product development process, a phase where critical decisions are made, not only with regard to the functionality of the product regarding the customer, but also related to the packaging, logistics channels, source materials, as well as the selection of process technology which will provide the end user the desired functionality (Petersen et al, 2005).

Thus, the importance of supplier development in support of a company's operational strategy helps to ensure that the performance and capabilities of suppliers meet the needs and requirements of a buying firm. The expectation of the purchaser to improve supplier performance also represents the direct involvement of a buyer on supplier development (Humphreys et al, 2004).

A SYNTHESIS OF RESULTS

In the following Table 1, some of the main results regarding the influence of the supplier in the development of new products, as well as other factors that contribute to a better partnership between the company and the supplier, are considered. The table presents selected studies that, in our view, were the ones that fulfilled in a more complete manner, our criteria of relevance and quality regarding the approach to the issue that is addressed in the article. The table intends also to provide the reader with a very concise overview of how the main concerns and approaches are effectively embraced and treated by the researchers in the field.

Table1: Results concerning the influence of the supplier in the development of new products

Author (Year)	Characteristics and contributions of studies
Jap (2001)	The research represents an incremental step towards a better understanding of the complex phenomenon of creating joint competitive advantages in current industrial supply relations.
Walter (2003)	The study provides good support for the hypothesis that the supplier involvement in customer NPD is driven by the commitment and trust of a supplier.
Yusuf et al (2004)	This article discussed the nature of an agile supply chain and explored some of their attributes and abilities that include Internet-based collaboration, a significant amount of sales volume and profit for the virtual business, open leverage capabilities within the networks companies and production rather than outsourcing, and marketing alliances.
Petersen et al (2005)	The results provide additional support, based on previous literature, concerning the value of supplier involvement in new product development process. The study provides strong support for the belief that the entry of a carefully selected supplier facilitates better decision making by the project development team.
Wagner and Hoegl (2006)	High quality collaboration between buyers and suppliers in NPD can only be achieved if the supplier is open and prepared to face the pre-established challenges.
Devaraj et al (2007)	The ability to e-Business is not directly linked to operational performance; However, integration is mediated by production information, which is related to the operating performance.
Su et al (2008)	In the field of relationship management of the chain in terms of theory development and managerial implications, the implication for suppliers is that they need to be early and quickly involved in the design of the product / process and quality planning.
Johnsen (2009)	Supplier involvement requires customers to qualify and evaluate the supplier's capabilities. The relationship with suppliers requires attention so that benefits of supplier involvement materialize: trust takes a long time to develop, but it takes only an instant of opportunistic behaviour to destroy it.
Feng et al (2010)	The study contributes to understand external engagement and integration, besides testing the impact of the involvement of the customer, as well as the impact of the engagement of the supplier at the same time.
Flynn et al (2010)	Internal integration is the basis for integration of customer and supplier. This suggests that the best approach for SCI is to begin to develop internal capabilities integration and then to build capacity for external integration with customers and suppliers.
Wu and Barnes (2011)	Existing research models proposed decision-making concerning the final stage of supplier selection, but very few works have considered the steps that precede or follow this phase. The success of any supply chain (...) is strongly dependent on its construction and selection of partners becomes a crucial issue.
Das (2011)	The introduction of a procedure for supplier membership based on QMS, to ensure quality input for the production and the development of a process to ensure the quality of the final product at the point of shipment.
Lin and Hsia (2011)	The development of basic skills is an iterative, repeating cycle, and these resources should be improved through continuous learning. Companies need to develop a strategic long-term focus by applying all their skills.

Fawcett et al (2012)	The study of trust and collaborative supply chain innovation was subdivided in two ways: the elaboration of the nature of trust, demonstrating when and how trust can be harnessed as a weapon, and the collaborative maturity framework that provides the basis for project evaluation and relationship risk.
Smals and Smits (2012)	Innovation oriented relations are more than a collection of serial transactions, requiring the commitment of both parties and matching of strategies. Value creation to the benefit of supplier is, in part, within the sphere of influence of the purchaser, with an option to share knowledge and skills with suppliers.
Yu and Ma S. (2013)	The effect of sequences of decision on investment, price and profits of the integrated supply chain, of the manufacturer and supplier of quality products, helps to find the dominant strategy from the point of view of each company.
He et al (2014)	The results suggest that integration of suppliers and client integration must be emphasized simultaneously in the development of new products. Managers can also adopt practices of supplier integration in the first place because these practices will enhance the integration of the customer in order to improve the performance of the new product.

Table 2 summarizes the main proposals for lines of future research identified in this study. The table is structured according to four main groups or focus of research: the topic concerning the factors affecting collaboration and partnership, the issue of the nature and quality of the relationship, topics specific of the involvement in new product development and the research on supply chain as a whole, of which involvement on NPD is a part.

Table 2: Proposals for future research concerning supplier involvement in new product development

Topic	Authors	Research Proposal
Collaboration and partnership	LaBahn, Douglas W., Krapfel, Robert.(2000); Walter, A. (2003); Yusuf, Y. ., Gunasekaran, a, Adeleye, E. ., & Sivayoganathan, K. (2004); Wagner, S. M., & Hoegl, M. (2006); Devaraj, S., Krajewski, L., & Wei, J. (2007); Cheung, M.-S., Myers, M. B., & Mentzer, J. T.(2010); Srinivasan, M., Mukherjee, D., & Gaur, A. S. (2011).	Clarification of the factors affecting collaboration and partnership in order to obtain better results for the parties involved. Issues relating to dependence on suppliers, to what extent is beneficial (for the supplier) supplier involvement, and what specific factors may influence these partnerships.

Supplier relationship	Walter, A. (2003); Petersen, K. J., Handfield, R. B., & Ragatz, G. L.(2005); Su, Q., Song, Y., Li, Z., & Dang, J.(2008); Johnsen, Thomas E.(2009); Zhao, X., Huo, B., Selen, W., & Yeung, J. H. Y.(2011); Smals, R. G. M., & Smits, A. a. J.(2012); Schoenherr, T., Modi, S. B., Benton, W. C., Carter, C. R., Choi, T. Y., Larson, P. D., ... Wagner, S. M.(2012); Shi, X., & Liao, Z.(2012).	Research on the value of dynamic relationships, other features of the relationship, such as relational capital and inter organizational trust, evaluation of different cultures and characteristics of suppliers, the pursuit of constant improvement concerning the processes of relationship with suppliers.
Influence of the supplier in NPD	Wagner, S. M., & Hoegl, M. (2006); Cheung, M.-S., Myers, M. B., & Mentzer, J. T.(2010); He, Y., Keung Lai, K., Sun, H., & Chen, Y. (2014).	Clarification of questions such as "How do we get a good cooperation in NPD projects from suppliers?". Focused on the supplier involvement in the product development process, on the factors affecting this specific form of supplier involvement, and on the comparison of the effects of supplier and/or client integration in different stages of development of new products.
Supply chain	Devaraj, S., Krajewski, L., & Wei, J.(2007); Su, Q., Song, Y., Li, Z., & Dang, J.(2008); Cheung, M.-S., Myers, M. B., & Mentzer, J. T.(2010); Srinivasan, M., Mukherjee, D., & Gaur, A. S.(2011); Zhao, X., & Shi, C. (2011); Shi, X., & Liao, Z.(2012); Yu, J., & Ma, S.(2013); Cao, M., Vonderembse, M. A., & Zhang, Q.(2014); He, Y., Keung Lai, K., Sun, H., & Chen, Y.(2014).	Future research should address the question of how deep and necessary is the integration of the supplier. It is valuable for future research to be conducted from the perspective of the supplier, and compare the influence of different perspectives on cooperative strategy. Further research in an important subset of the possible variables in the light of increased competition in the supply chain. Investigate the effect of other types of supply chain risks on the quality of the partnership and SCP.

CONCLUSION

It became evident from the research done the importance of partnerships between suppliers and the company, in several areas where the parties involved can be compensated for achieving results (Smals and Smits, 2012), among which it is included the development of new products. The respective results are composed of tangible and intangible factors, emphasising trust, performance, involvement, partnership, relationship management, resource utilization, innovation of business and technology, management and strategy to suppliers (Shi and Liao, 2012; Walter, 2003; Humphreys et al, 2004; Wagner and Hoegl, 2006; Hsia and Lin 2011).

Regarding the advantage of supplier involvement in new product development, it can be seen from the studies that the level of involvement of a chosen supplier is an important strategic decision, because it requires a significant investment of resources, and monitoring and attendance opportunity costs, and may foreshadow the future of the business relationship (LaBahn and Krapfel, 2000).

The study is more an exercise on synthesis than on critique, so that it can serve as a source of research clarification and questioning involving the important issue of the influence of the supplier on new product development, and its determinants.

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Methodology to reduce cancellations of scheduled surgeries

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ABSTRACT

Purpose. This study presents an integrated methodology to support the logistics management in health facilities in waste reduction and elimination, by providing simple and low cost solutions to minimize the cancellation of scheduled surgeries. The methodology is applied in a Portuguese public hospital. This approach promotes and improves the quality of services to patients.

Design/methodology/approach. The methodology is a problem-solving process which could be applied to manage the flows of services (and materials), and associated information, from the point of origin to the point of care. This approach integrates several stages such as definition, measurement, analysis, improvement and control (DMAIC), and uses the quality and management tools required to obtain efficient and effective solutions to patients.

Findings. The enhanced methodology contributes to an understanding the origins of the difficulties and waste. For the case study, the cancellation rate ranges from 19% and 21% in 2011 and 2012, respectively, and increases to 29% in 2013, although, this year the operating room performed the highest number of operations. The most critical root causes of cancellations are related to the changing patient's state of health, delays in previous surgeries, scheduling of emergency operations, refusal to undergo surgery and other causes.

Originality/value. One of the main contributions of this paper is to apply the DMAIC based approach to study the cancellations of scheduled surgeries in a given Portuguese public hospital, which is an issue rarely addressed in the literature.

Keywords: Quality, Surgery, Logistics, Improvement

Article Classification: Research paper

INTRODUCTION

This paper proposes a methodology to support the logistics management in health facilities in waste reduction and elimination, by providing simple and low cost solutions to minimize the cancellation of scheduled surgery in a given healthcare facility. This approach requires the study of the waste associated with forward and reverse flows of services (and materials) and associated information, from the point of origin to point of surgery performed. Only this logistics and integrated perspective can allow an effective reduction of waste, avoiding its transference from one subsystem to another, or internally, from a clinical department to another.

The cancellation of scheduled surgery is one of the parameters which is used to assess the quality of care provided to users, and the quality of the management system. According to Taner et al., (2007), the quality of a healthcare system is characterized by providing safe, equitable, efficient and effective health services to the user at the right time and on equitable access which should be patient-centred. The proposed methodology focuses on achieving efficient patient-centred solutions at the right time by reducing waste. The waste is related to waiting time or delay, medical and diagnostic errors, long or redundant processes, unnecessary transport and movements, excess stock, a variety of materials and unpredictability which often prejudices the delivery of safe and effective patient care.

The proposed methodology involves making decisions taking into account the interdependence and coordination between all stages of the process and functional areas, by ensuring that the surgery is performed at the scheduled time. Thus, the need to provide a high service to the patient, at the right time and at the lowest cost, makes the logistics more complex in healthcare management (Vaz, 2012). A further objective is to investigate the cancellations problem in the Portuguese public hospital.

The methodology integrates several stages such as definition, measurement, analysis, improvement and control (DMAIC), and uses the quality and management tools required to obtain efficient and effective solutions for patients. DMAIC (Montgomery, 2005; Taner et al., 2007), is a five-step improvement methodology with the aim of continuously reducing waste which can be used in developing and improving the service performance.

Cancellations of scheduled surgeries has been an important and longstanding problem for global healthcare organizations (Dimitriadis et al., 2013). This problem affects also the Portuguese health facilities which are characterized by the increasing costs of providing care services, deterioration of the financial situation and time-consuming processes which, combined with increasing demand, result in providing poor quality service to the patients (Kumar and Gandhi, 2012). There is a scarcity of studies which investigate this problem in Portuguese health facilities. One of the main contributions of this paper is to apply the methodology proposed to study the magnitude of this problem in a given Portuguese public hospital.

The proposed approach should be performed by multidisciplinary teams which requires the involvement of professionals in health and management areas (Carvalho and Ramos, 2009). This increases the success rate on implementation of the proposed improvements by avoiding the conflict between managers and health professionals and the possible risk of penalizing the quality of health services to patients.

The following section presents the literature review about the cancellations of scheduled surgeries. Section 3 describes the proposed methodology which is applied to a Portuguese public hospital and discusses the results obtained. The main conclusions are presented in section 4.

LITERATURE REVIEW

In international studies, the rate of cancellation of surgeries in different hospitals is highly variable and could reach 40% (González-Arévalo et al., 2009; Haana et al., 2009; Kumar and Gandhi, 2012; Rai and Pandit, 2003; Schofield et al., 2005).The variability of this value is dependent on the definition of the point in time at which it is considered that the surgery was cancelled, which can vary from hospital to hospital, type of surgery, size of the institution, characteristics of population health and health system

(Dimitriadis et al., 2013; González-Arévalo et al., 2009; Kumar and Gandhi, 2012). It is observed that there are a few studies (González-Arévalo et al., 2009; Robb et al., 2004; Seim et al., 2009) that investigate data for more than one year although the evolution of the cancellations problem is rarely explored.

There are studies that focus on collecting data and identifying the services (Cavalcante et al., 2000) most affected by cancellation of surgeries. Other studies also investigate the main causes for cancellations (González-Arévalo et al., 2009; Kumar and Gandhi, 2012), classifying them into several groups (e.g., patient, medical and surgical, operating theatre, administrative and logistical). Most of the studies indicates that the lack of time available in the operating-room, increased number of emergency admissions, failure of patients to attend and deterioration of health status of the patients are the most important causes of cancellation of operations (Basson et al., 2006; Haana et al., 2009; Kumar and Gandhi, 2012; Rai and Pandit, 2003; Robb et al., 2004; Schofield et al., 2005).

The literature emphasizes the importance of health units identifying the main causes of cancellation, since, although some causes are unavoidable, others can be avoided (González-Arévalo et al., 2009; Kumar and Gandhi, 2012). The different studies agree that over 50% of cases of cancellation of surgery occurring on the day of surgery, can potentially be avoidable (Dalwani et al., 2010; Schofield et al., 2005).

The following section describes the proposed methodology which is applied to a Portuguese public hospital and the results obtained. The main conclusions are presented in section 3.

METHODOLOGY

The methodology is based on the DMAIC approach and uses the quality and management tools required to obtain efficient and effective solutions for patients. In the first stage (Definition), the process where the problem occurs is identified by collecting information, clarifying scope and defining goals. In the second stage (Measurement), the performance of the current process is measured by collecting the data required. In the third stage (Analysis), the root causes of waste, which hypothetically influence the problem, are analyzed and the most critical factors are identified. This stage requires the involvement of employees who contribute to the process. In the fourth phase (Improvement), the improved process is proposed which enables the elimination of/decrease in the root causes of waste, measurement of results, definition of standard solutions and implementation of changes by designing solutions to enhance the quality of services provided to patients. Lastly (Control), it is necessary to control the changes proposed by monitoring the performance of the process studied.

The waste elimination or reduction observed in the processes is supported by the use of quality tools and lean principles which allow the obtaining of simple, and low cost solutions by involving all employees. The next sections describe how the DMAIC approach can be used to eliminate/reduce the cancellation of scheduled surgeries. The methodology is illustrated by studying the cancellation of operations in a Portuguese public hospital which provides health services to a population from two cites in the same geographical area. This hospital receives about 5% patients from the north of Portugal. The central hospital has two operating rooms: the central room is devoted to non-day surgery and another unit is devoted to day surgery services. The other facility has only one operating room which is devoted to day surgery. This study investigates the cancellations of scheduled non-day surgeries in the central operating room, during the period from January 2011 to December 2013, in which operations in the following specialities were performed: orthopaedics, general surgery, otorhinolaryngology, urology, vascular surgery, gynaecology, obstetrics and obesity surgical treatment. This study classifies a "cancellation" as any surgery that is scheduled in the information system but subsequently did not occur.

Definition. The main objective of this stage is to visualize where the root waste to eliminate/reduce is, and identify opportunities for improvement. In this stage, a multidisciplinary group is established by involving managers and health professionals who participate in the process.

The flowchart or value stream mapping are some visual tools that can be used to graphically represent the current state of process, which helps to identify unnecessary procedures, simplify and visualize waste. Due to space restrictions imposed, the main steps of the current process of scheduling surgeries are represented in Figure 2, from the consultation for initial examination of the patient to the phase that the surgery is performed or cancelled.

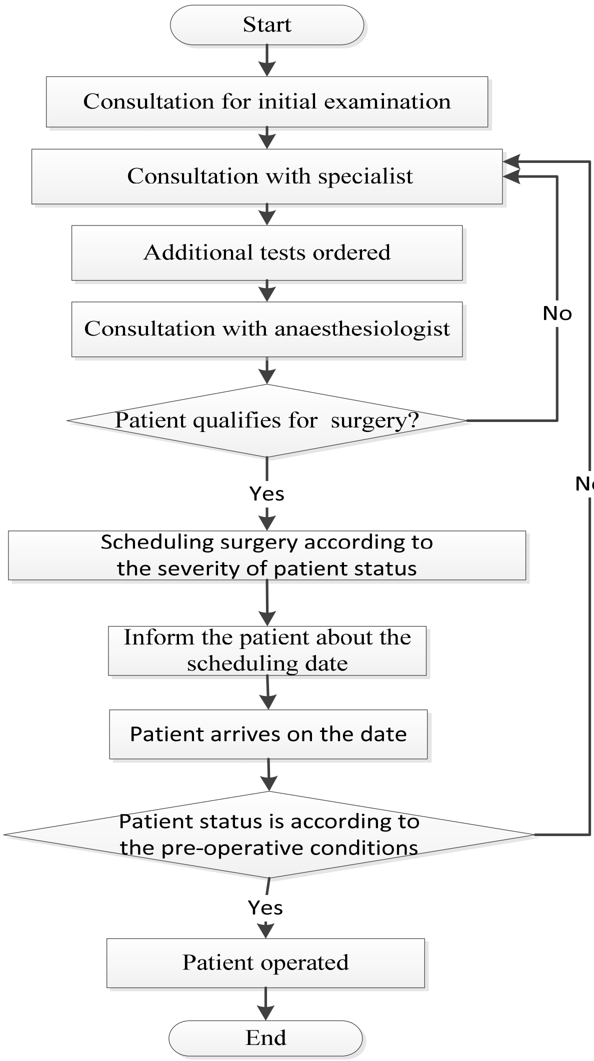

Figure 2 - Scheduling surgical operations process

Measurement. The purpose of the measurement stage is to evaluate and understand the current state of the process. This stage involves collecting data on measurements of the magnitude of the problem which enables us to assess the performance of the current process and monitor the impact of future improvements. These measurements can be indicators of the utilization of health services or indicators of resource utilization. The cancellation rate of scheduled surgical operations (r_c) is defined as the ratio between the number of cancelled operations (n_c) and the total number of scheduled operations (n) to assess the performance of the scheduling surgery process.

Table 2 - Rate of cancellations of scheduled operations

Year	**n**	$\mathbf{n_c}$	$\mathbf{r_c}$ **(%)**
2011	3518	675	19%
2012	3984	837	21%
2013	4861	1430	29%

During the three years, the hospital scheduled an increasing number of operations, from 3518 in 2011, to 4861 in 2013. The cancellation rate ranges from 19% and 21% in 2011 and 2012, respectively, and increases to 29% in 2013. Specifically, this year the operating room performed the highest number of operations, 3431. Next, we explore the extent of cancellations relative to the various specialities.

Table 3 - Rate cancellations of scheduled surgical operations by speciality

	Year								
	2011			**2012**			**2013**		
	n	$\mathbf{n_c}$	r_c	**n**	$\mathbf{n_c}$	r_c	**n**	$\mathbf{n_c}$	r_c
Orthopaedics	939	243	36%	1095	310	37%	1522	798	56%
General surgery	953	163	24%	1176	187	22%	1566	318	22%
Otorhinolaryngology	453	111	16%	430	138	16%	464	136	10%
Urology	378	71	11%	453	91	11%	447	76	5%
Vascular surgery	184	22	3%	200	34	4%	205	41	3%
Gynaecology	406	21	3%	453	45	5%	475	25	2%
Obstetrics	99	32	5%	95	16	2%	32	18	1%
Obesity Surgical Treatment	106	12	2%	82	16	2%	150	18	1%
Total	3518	675		3984	837		4861	1430	

Table 3 shows that the highest cancellation rate is observed for Orthopaedics which has increased significantly over time. It is critical to investigate the causes of the poor performance in this speciality. The decreasing trend has been observed for the remaining specialities, with the exception of vascular surgery which has maintained the cancellation rate at 3%. The lowest cancellation rate is observed for obstetrics and in the Obesity Surgical Treatment Unit, in 2013.

Analysis. The root causes of waste which hypothetically influence the problem are analyzed and the most critical factors (reasons for cancellation) are identified. This stage requires the involvement of staff which contributes to the analysis.

The factors (causes) that, hypothetically, influence the problem of cancellations (effect) are analysed by using the Cause-and-Effect Diagram (or fishbone diagram) to select the most critical factors. The Cause-and-Effect Diagram is a graphical tool frequently used in uncovering potential causes which allows the ranking of factors by order of importance. For the case study, the causes of cancellation for scheduled surgical operations were collected and structured by using the Cause-and-Effect Diagram. Thus, the main causes (factors) for the cancellations can be initiated by issues related to the patient, logistics and administration, medical, equipment, clinical material and medications, operating room, staff and other reasons. The main factors and the subsequent breaking down into secondary factors are structured by a Cause-and-Effect Diagram, presented in Figure 3.

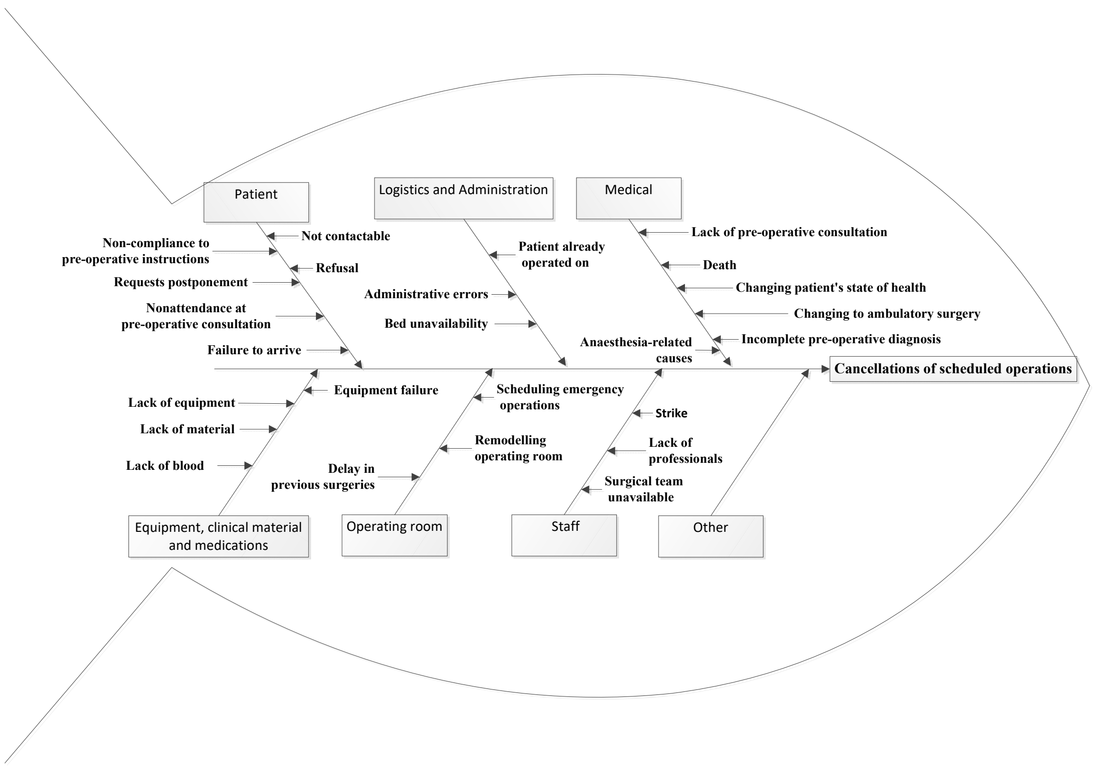

Figure 3 – Cause-and-effect diagram for cancellations of scheduled surgeries

The majority of causes for cancellation are self-evident but some need a little explanation. Cancellations due to ‘Changing patient's state of health’ can be due to the improvement in patient health, or the original diagnosis was judged incorrect for the surgery or sometimes the intervention was not necessary. In this case, the operations can be booked by junior staff or by a different consultant than the one responsible for the operating room list (Haana et al., 2009; Rai and Pandit, 2003).

As the hospital has an ambulatory surgery unit, the non-day surgery can be cancelled and replaced by scheduling a day-surgery.

Cancellations due to 'Delay in previous surgeries' are very common because the duration of surgeries scheduled exceed the available operating-room time and, frequently, the list is overbooked with surgeries. Sometimes the duration of the procedures can be underestimated and the preparation time between the procedures is not included in the scheduling. At other times, the late starts and long waiting times between cases can be due to delayed transportation, operating room cleaning and preparation which involves other services related to the surgical care provision. Another different cause is when the surgery cancellation occurs due to performing an emergency surgery.

Sometimes, some error can occur in the process and the pre-operative consultation is not scheduled. At other times, the patient does not attend the scheduled pre-operative consultation.

The patient may be operated on in another facility if the hospital does not schedule the surgery in the time regulated by the public health administration and, in this case, the surgery can be transferred to another health facility. In other cases, the patient can arrange to have the surgery performed in a private health facility by using health insurance.

At other times, the patient needs to postpone the date due to personal reasons, such as death of a family member, new job or family. In these cases, the public health administration assesses the cancellation causes which are acceptable to schedule again the surgery. Other cancellations can occur due to the patient not accomplishing the pre-operative preparation such as fasting or not stopping the medications. Other reasons include the cases of cancellation that are not classified by the staff who do not register the cause. Regarding the staff, sometimes the surgeon or the anesthesiologist is not available or, at other times, all the professionals are unavailable.

The hospital has a procedure which enables the registrations and classifications can be made by administrative services, although some causes of cancellation are classified as "Other causes" without explanation of the reason. This information is collected and analysed to quantify the causes selected, as this simplifies the further selection of causes which influence more significantly the problem. The rate of cancellation for each main and secondary factor is assessed, as is indicated in Table 4.

Broadly speaking, medical causes are more significant, although this magnitude decreased during the period analysed from 35.6% in 2011 to 29.8% in 2013. This is also observed for the causes relating to the operating room which decreased from 28.1% in 2011 to 15.8% in 2013. An opposite behaviour is observed for patient causes which increased from 13.8% in 2011 to 20.8% in 2013. This is also noted for other causes that went up from 10.2% in 2011 to 17.7% in 2013. The main causes relating to equipment, clinical material and medications are less frequent than the problems with Logistics, Administration, and staff. Next, the Pareto analysis is used to investigate the individual factors causing cancellations to identify potential improvements in the process.

The Pareto analysis can be used to select the most critical factors and identify priority causes responsible for cancellations of scheduled operations, by quantifying their impact. The stacked Pareto chart, presented in Figure 4, shows the frequency distribution arranged by cause of cancellation, over the period analysed. Through this chart, the user can quickly and visually identify the most frequently occurring types of causes of cancellations.

Table 4 – Causes for cancellation in relation to the total of cancellations

	Cancellation as % of total cancellations		
	2011	**2012**	**2013**
Medical causes	35.6%	30.3%	29.8%
Changing patient's state of health	29.8%	25.0%	23.3%
Changing to ambulatory surgery	2.4%	4.2%	4.8%
Death	0.9%	0.6%	0.8%
Anaesthesia-related causes	1.0%	0.1%	0.4%
Incomplete pre-operative diagnosis	0.9%	0.4%	0.2%
Lack of pre-operative consultation	0.6%	0.1%	0.3%
Operating room causes	28.1%	26.8%	15.8%
Delay in previous surgeries	17.9%	12.2%	9.3%
Scheduling emergency operations	8.7%	14.6%	6.5%
Remodelling operating room	1.5%	0.0%	0.0%
Patient causes	13.8%	14.5%	20.8%
Refusal to undergo surgery	6.7%	9.2%	9.5%
Failure to arrive	4.4%	3.7%	2.0%
Nonattendance at pre-operative consultation	0.3%	0.1%	5.7%
Patient requests postponement	0.1%	0.2%	2.7%
Non-compliance to pre-operative instructions	1.6%	0.8%	0.5%
Patient is not contactable	0.6%	0.4%	0.5%
Other causes	10.2%	9.8%	17.7%
Logistics and Administrative causes	5.8%	4.7%	5.7%
Patient already operated on	3.4%	2.2%	4.0%
Administrative errors	2.4%	1.0%	0.6%
Bed unavailability	0.0%	1.6%	1.2%
Staff causes	3.7%	8.4%	7.8%
Strike	1.5%	7.5%	6.8%
Surgical team unavailable	2.1%	0.8%	0.3%
Lack of professionals	0.1%	0.0%	0.7%
Equipment, clinical material and medications causes	2.8%	5.6%	2.4%
Equipment failure	1.5%	1.8%	0.7%
Lack of material	1.3%	3.7%	1.5%
Lack of blood	0.0%	0.1%	0.1%
Lack of equipment	0.0%	0.0%	0.1%

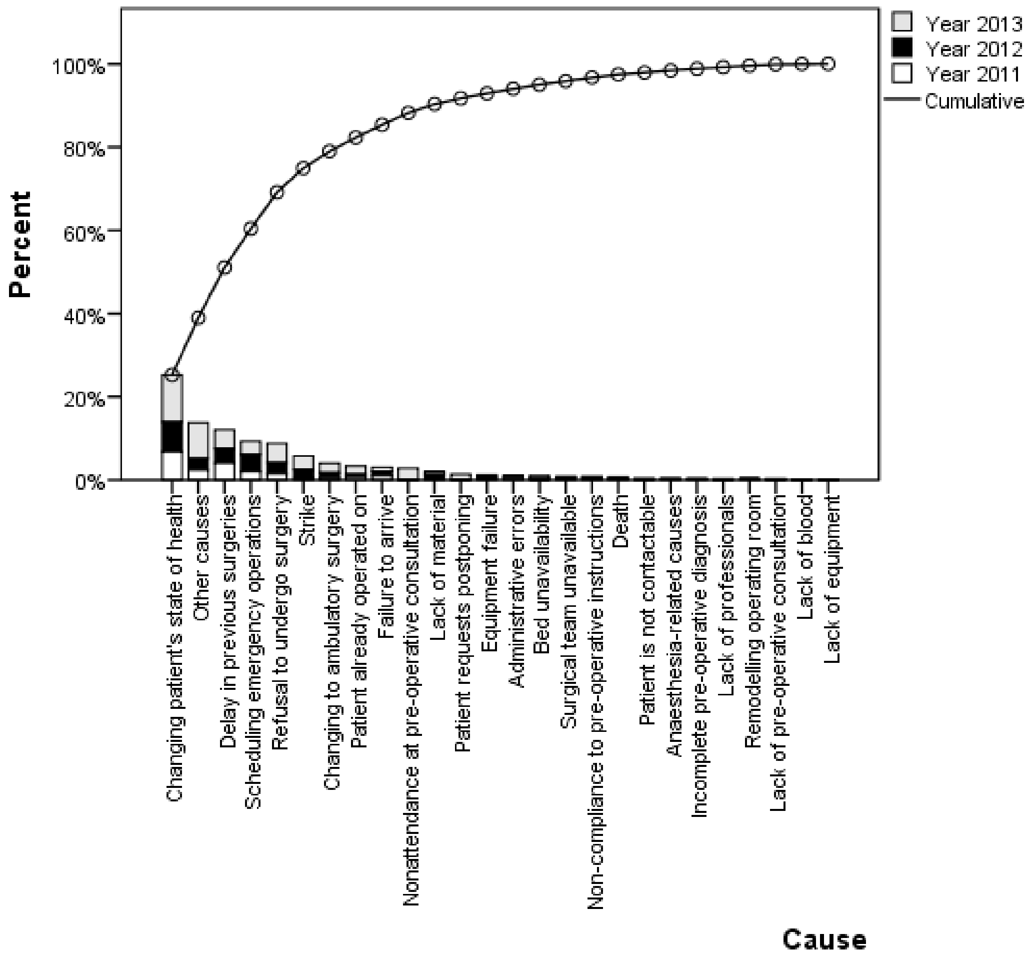

Figure 4 – Stacked Pareto chart of the causes of scheduled surgeries cancellations

The Pareto chart identifies that the most critical root causes of cancellations are related to the changing patient's state of health, delay in previous surgeries, scheduling of emergency operations, refusal to undergo surgery and other causes whose possible solutions are discussed in the next stage. It is interesting to observe that the causes of cancellations have remained the same during the three years analysed.

Improvement. In the fourth stage, the improvements in the process should be proposed which enables the elimination of/decrease in the root causes of waste. The cancellations of scheduled surgeries should be eliminated or reduced and the best practices should be identified. Generally, this analysis involves studying the activities of processes, eliminating unnecessary tasks, combining or simplifying tasks relative to the flows of materials, services and associated information (Montgomery, 2005).

In the case study, the possible solutions to cancellations of scheduled surgery are explored by focusing critical causes identified in the previous stage and by taking the best practices referred to in the literature. It is also important that the improvements should focus on the causes that can be avoided.

Changing patient's state of health

This cause can be reduced by the establishment of pre-assessment clinics before the operation (Knox et al., 2009; NHS Institute for Innovation and Improvement (Great Britain), 2010). This can be performed by a multidisciplinary team supervised by an anaesthetist assisted by a check-list to verify important information about the patient's state of health. The pre-assessment clinic should involve checking the protocol of performing surgery to decide if the operation is even necessary or if the operation should be performed in the non-day regime. In case of surgery, it is very important to clarify the pre-operative instructions which should be adjusted to the current medications of the patient. If the patients are pre-assessed too early before the surgery, their health status can change in the time period until their intervention and if patients are pre-assessed too late, the time available for any procedures implemented (such as the request of additional diagnosis exams) in order to avoid the cancellation, is limited. In this case, the reduced time available reduces the possibility of making the appropriate changes to the operative list. The pre-operative assessment can also enable the decrease in cancellations due to other medical and patient causes identified before.

Delay in previous surgeries

It is necessary to reduce/eliminate the causes of delay in previous surgeries by improving the current utilisation of the operating room time (Garg et al., 2009; Kumar and Gandhi, 2012). This involves the monitoring the deviation from the planned to the actual start time, duration and waiting time for each intervention and by achieving more accurate operative lists. It is also necessary to reduce/eliminate waiting times between cases by improving the efficiency of the multidisciplinary team operations such as transportation, operating room preparation and cleaning, material and medications supply, equipment maintenance and other services related to surgical care provision.

Scheduling emergency operations

This has to be seen as a non-avoidable cause due to the severity of health status of the patient. One way that can be used to reduce its impact on the cancellations of scheduled surgeries is to monitor the time of operating room that is used for emergency operations to forecast the time that is required for these kinds of interventions in the operative list.

Refusing to undergo surgery

The pre-operative assessment can significantly decrease the refusal of a patient to undergo surgery as this situation is identified early to introduce changes in the list of scheduling operations. Other possible solutions to reduce this cause is to communicate with patients the day before the operation by telephone in order to confirm their attendance for surgery (Haana et al., 2009). If the cancellation is confirmed, some arrangements can still be made in order to minimize the waste of resources such as calling other patients to cover the vacancy in the operative list.

Other causes

The staff should classify each cause of cancellation to allow the investigation of the causes of the problem, avoiding the use of "Other causes". As the data set considers all the cases of cancellation during the period analysed, it is expected that the distribution of the causes investigated will remain the same if the other causes were classified.

These solutions should be described and illustrated. This proposal should also be supported by the use of graphical and visual tools. Thus, the comparison between the graphical representations "as is" and "to be" regarding the current state process and future state process, respectively, should be provided as clear evidence that the problem has been reduced or eliminated. This facilitates the acceptance of the solution proposed by the administration and the staff involved in the process. The application of the methodology to the case study is in this stage, where the improved solutions are proposed to the hospital.

Finally, the proposed improvement should require some organizational changes which should be performed. The procedures of the proposed improvement should be documented to avoid future deviations and variations from the standards proposed. The changing procedures require the training of staff involved in the process studied. The visibility of the proposed improvement in the process should be underlined by using visual tools during the entire process.

Control. The performance of the process must be assessed in order to determine whether the improvement was implemented. Thus, the performance indicators should be monitored to check the impact of improvement and to correct some deviations from the plans and objectives. In the case study, it is necessary to control the changes proposed by monitoring the performance of the process studied through the use of the rate cancellations of scheduled surgical operations over time and per specialty. It is necessary to register and classify all the causes of cancellation.

CONCLUSIONS

This paper proposes a methodology to support the logistics management in health facilities of waste reduction and elimination, by providing simple and low cost solutions to minimize the cancellation of scheduled surgery in a given healthcare facility. This approach is a problem-solving process and service/process improvement system which should be applied to manage the forward and reverse flows of services, and associated information, from the point of origin to the point of care. Only this integrated perspective can allow a continuous reduction of waste, avoiding its transference from one clinical department to another.

This methodology is a DMAIC based approach that integrates the quality and management tools required to achieve efficient patient-centred solutions at the right time by reducing waste. A high success rate on implementation of these solutions requires that the methodology should be performed by multidisciplinary teams which involve professionals in health and management areas.

This paper applies the DMAIC to study the cancellations of scheduled surgeries in a given Portuguese public hospital. This can contribute to the investigation of the magnitude of this problem in Portuguese health facilities, which is an issue rarely addressed in the literature. From the application of the methodology to a case study, we concluded that it facilitates the analysis of the problem, contributing to the ranking of causes of problems and understanding of the origins of difficulties and waste, making the proposal more obvious and acceptable to the staff.

For the case study, the cancellation rate ranges from 19% and 21% in 2011 and 2012, respectively, and increases to 29% in 2013, although, this year the operating room performed the highest number of operations. These results can be explained by the worst performance of the Orthopaedic speciality, whose cancellation rate has increased significantly over time, while a decreasing trend has been observed for the remaining specialities, with the exception of vascular surgery which has maintained the cancellation rate. This may indicate that the hospital has developed efforts to decrease the cancellations for some specialities, although it is critical to investigate the causes of the poor performance in Orthopaedics.

The main causes for the cancellations of scheduled surgical operations can be explained by issues relating to the patient, logistics and administration, medical, equipment, clinical material and medications, operating room, staff and other reasons. These main factors and the subsequent breaking down into secondary factors are structured by a Cause-and-Effect Diagram. The Pareto chart identifies that the most critical root causes of cancellations are related to the changing patient's state of health, delays in previous surgeries, scheduling of emergency operations, refusal to undergo surgery and other causes whose solutions are explored by taking the best practices referred to in the literature. It is observed that the causes of cancellations have remained the same during the three years analysed. The improvements proposed focus on the causes that can be avoided by the establishment of pre-assessment clinics before the operation, monitoring and auditing the utilisation of the operating-room time, improving the efficiency of the services related to surgical care provision, monitoring the time of operating-room that is used for emergency operations and confirming the attendance for surgery with patients the day before the operation.

In the future, this methodology can be applied to solve other logistical problems of health facilities, to improve the quality of care provided to patients.

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Redesigning a job using the QFD approach: the case of the customer service in a call centre

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ABSTRACT

Purpose. The paper aims to illustrate how Quality Function Deployment (QFD) can assist the identification of the service features that best respond to the customer demands of a Call Centre. In addition, it discusses the central role of job design in this regard.

Design/Methodology. The research uses the case study of a big Portuguese telecommunications company. Data were initially collected by means of a questionnaire survey applied to both customers and frontline employees. Later, when the House of Quality (HoQ) was built, a panel of experts was involved at different stages, from assigning priorities to customer requirements to evaluating alternative solutions.

Findings. Twenty-seven requirements and thirty-two service features were considered. Job design was found to be associated with the vast majority of the demands. Skills variety, autonomy and feedback are of particular importance and need to be enhanced.

Research implications. The study shows that, despite cost reduction concerns, organisations must invest in enriching the job performed by frontline employees in Call Centres so that customer demands are met. The technological component of the job must be combined with functional contents.

Originality/value. Although the use of the QFD methodology is not new, it is normally targeted towards the development of a new product, service or process. The idea of applying it to the redesign of a job, an under researched topic, is original. Moreover, taking both customers and employees as "clients" of the job design is also uncommon.

Keywords: Job design; QFD; House of Quality; Call Centre

Article classification: Case study

INTRODUCTION

Over the two last decades, Contact Centres have been more and more in the spotlight in what the commercial strategy of an organisation is concerned. Organisations expect Call Centres to provide a service that is well regarded by customers while complying with tight cost control targets. In addition, Contact Centres use a workforce that is not highly valued and that has a significant turnover rate (Castanheira et al., 2010). Facing considerable pressures to reduce costs, the tendency is to implement high-technological solutions as a replacement of human intervention.

Yet, as in any other service context, frontline employees have a key role in the so-called "moments of truth" (i.e. when the customer is in direct contact with the organisation that provides the service). It is in such moments that the customer builds an image (either positive or negative) of the organisation (Gil et al, 2008). The way employees behave in such circumstances strongly depends upon the way their work is designed. Job design has a great impact on the way the work is done and on the overall functioning of an organisation. Additionally, a vast literature has shown that job design has important consequences in terms of the individuals' commitment and satisfaction (Hackman and Oldham, 1980).

Typically, customer-contact employees perform a job that is highly standardised and closely monitored. Moreover, scripts increasingly play an important role in shaping employees' behaviours and tend to reduce human autonomy by defining standard answers to customer demands. Yet, when contacting call centres, customers might well have different expectations in terms of customisation and individual attention. Not rarely, customers perceive those responses as being too mechanical and not sufficiently linked to their own/specific problems. Current work design can therefore prevent employees to have a flexible and kindly attitude, having a negative impact on customer satisfaction.

The issue of a poor work design and of the consequences that it might raise is not sufficiently addressed in the majority of the satisfaction surveys developed by the firms and should be incorporated from the beginning when developing a service. The problem is particularly relevant for telecommunication companies given the high volume of customers served, the high number of frontline employees who work in Call Centres, the turnover rates and the geographical dispersion.

The current research uses a quality planning tool –the Quality Function Deployment (QFD) – to (re) design the job performed by the frontline employees of a Contact Centre of a big telecommunications company operating in Portugal. Both the characteristics of the job and the organisational practices (such as recruitment, training, appraisal) that surround it are embraced here in the idea of job design.

Data were collected from customers and employees using both qualitative and quantitative approaches. Shortly, the questionnaires applied incorporate the service quality determinants proposed by Parasuraman, Zeithaml and Berry (Parasuraman et al., 1988) and the dimensions of the job suggested by Hackman and Oldham (Hackman and Oldham, 1980). Qualitative data was essentially collected from the firm records of complaints and from meetings with a panel of experts.

The QFD methodology (Hauser and Clausing, 1988) explicitly incorporates the quality requirements identified by customers and employees in a matrix – the House of Quality (HoQ). Although the QFD methodology has been used by numerous organisations worldwide for more than thirty years, it is normally targeted towards the development of a new product, service or process. The idea of applying it to the redesign of a job is original. Moreover, taking both customers and employees as "clients" of the job design is also uncommon.

The remainder of the paper is structured as follows. Firstly, the core issues on work design are briefly discussed. Next, the research design is presented. Then, the case study is described and the application of the QFD methodology is, step-by-step, illustrated. Finally, based on the findings, some practical implications are derived and recommendations made.

CORE ISSUES ON WORK DESIGN

Work design has changed over the years and also varies across organisations. It essentially reflects the various organisational models. For the purposes of this paper, two models are discussed: the scientific model and the organic model.

At the shopfloor level, the scientific model is associated with the works of Taylor, who has conducted several studies to find the "one best way" to perform a job (i.e. the sequence of tasks and moves that leads to the maximum efficiency). To achieve this, each work is decomposed into smaller steps and its complexity is reduced. In accordance, workers are quickly trained to perform the tasks assigned to them and the degrees of freedom to perform the jobs are virtually non-existent. The emphasis is on compliance and conformity (Clemmer, 1992).

On the other hand, the organic model regards the organisation as an open system and takes a holistic perspective of its components. Consequently, interdependency and sense of purpose are stressed and the need of the organisation to make adjustments according to the context acknowledged.

Total Quality Management (TQM) philosophy combines elements of both paradigms (Spencer, 1994) even if the organic view is somehow dominant. In fact, TQM also looks for efficiency and values a certain degree of standardisation on the way jobs are performed with the aim of ensuring consistency. However, TQM clearly criticises the scientific model tendency to over-specialisation and the planning/execution dichotomy, which together kill the employees' creativity and lead to lack of innovation. In line with the organic model, TQM gives emphasis to continuous improvement, innovation and learning.

Quality management tends to put some demands on work design. Employee involvement is a key element of the TQM philosophy. Employees are expected to be more autonomous, control the quality of the work they are doing, and continuously suggest improvement actions. To meet these challenges, TQM argues that education and training to all employees is essential and that job enrichment is beneficial.

The literature often stresses the importance of employee satisfaction, namely given its role as a potential driver of customer satisfaction (Comm and Mahaisel, 2000; Mansour and Nusairat, 2012). The well-known Hackman and Oldham model (Hackman and Oldham, 1980) suggests that employee satisfaction is linked to the characteristics of the job, giving thus emphasis to work design.

In modern Contact Centres the work performed by frontline employees is closely monitored using sophisticated information systems. The organisation knows in real time how long it took an employee to answer a phone call and which applications were used and how. Everything is recorded and controlled. Theoretically, almost all responses to customer demands are predicted in detailed scripts that employees are expected to follow. Therefore, standardisation is paramount and is facilitated by the extensive use of technology. Cost concerns mean that efficiency must be pursued at all time. One can thus conclude that the work design clearly follows a Tayloristic approach.

This scenario raises several questions:

- Does this work design respond to customers' expectations?
- Are frontline employees committed to the job they perform? Do they feel motivated?
- Which changes need to be introduced?

RESEARCH APPROACH AND ASSOCIATED INSTRUMENTS

Given the need to understand what drives a certain work design, what are its consequences in terms of organisational practices and how it can be modified to better meet customers' and employees' demands, a case study approach (Yin, 1993) is followed.

Telecommunication companies extensively use Call Centres and have developed sophisticated solutions to standardise the work using complex technologies and information systems. A self-care system is in place and often the customer simply interacts with the machine without human intervention on the company side. Organisations invest in more and more intelligent machines to make them able to give automatic responses to an increasing number (and variety) of customer demands. In other situations, the customer comes in direct contact with the organisation to solve a more complex problem. In such circumstances, customers increasingly expect individual attention and demand from the frontline employee responses that fit their specific needs (Leelakulthanit and Hongcharu, 2011). The main problem is that the employee's behaviour is severely constrained by the scripts. Responses tend to remain highly standardised and the customer feels that he/she is not being listened to. Due to these two completely different service modes, frontline employees face contradictory demands and tension is likely to raise (Dean and Rainnie, 2009). Thus, selecting a telecommunication firm became a logical option to analyse this kind of pressures upon job design.

Secondary data sources collected from the case study organisation confirmed this scenario of contradictory demands and pressures. In fact, when analysing the results of customer surveys and other service performance indicators implemented in the firm it was possible to notice that, despite relatively high levels of customer satisfaction, a significant number of negative comments and complaints concerned the way customers felt treated when contacting customer services.

One Contact Centre in particular was selected for this study. It interacts with residential customers for non-technical matters, has around 1000 employees and deals with about 5 million calls a year.

By using Hackman and Oldham model (Hackman and Oldham, 1980) that characterises the work according to five key dimensions (skills variety, task identity, task significance, autonomy and feedback), two questionnaires following the lines of the JDS – Job Diagnostic Survey – instrument were developed. One was administered to a sample of 424 customers and the other was applied to 484 frontline employees of the Call Centre. The customer survey, besides analysing how customers regard the job characteristics of frontline employees, also included some questions to measure certain aspects of service quality and so-called "trade-off questions" that made the customer decide between two opposing features (e.g. speediness vs. long explanations).

Questionnaire results were essential to have a first list of requirements. To complete the list and structure the requirements a group of experts was used. An affinity diagram (KJ) (Akao, 1995) was built at this stage.

Finally, the HoQ was used to integrate all data and to identify the features of the job that best responds to the requirements. The HoQ is the central matrix of the QFD methodology. It helps to translate requirements into product/service/process specifications (Hauser and Causing, 1988). It is also possible to establish priorities based on the importance assigned by customers to the various requirements and on the strength of the relationship between each service feature and each requirement.

It is important to notice that the whole process is customer-driven. Everything starts with the Voice of the Customer (VOC) and product specifications derive from customer needs rather than from the feelings of the firm technicians or marketers.

The HoQ simultaneously addresses the following questions:

- WHAT does the customer want?
- What is the RELATIVE IMPORTANCE of each customer requirement?
- HOW can the product/service respond to customer requirements?
- How does each product/service feature RELATE TO others?

The answers to these questions are given in the various "rooms" of the HoQ (see Figure 1), namely:

- Room 1 – Customer Requirements
- Room 2 – Product/Service Features
- Room 3 – Relationships Matrix
- Room 4 (Roof) – Relationships among Features
- Room 5 – Competitive Analysis
- Room 6 – Technical Importance
- Room 7 – Features Planning
- Room 8 – Target Values (Specifications)

The results from the questionnaire survey applied to the sample of customers of the Call Centre were used to identify the customer requirements (Room 1). Although the questionnaire did not directly ask the customers about their requirements, section 1 measured customer satisfaction on a series of items and section 3 requested them to choose between alternative service models. Customer requirements in Room 1 correspond to the items with lower satisfaction levels and to the features of the service models that received more preferences. In addition, a group of experts also identified some requirements based on their experience in analysing customer feedback. The requirements in Room 1 were structured using an affinity diagram (KJ).

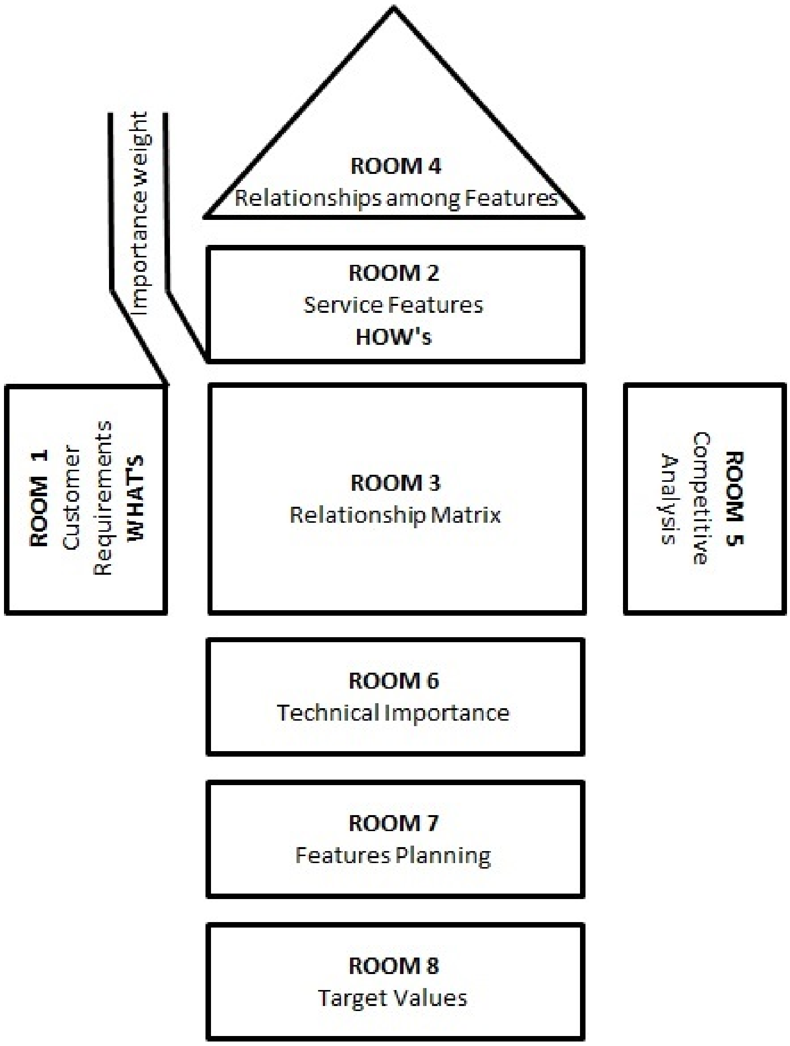


Figure 1 – House of Quality

To fulfil the customer requirements a set of service features were identified by the experts in Room 2. Such features mainly correspond to job characteristics, HRM practices and work processes that need to be redesigned if new service models are to be introduced.

Room 3 and 4 analyse the impact of service features on customer requirements and the possible synergy/conflict among service specifications, respectively. The group of experts assistance was essential to evaluate the strength of such relationships.

The House of Quality thus integrates results from previous studies, which, due to length constraints, are not fully presented in this paper. In the next section, the process of building the HoQ is described in some detail.

BUILDING THE HOQ STEP-BY-STEP

Room 1 – Customer requirements

Room 1 in the HoQ presents the requirements structured according to their affinities (in our case a KJ diagram was used to structure the requirements).

Customer requirements were identified based on the results of the questionnaire administered to a sample of 424 customers and on the views of a group of experts. The group of experts (4) combined middle managers with responsibilities in Customer Care with operators who are in direct contact with customers. They all have (or had in the past) contact with customer complaints or deal with conflict solving situations, thus having an idea of the most common reasons of dissatisfaction and/or expectations that are still not met by actual service standards. Due to their background, the researchers felt that they could evaluate the data collected from customers through the questionnaires and somehow complement it.

Twenty-seven requirements were identified. Each expert was asked to select the top 10 requirements and to assign 10 points to the one he/she considered to be the most important one, 9 points to the next, and so on. Preferences were somehow scattered. Table 1 shows some customer requirements with relatively high importance scores.

Table 1 – Examples of customer requirements

Customer requirement	Score*
The situation is solved in a single contact and the customer is informed.	20
A solution is found in a short period of time	19
The frontline employee communicates in a positive tone	17
The frontline employee sounds committed to provide a quality service	16
The solution proposed fits the individual/specific problem presented by the customer	15
The frontline employee shows that he/she is aware of previous contacts and events	12
The frontline has technical expertise	10

* to simplify calculations in the HoQ matrix, the scores were converted using the following scale: Extremely important (5) – 20 points or more; Very important (4) – at least 10 points and less than 20 points; Important (3) – at least 5 points and less than 10 points; Somehow important (1) – at least 1 point and less than 5 points; Not important at all (0) – 0 points.

It is worthwhile to notice that many of the most important customer requirements directly relate to the quality of the answer/solution given to the problem the customer faces and not as much to interaction aspects. In this case, using Gonroos terminology, technical quality sounds at least as important as functional quality. Moreover, speed and solution in a single contact are emphasised. Customisation seems to be more associated with individual attention (to the specific problem the customer faces), i.e. being able to listen to what the customer says, rather than showing sympathy or empathy.

The experts group also collaborated in the KJ. First, each customer requirement was written in a post-it. Then, the ones that sounded more ambiguous were rewritten and their meaning clarified. In the next stage, through an iterative process, the experts grouped the requirements that shared some kind of affinity. Three groups emerged:

- Knowledge/Competencies
- Attitudes and Behaviours
- Solution elements

Room 2 – Service features

Room 2 covers the characteristics that should be part of the Customer Care Service. The goal is to understand how to meet customer requirements. Based on the experience of the experts and on the researchers' knowledge, thirty-two features were identified. Table 2 presents a selection of such quality attributes.

Table 2 – Examples of service features

Service Feature	Category*
Task identity	WD
Variety of skills	WD
Autonomy	WD
Continuous training	OP
Commitment	ATT
Individual Performance Assessment	OP
Rewards and recognition schemes	OP
Customer Orientation	ATT
Willingness to take risks	ATT
Opportunities for employee's suggestions	OP

* Service features were grouped according to their underlying meaning (WD – Work Design; OP – Organisational Practice; ATT – Attitude).

Some of these features, directly relate to job characteristics (Hackman and Oldham model), some others concern organisational practices that should be in place to foster certain attitudes on the part of the customer-contact employees. A few characteristics are related to working attitudes in particular.

Looking at the quality attributes identified, it is possible to notice that the telecommunications company need to take care of eleven aspects when managing its frontline employees:

- Recruitment
- Selection
- Work design (covering the five JDS dimensions)
- Technical training
- Development of cross functional skills
- Job integration
- Organisational culture
- Performance assessment
- Career development
- Individual attitudes
- Work procedures

Room 3 –Relationship matrix

Room 3 reflects the strength of the relationship between each pair of customer requirement and service feature (quality attribute). If a given attribute has a noticeable impact on a certain requirement (i.e. contributes to meet a customer demand) than a symbol is inserted in the corresponding cell. Different symbols indicate different degrees of association (naturally, when no relationship exists the cell remains blank).

Figure 2 shows a piece of the relationship matrix.

When looking at the relationship matrix as a whole, the main concern is to ensure that all customer requirements are covered by the solution proposed (i.e. there is at least one feature that meets a given demand). Additionally, to ensure an optimal design, it is important to check that all features add value to the system proposed (i.e. there are no unnecessary quality attributes).

Room 4 (Roof) – Relationships among Features

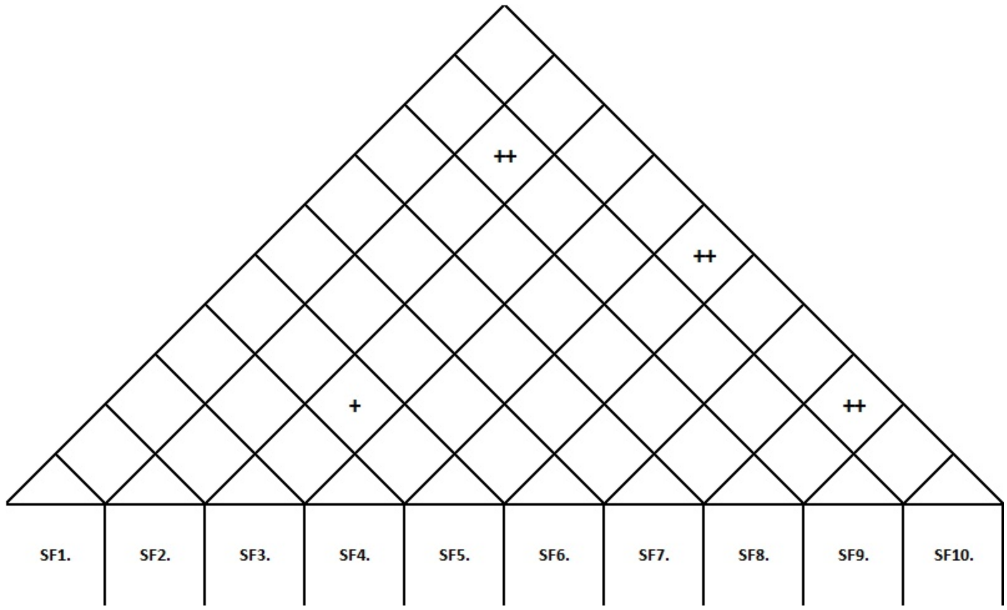
The impact of each feature on the others is assessed in the Roof. Positive correlations mean that there are synergies among characteristics (i.e. that a certain attributes reinforces another one). In practice, the existence of such situations give freedom to relax a bit one feature and thus finding a more cost-effective design. On the other hand, negative correlations are particularly worrying since they indicate conflicts among features. In such cases, a good performance in one dimension jeopardises another. It is critical to solve these conflicts as soon as soon possible, by finding alternative designs or establishing the most adequate trade-offs.

		Importance weight	SF1. Task identity	SF2. Variority of skills	SF3. Autonomy	SF4. Commitment	SF5. Customer Orientation	SF6. Willingness to take risks	SF7. Continuos training	SF8. Individual Performance Assessment	SF9. Rewards and recognition schemes	SF10. Oportunities for employee's suggestions	... ...
R1.	Situation solved in a single contact and customer Informed	5	△	●	●	△	●	△	●	△	△		...
R2.	Solution found in a short period of time	4		●	●		●	△	●	△	△		...
R3.	Frontline employee comunicates in a positive tone	4	○	○	△		○	△	●	●	△	△	...
R4.	Frontline employee sounds committed to provide a quality service	4	△	△	△	○	●	△	●	●	△	△	...
R5.	Solution porposed fits the individual specific problem	4		●	●		●	●	○	△	△	△	...
R6.	Frontline employee is aware of previous contacts and events	4	△	△	○		●		○	○	△		...
R7.	Frontline employee has technical expertise	4		△			△		●	△	△	△	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...

Note: Strong relationship (●); Moderate relationship (○); Weak relationship (△)

Figure 2 – Portion of the relationship matrix

A portion of the roof is depicted in Figure 3.



Note: ++ denotes a strong positive correlation; + denotes a positive correlation; – denotes a strong negative correlation; and – denotes a negative correlation.

Figure 3 – Portion of the Roof

When the whole roof is analysed, it is possible to observe that two quality attributes are strongly correlated with many other features, namely "Customer Orientation" (SF5) and "Individual Performance Assessment"(SF8). It is importance to notice that these two characteristics are complementary. In fact, Customer Orientation seems to be essential to promote less standardised, more customised answers/solutions to the problems presented by customers. At the same time, Individual Performance Assessment is critical for the organisation to assure that an adequate degree of consistency and conformity is achieved, especially when, such is the case here, the service is provided by many employees in many different locations. Together, they contribute to increase flexibility while keeping the responses aligned with the organisation's standards and values.

Room 5 – Competitive Analysis

The HoQ aims in our case to assist the identification of the most appropriate work design for the job performed by customer-contact employees of a Call Centre. Many of such dimensions refer to people management aspects. A competitive benchmarking would be extremely difficult to carry out due to the lack of data on such matters.

Room 6 – Technical Importance

The technical importance of each service feature (TIj) is found by using the following formula:

$$TIj = \sum_{i=1}^{n} x_i \times y_i$$

Where i represents each customer requirement, x_i its corresponding importance and y_i the strength of the association between the requirement and the feature under assessment.

Thus, the value obtained (TIj) gives an indication of the criticality of the corresponding feature (j), since it combines an evaluation of its potential to meet the various requirements with the relative importance of each customer demand.

As mentioned earlier, in this case study a scale from 1 to 5 was used to show the importance of the various customer requirements, while the degree of association between each service feature and each customer requirement varied from 9 (when the relationship is strong) to 1 (when the relationship is weak).

The technical importance of the services features selected is shown in Table 3.

Table 3 – Technical importance for a sample of service features

	SF1.	SF2.	SF3.	SF4.	SF5.	SF6.	SF7.	SF8.	SF9.	SF10.
For the requirements in Figure 2	25	141	137	17	205	53	213	101	29	16
Overall	79	320	306	71	520	166	470	258	62	80

In total, thirty-two features were considered. Variety of shills (SF2), autonomy (SF3), customer orientation (SF5), continuous training (SF7) and individual performance assessment (SF8) are among the ten most important quality attributes. Besides "variety of skills" and "autonomy", the list includes also "feedback" what gives an idea of the importance of job design in meeting customer demands. It is interesting to notice that, according to the questionnaires administered to customers and employees, autonomy and feedback were indeed the job dimensions in need of further development. Investing in these aspects will have a positive impact on the satisfboth customers and employees satisfaction. Continuous training is essential to develop new skills and attitudes and cannot be underestimated by the organisation. Interdisciplinary skills in particular are paramount to meet customer demands.

Room 7 – Features Planning

In room 7 it is decided how to measure each feature. This room is not presented here.

Room 8 – Target Values (Specifications)

Defining a target for each feature requires an in-depth reflection and the integration of information from various sources. This work has not been carried out yet.

CONCLUSIONS AND IMPLICATIONS

As in many other contexts, the HoQ was a valuable tool. It calls for the integration of different types of data (and data sources) in a single matrix, leading to a work design that is clearly driven by the customer requirements but that also values other kinds of inputs (namely in the assessment of the service features).

Quality planning has confirmed the need for Call Centres to combine high-technological solutions with personal contact in a mix of cost efficiency and individual care and attention. It became clear that in order to ensure the kind of service the customer expects both job specifications and organisational practices need to be adjusted. Along with the design of the job to be performed by frontline employees, it is necessary to consider issues such as training, in particular the development of cross-functional skills, and changes in performance appraisal schemes.

Autonomy and feedback emerged as the dimensions of work design that need to be more reinforced, since they are strongly associated with various service quality requirements. Customer orientation is essential to give the employees opportunity to listen to customer demands and have freedom to act accordingly. Individual performance assessment needs to be in line with the new work design so that the desired behaviours and attitudes are fostered. Efficiency, effectiveness and consistency must be simultaneously considered when identifying the new performance indicators. This is essential to meet the challenge of combining control and customisation. The new work design incorporates control practices associated with standard procedures with a certain degree of empowerment. The frontline employee makes some decisions and becomes more accountable as a way to meet customer expectations and needs of individual care and solutions in a single contact.

Future studies could further investigate the relationship between the traditional work characteristics proposed in the Hackman and Oldham model and customer orientation and performance appraisal, since they seem essential to give plasticity to work design.

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Use of sectorial essential models in organizational interventions aiming at the implementation of quality assurance processes

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ABSTRACT

In view of the growing supply of models in various domains and in different formats, and the potential benefits to organizations using them, this article proposes to (1) present the theoretical background to the organizational developments, (2) to propose a framework for defining organizational models of quality in HEIs, and (3) situate and discuss issues associated with the use of methodological approaches that employ, "as is" and "to be" models, but also "ought to be" models and the benefits of the use of sectorial essential models, in organizational interventions. Organizational intervention is a generic designation for any activity involving organizational change, in order to achieve benefits for the organization. The interventions that adopt information technologies, or at least, the introduction of significant changes in activities with a strong emphasis in information processing, are especially relevant. This definition comprises organizational interventions, which aim at implementing quality assurance processes.

This work in progress emphasises the following representations: business processes; management indicators for a business' sector; business conceptual model (ontology). These models correspond to good organizational practices of a specific sector, and are generally promoted, developed and disseminated by corporate associations, or professional societies within a business area. The use of these models in organizational interventions has numerous benefits, primarily those related to the use of methodological approaches that employ, not only "as is" and "to be" models, but also "ought to be" models. The combination of these models is recommended in several informational systems' development methodologies.

Keywords: Organizational Development, information systems, models, quality assurance system, Sectorial essential models.

INTRODUCTION

Quality engineering and management can be presented as a form of organizational development, i.e., a course of action that aims at improving some aspect of an organization. On the other hand, the implementation of quality assurance mechanisms in an organization typically involves the implantation of IT applications. These IT applications address aspects such as: support to quality manuals production, sharing and update; record of objectives and goals; recording and sharing of documentation related to the processes that are object of quality intervention; recording of non-conformities and follow-up of measures to correct them; reporting; etc. So, in this article the implementation of quality assurance mechanisms is viewed as a form of *information systems development* – ISD. ISD is a special case of organizational development, one where the adoption and exploitation of IT applications plays an important role.

Organizational development, like ISD, inevitably involves dealing with models of the organization that is being developed. These models are used to support the reasoning and decision-making associated to the development process. In ISD it is common to consider two types of models: models of the current situation or AS IS models; models of the desired future situation or TO BE models.

The work in progress described in this article addresses the use of a third type of model, a model of a situation that incorporates the current best practices for the market sector the organization fits in – OUGHT TO BE model. OUGHT TO BE models correspond to ideal situations that will be used to critically examine the existing situation of an organization (later conveyed in AS IS models) and to support the production of TO BE models.

The production of OUGHT TO BE models is however difficult to achieve. Mature developers use the knowledge they accumulated along their professional experience. But even veteran developers didn’t go through all possible situations covering all the different market sectors that inevitably bring too much diversity to the organizational configuration. Both mature and novice developers can benefit from the existence of reference models that combine state-of-the-art knowledge from both academia and professional practice. It makes sense that these reference models are adjusted to the restrictions of market sectors, thus providing an essential perspective of several organizational aspects pertinent to any organization within the market sector.

The objectives of the research work described herein include:

- Define a basic set of elements to be included in essential/reference models;
- Explain how these models can be used to produce OUGHT TO BE models;
- Appraise the benefits of using OUGHT TO BE models in organizational development projects, especially in ISD;
- Propose a form of using essential/reference models as proto OUGHT TO BE models.

MODELS IN ORGANIZATIONAL DEVELOPMENT PROCESSES

Organizational development. Cummings and Worley (2005) presented organizational (OD) development as proposed the following definition: “a system wide application and transfer of behavioral science knowledge to the planned development, improvement, and reinforcement of strategies, structures, and processes that lead to organization effectiveness”. The term development suggests that it is sought some sort of grow, an increase in maturity or the achievement of more advanced status that will enable an organization to realize its potential and attain desired goals.

Organization development is any process or activity, based on the behavioral sciences, that, either initially or over the long term, has the potential to develop in an organizational setting enhanced knowledge, expertise, productivity, satisfaction, income, interpersonal relationships, and other desired outcomes, whether for personal or group/team gain, or for the benefit of an organization, community, nation, region, or, ultimately, the whole of humanity [McLean, 2001].

Usage of models in organizational development – AS IS and TO BE models. Anderson and colleagues (1991 in Shehabuddeen *et al.*, 1999) state that "models are representations of real objects or situations. These representations, or models can be presented in various forms or format". They categorize models into three types: (1) models that do not have the same physical appearance as the object modeled, but are an analogy; (2) models that are physical replicas of real objects; and (3) models that represent problems by a system of symbols or mathematical representations. The models we address in these article correspond to the third type of Anderson and colleagues' models, often based on diagrammatic languages but not in mathematical formalisms.

Organizational development processes are typically conducted in accordance with a vision that involves the production of two types of models:

- Models that describe the current state of the organization - AS IS models;
- Models that describe the desired situation for the organization - TO BE models.

The AS IS model depicts the current reality of an organization. One of the main purposes of the AS IS model is to establish a baseline so that an analysis of the current business can be performed, and to identify areas that require attention. AS IS models typically address the various dimensions of an organization, including the structure, its relationship with the outside world, their workflows, information systems and machines that support execution of processes [Castela & Tribolet 2004].

The need for this model can be justified with arguments such as: i) before proceeding, it is necessary to know "where it is", ii) modeling the current situation helps the organization to understand how the existing assets - skills, organizational structures, processes and technologies - come together to support the business strategy [Pournara 2012].

AS IS models support several tasks during the development process, such as the reengineering of business processes, the implementation of quality management systems, and the capture of requirements for the development of information systems. Despite the recognition of their value AS IS models are regarded as disposable after use [Castela & Tribolet, 2004]. This means that new AS IS models have to be built whenever a new development process is launched. Because organizations are dynamic and demand recurring interventions, several AS IS models will be necessary along an organization's lifetime [Castela & Tribolet, 2004].

To produce an AS IS model it is necessary to go through an analysis of the current state of the organization. The model will then be used to support the "design" stage.

During the design phase decisions are made regarding the desired future situation. The desired future situation incorporates the solutions for the perceived problems and whatever is considered to be necessary to achieve a more developed organization.

The TO BE model is a description of the desired future situation. It will be used during the implementation stage to guide developers on the action to carry out that will enable to attain the desired future situation.

Figure 1 illustrates the usage of AS IS and TO BE models in organizational development projects.

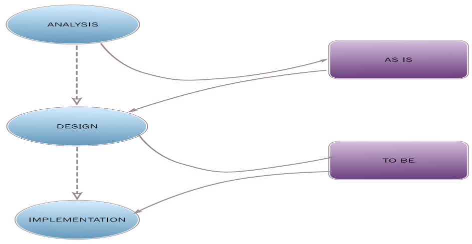

Figure 1: The usage of AS IS and TO BE models in organizational development projects

This approach to organizational development that involves the AS IS and TO BE models has some inconveniences as it involves considerable costs related to modeling [Owens, 2013].

Other limitations can be attributed to the approach; Owens [2013] mentions that it has proved to be inadequate to the reality of today's institutions. Besides the cost, the approach also leads to long duration interventions due to the need of surveying the organization in order to documents its structure, ways of working and other dimensions relevant to the intervention proves. These limitations affect the necessary agility modern organizations have to exhibit.

Ought To Be Models. We live in a great change era, what is new today may become obsolete tomorrow and the same is applied to the information that forms the basis for decision-making in organizations [Amaral & Varajão, 2000]. The current situation is important to assist the process of change. The problem is not the AS IS models but the mismatch of its detail and the conditions of strategic alignment that are not normally associated [Coelho, 2005].

An alternative to the approach described in section 2.2 involves a third model – the OUGHT TO BE model.

The OUGHT TO BE model describes an ideal situation for the organization. Ideal in the sense that it doesn't take into consideration the restrictions that might be imposed by the current existing situation. OUGHT TO BE models should be produced before the AS IS models. They enables developers with a powerful basis for criticizing the current existing situation and for supporting the design and planning of improvements that take into account a previously defined future desired situation.

The idea of using of OUGHT TO BE models is not new. Checkland's Soft Systems Methodology (SSM), for example, suggest the creation of such models corresponding to the root definition of each of the relevant systems corresponding to one problematic situation [Checkland, 1991]. In SSM these models are named conceptual models. In a later step of a development process following SSM, the conceptual models are compared with the existing situation as a basis for diagnostics. The outcome of the diagnostic supports the definition of changes that are simultaneously "systemically desirable and culturally feasible" [Checkland, 1991].

Owens (2013) reinforces this idea when he confirms that an organizational intervention should include a description of what the organization "should do". This model adds value to the organization, once it abandons the existing processes as a starting point and begins with an ideal situation.

Supporters of this approach to organizational development suggest that the organizational intervention should not be initiated by the traditional analysis of the current situation (leading to AS IS models), but the designing an ideal organizational model (something close to OUGTH TO BE model). The production of the OUGTH TO BE model might be based on reference models that embed theoretical principles and/or good practices. These models are then used in combination with the models introduced earlier – AS IS and TO BE models [Coelho, 2005].

THE PRODUCTION OF OUGHT TO BE MODELS

To produce an OUGHT TO BE models is not an easy task. OUGHT TO BE models correspond to one supposed ideal situation/configuration for one particular organization. To be credible, OUGHT TO BE models should be justified by their proponents. Mature developers might use the knowledge they accumulated along their professional experience to produce such justifications. However, even veteran developers did not go through all possible situations covering all the different market sectors that inevitably bring too much diversity to the organizational configuration.

Both mature and novice developers can benefit from the existence of reference models that combine state-of-the-art knowledge from both academia and professional practice. On one side, theoretical principles relevant to the different dimensions of an organization. On the other hand, good practices developed by practitioners, consulting companies or institutions interested in professional practices.

The reference models might exist at a high level of abstraction, thus being applicable to all sorts of organizations, or they may convey specializations adjusted to specific market sectors.

In each organizational development project, these reference models provide a basis for the production of an OUGHT TO BE model for that organization. In that sense, reference models can be presented as proto-OUGHT TO BE models.

The process of applying the reference model is divided into the following steps: selecting the reference model; adapting the reference model to the organization. The main goal is given by the notion of the organization's re-utilizing the information and knowledge base contained in the model for the purpose of structuring its policies, practices and processes in such a way as to achieve best performance.

Figure 2 illustrates the usage of reference models to product OUGHT TO BE Model in organizational development projects.

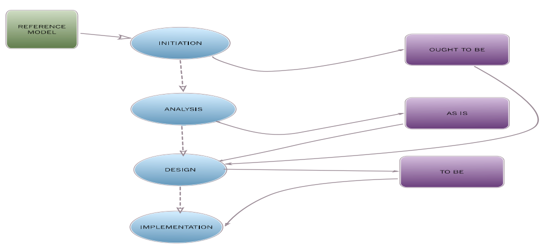

Figure 2: The usage of reference models to product OUGHT TO BE model in organizational development projects

Although their usefulness, the reference models do not provide a comprehensive basis for the production of OUGHT TO BE model. Each of the models typically covers only a few of the relevant dimensions that are relevant for an extensive description of an organization.

Furthermore, existing reference models have not been developing to focus on specific market sectors. By focusing on specific market sectors, reference models can maximize their utility to the production of OUGH TO BE models. The exemplary model addresses the essential aspects of an organization with detail enough to be adjusted to a market (economy) sector. For this reason these reference models are named in this work as essential sectorial models.

REFERENCE MODELS

There is a problem associated with the use of the term "reference model" (Fettke & Loos, 2007). In research and in practice, different types of model are denominated "reference models" [Thomas, 2005]. The term "reference model" has become very popular in recent years, and has come to be surrounded by considerable confusion [Fettke & Loos, 2007; Rosemann & Van Der Aalst, 2007]. It belongs to a class of terms that are widely used, but still not very clearly defined [Hars, 1994 *apud* Thomas, 2005].

Shehabuddeen *and colleagues* (1999) report that a broad literature review reveals that authors using this term do not define exactly what they consider to be a "reference model". The confusion starts with the word "reference" itself. Thomas (2005) explains that etymologically the term "reference" has a double meaning: a recommendation, and the meaning of bearing a relation to something, quoting something or alluding to something.

In this article we use the term reference model to name a model that:

- Describes several aspects of organizations embedding theoretical organizational principles and/or good practices of organization established and recognized in industry;
- Are general in the sense that they apply to a large set of enterprises; in some cases to any organizations; in other cases to organizations that belong to one sector of the economy;
- Address essential aspects, i.e., they cover aspects that are common to a set of organizations, thus abstracting from specificities of particular organizations.

Organization developers will refer to these models in search for a basis to produce OUGHT TO BE models. Reference models will hence be used as proto-models for OUGHT TO BE models.

Use of reference models. In recent years, many organizations have developed references to guide and improve management. These models are "packages" (sets of structured concepts) of guidelines and/or solutions used by other organizations, and are being known in management as "reference models".

Normally organized as a hierarchy of functions, processes and activities, with or without interdependencies, they provide names, descriptions, indicators and other elements that can be re-utilized. However, these frameworks are not always relevant to the specific nature of the business. They may also use terminologies that clash culturally. Few organizations can expect simply to take such references and apply them unthinkingly or without some evaluation and modification [Burlton, 2010].

The fact that each model has a specific focus and poses particular needs makes them difficult to manage in isolation. Managers are realizing that using these models without integrating them can cause a lot of problems [Pagliuso et al., 2010]. For that reason, one of the present focuses of research in this field is how these reference models can be used as proto-models for OUGHT TO BE model (Coelho, 2005) for coordinated deployment of all the potential such tools have to offer.

Reference models have different characteristics: they can be made up of requirements or guidelines. Guidance reference models offer a series of recommendations on how to deal with aspects of organization management and, accordingly, can be identified as prescriptive. Requirement reference models, in turn, are made up of questions with respect to these various aspects of organization management, and can thus be identified as non-prescriptive.

Shütte (1998 *apu*d Mendling *et al.*, 2005) identify three types of reference models found in the literature by their application/use: (1) process reference models: these present the stages to be completed in order to achieve specific objectives more efficiently, and are often found in the fields of Software Engineering and Business Process Engineering [Schelp & Winter, 2006]; (2) Information Systems Reference Models are systems models whose purpose is to guide the development of specific solutions for a given organization. The main reference for this category in the literature is the SAP R/3 reference model, which is much used in organizations and other information systems; and (3) Organizational Reference Models describe the different aspects of subdivisions of a given type of organization, for example, bank management, manufacturing, public administration, retail etc. [Schelp & Winter, 2006].

Another typology is proposed by Burlton (2010), who distinguishes reference models into: (1) generic models, intended to describe organizations of all types in all sectors; (2) industry-specific models, that designate a set of existing and emerging models designed to describe an industry as a whole; (3) domain-specific models, developed around specific functions in an organization and the processes within them; and (4) process, lifecycle and value chain models.

Examples of reference models. Both the scientific and professional literature provides examples of reference models that can be use as described in figures below. Among such examples it is worth to mention those described in the following sub-sections.

APQC's Process Classification Framework (PCF)

American Productivity and Quality Center (APQC)[1] is a non-profit organization established for helping organizations to improve their productivity and quality in 1977. The Process Classification Framework (PCF) was developed by APQC involving its member companies in 1992 to facilitate improvement through process management and benchmarking regardless of industry, size, or geography. The PCF is supported by the Open Standards Benchmarking Collaborative (OSBC) database of APQC and their advisory council of global industry leaders as an open standard.

The PCF organizes operating and management processes into 12 enterprise-level categories, including process groups and more than 1,500 processes and associated activities.

PCF is available for both cross-industry version and also industry-specific version for the following industries: Aerospace and defense, Automotive, Banking, Broadcasting, Consumer products, Education,

[1] http://www.apqc.org/process-classification-framework

Electric utilities, Petroleum downstream, Petroleum upstream, Pharmaceutical, Retail, and Telecommunication.

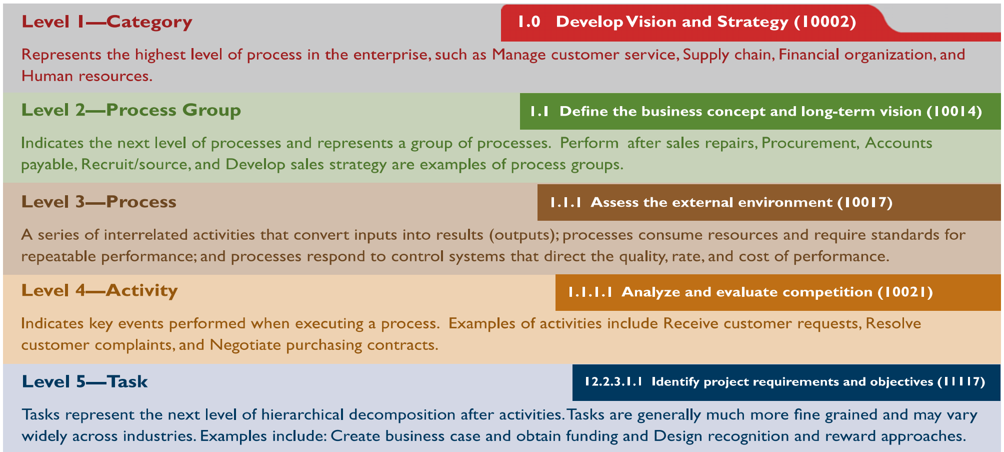

Figure 3: The layout of PCF

PCF processes are structures in five levels:

- Level 1 – Category: The highest level within the PCF (e.g., Design and Manage Operations.
- Level 2 – Process Groups: Process areas within each category (e.g., Plan for and acquire necessary resources—requisition planning.
- Level 3 – Process: Processes within each group (e.g., Manage enrollments for programs and services.
- Level 4 – Activity: Activities within a process (e.g., Develop baseline forecasts, Collaborate with community. Some processes include one more level detail within activity which is named as task.
- Level 5 – Task: Tasks within an activity (Develop improvement-planning and goal-setting procedures.
- An interesting aspect of PCF is that it presents cross-industry processes while serving for specific industries at the same time. On the other hand, processes introduced by the framework may be too generic for some organizations to apply and this may be considered as a disadvantage.

Enhanced Telecom Operations Map (eTOM)

The Enhanced Telecom Operations Map (eTOM)[2] is a business process framework developed for the telecommunication, media and entertainment industries. The eTOM provides a library of business

[2] http://www.tmforum.org/BusinessProcessFramework/1647/home.html

processes that are then decomposed at different levels. The amount of details in process definition increases as leveling down from corporate level to lower levels. The structure of the processes is composed of horizontally and vertically crossing processes. Vertical processes are separated as corporate management and supporting processes, and operational processes. These can be thought as covering lifecycles and include end-to-end activities involving customers, supporting services, resources and suppliers/partners. On the other hand, horizontal processes represent major programs or functions that cut horizontally across the vertical ones, i.e. an enterprise's internal business activities.

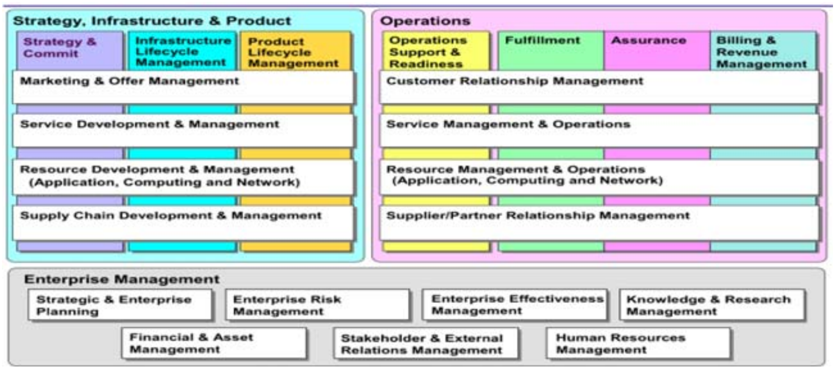

Figure 4: The layout of eTOM

The special characteristics of the telecommunication, media and entertainment industries justify the existence of a specific reference model where the typical processes of the industry are presented without the hindrance of trying to cover as well more traditional industries such as manufacturing.

Value Reference Model (Value Chain)

A Value Reference Model (VRM)[3] is an integrating framework, established by the trade consortium Value Chain Group, supporting organizations for planning, governing, and executing with the objective of improving performance of all value chain. Value chain is a business management concept. Value chain is a high-level model of how businesses receive raw materials as input, add value to them through various processes and transform them to finished products, and sell finished products to customers as outputs. The value chain categorizes the generic value-adding activities of an organization [Brown, 2009]. The framework provides a semantic dictionary including processes, inputs/outputs, metrics and best practices in order to support and enable corporations to integrate their three critical domains; Global Product Developments, Global Supply Network Integration and Global Customer Success. The framework has three levels and the processes are categorized in these levels.

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[3] http://www.value-chain.org

Figure 5: Value Reference Model

Supply Chain Operations Reference (SCOR)

Supply Chain Operations Reference (SCOR)[4] is established by Supply Chain Council (SCC), which is an independent, nonprofit, global corporation with membership open to all companies and organizations interested in supply chain management systems and practices. SCOR is a unique framework that links business process, metrics, best practices and technology features into a unified structure in order to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities.

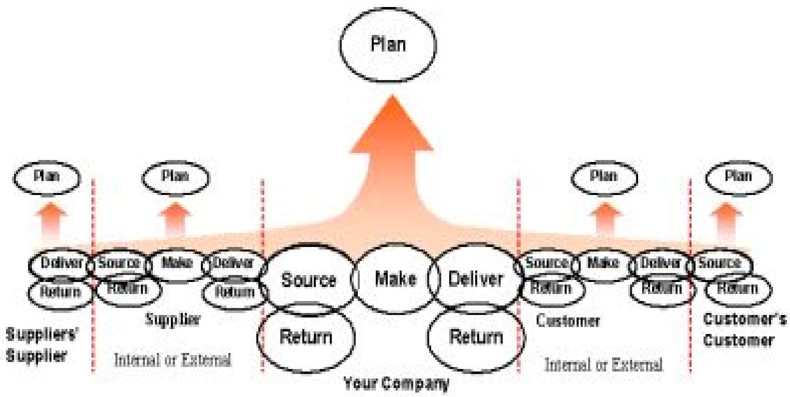

Figure 6: Supply Chain Operations Reference

[4] https://supply-chain.org/scor

EFQM

The Business Excellence Model introduced by The European Foundation for Quality Management (EFQM)[5] in order to be the driving force for Sustainable Excellence in Europe concerning Quality Management. The Business Excellence Model of EFQM is a self-assessment method focusing on five "enablers" and four "results". The five "enablers" are Leadership, Strategy, People, Partnerships & Resources and Processes, Products & Services; and four "results" are Customer Results, People Results, Society Results, and Key Results. Enablers include what an organization does and results include what an organization's achievements. The relation between enablers and results is the fact that enablers help for achievement in results and feedback from results help to improve enablers (Franchescini et al., 2007). This model shows the complexity in cause and effect relationship within an organization [Neely et al., 2000].

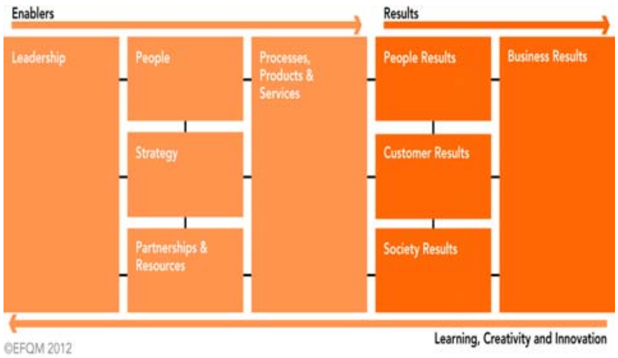

Figure 7: The layout of EFQM Model

HERO

Reference Ontology for Higher Education (HERO)[6] is the one of the ontology, which represents the Higher Education domain of knowledge.

The basic characteristic of an educational process is knowledge sharing. In this context it is important to have an efficient method for knowledge representation that uses the concepts specific to the educational domain [Oprea, 2012]. Ontologies provide a solution for solving the problem of knowledge representation. Educational ontologies can model the content of the course for all three phases of a didactical activity: teaching, learning and examination [Oprea, 2012].

[5] http://www.efqm.org/en

[6] http://www.herontology.esi.dz

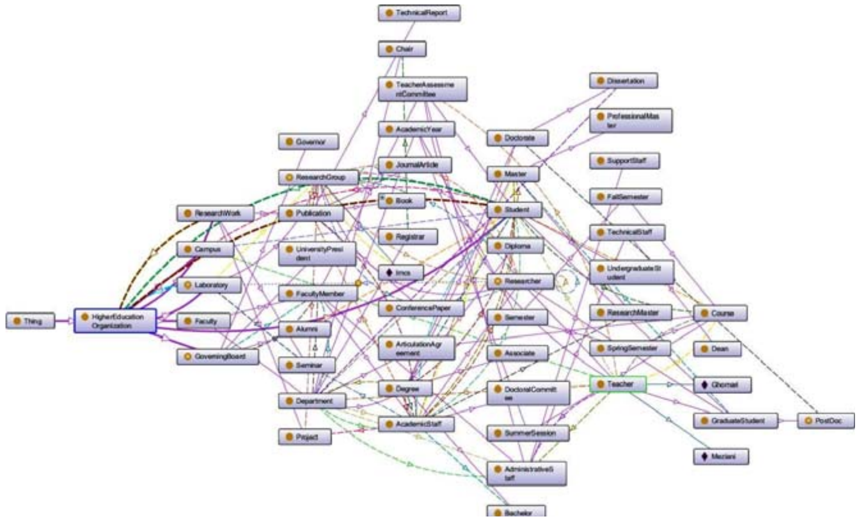

Figure 85: The ontology of higher education reference

This ontology defines elements for describing universities and the activities that occur at them. It includes concepts such as departments, faculty, students, courses, research, and publications. This ontology is a lightweight ontology (no inference rules are defined) [Ghomari, 2013].

PROPOSAL OF A FRAMEWORK FOR DEFINING ORGANIZATIONAL MODELS OF QUALITY IN HEIS

Fettke & Loos (2007) present a framework that organizes the process of formulating reference models into two stages: (1) the construction process, which is the first stage of reference modeling and results in a generic model; and (2) the application process, which is the utilization of this model by an organization, which results finally in its adaptation to that organization's specific situation. The goal of the construction process is to design and build a specific framework. Its main activities are definition of the problem, and the development, evaluation, and subsequent maintenance of the model. Schuette & Rotthowe (1998) note that this process can be considered a non-deterministic process, because different designs can produce different reference models of the same firm. Figure 9 illustrates the Proposal of a framework for defining organizational models of quality in HEIs.

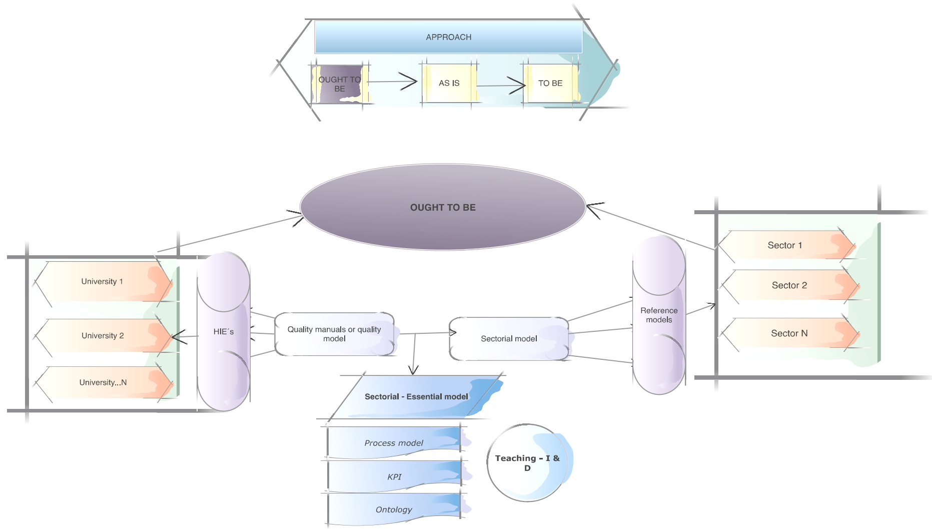

Figure 9 Framework for defining organizational model of quality in HEIs

Based on the structure shown in Figure 9, starts up to generate an OUGHT TO BE, in its original version, with 4 elements, including: clarification of the strategy, model of organizational architecture, objectives and indicators, and ontology. The representation is diverse, remaining unchanged OUGHT TO BE. All steps for this framework are described in sections 3 and 4 of the current article.

CONCLUSIONS

This article sought to highlight a real problem faced by many organizations today: their need to structure the deployment of references available on the market and in academia. It began by definitions of what is understood by “organizational development” and “reference model”, and then listed the some types in existence and their intrinsic characteristics. The article then sought to develop the conceptual structure surrounding the role of reference models in an organization’s development. In the same way, this article sought to discuss about models in organizational development project namely the AS IS, TO BE and OUGHT TO BE Models. Sought to evidence that most organizations use the AS IS - TO BE approach, seeking to bring an alternative form of this approach using OUGHT TO BE model.

We suggest that instead of starting with the traditional approach AS IS then TO BE can start by OUGHT TO BE then - AS IS and finally TO BE, according the figures 2 and 9 of the present article.

Similarly, the article explained how to product the OUGHT TO BE model and how to use the reference models in this case.

The desired result was a single organization model that contemplated characteristic traits of the organization’s culture and business. No methods were found in the literature to guide the work of formulating such a model.

Here it should be stressed that the issues discussed relate to the conception of a first version of the framework for defining organizational models of quality in HEIs, which tends to be dynamic. This article concludes then, in view of the scenario of an evolving model, by mentioning the that reference model's potential in future stages of its maturation. By the fact that it defines the relationship among the themes, and states them explicitly, it can be more easily able to include new models that may come to be adopted by the organization. As soon as the focus of the new reference is identified, it will be easier to define what parts of the integrated reference model it should be "added" to.

Finally, the OUGHT TO BE approach tend to be a essential for developing models for organizational intervention and would be important if organizations could begin to adopt this kind of approach, this is simple and easy, once do not take into account what exists in the organization.

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Supply chain management practices and firms' operational performance: An empirical study of Vietnam garment industry

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ABSTRACT:

Purpose. This study aims at providing an empirical evidence about the relationship between practices of supply chain management (SCM) and operational performance.

Design/methodology/approach. Based on a comprehensive literature review and the practical experience in the field of the Vietnam garment industry, a set of management practices have been identified and selected to develop a conceptual model as well as to establish their relationship to companies' operational performance. Structural equation modelling (SEM) was used to evaluate the validity of the model. The measurement instrument of practices was developed in 4 steps: (1) identification and development of initial instrument, (2) personal interviews and Q-sort, (3) large-scale data collection and (4) large-scale analysis in order to ensure unidimensionality, reliability and validity. Data were collected in Vietnamese garment enterprises.

Findings. The study showed that the four practices: customer focus, supplier management, process control and improvement, top management support are positively related to operational performance. In addition, this study also showed that these SCM practices could explain 52.6% variance of operational performance.

Research limitations/implications. There were some limitations that can guide academics to new lines of further research: (i) to extend the scope of the survey to include different countries and new situations, so results can be generalized and (ii) to explore additional factors that can further explain operational performance, such as operational environment, capital, technology, human resource, etc.

Practical implications. Research results gave some suggestions for business associations and government in order to issue the specific and practical policies creating good conditions for enterprises to get higher performance.

Originality/value. The proposed research model analyzing the relationship among SCM practices and operational performance and its validation using the Vietnam garment industry provided valuable insights both from theoretical and practical perspectives. The results of this study, moreover, help to understand the weaknesses of this industry. SEM, which was used in this study to test the measurement instrument and structural model, is one of modern and complex data analysis methods and can provide higher accuracy in the quantitative research.

Keywords: Supply chain management, Supply chain management practices, Operational performance, Garment industry, Vietnam.

Article Classification: Research paper

INTRODUCTION

The garment sector plays an important role in Vietnam socio-economic development in terms of creating huge employment, especially jobs for females, contributing as a major source of foreign exchange accumulation for the nation and creating a tremendous integration opportunity for Vietnam in the global economy.

However, after two decades of integration and development, among five main segments including raw material, garment accessories production, cutting and sewing, exporting and distributing, Vietnam garment industry still mainly focuses on cutting and sewing stages -the lowest value-added segment in the value chain.

Most of Vietnamese garment companies, containing service and manufacturing enterprises, are facing competitive disadvantages due to their inherent issues such as high operating costs, high lead-time, high rates of damaged materials, late delivery, and decreasing operational efficiency. To increase the competitive advantage, firms should consider operational performance as a way to leverage competiveness (Samson and Terziovski, 1999).

There are many worldwide researchers conducting studies to develop efficient methods to improve operational performance. As competition move from organizations to supply chains, the term of Supply Chain Management has become popular. The implementation of SCM practices is considered as a base for improvement of operational performance (Li et al., 2005).

There were many researchers investigating the relationship between SCM practices and operational performance (Christopher, 2013). However, these studies still exists some limitations that reduce their value in the literature. Those are:

- The inconsistency in results of previous studies.
- The mutual interaction among practices has not been taken into account.
- Data analysis approach.
- Specially, in Vietnam, with referenced documents, the related research is restricted.

This study aim at filling the above voids by proposing a new framework based on Structural Equation Modeling (SEM) and applying it in the Vietnam garment industry. It is also expected that the practical findings achieved from this research could contribute to the development of Vietnam garment industry in particular and to its global economic performance.

The structure of this paper includes: the following section presents further discussion of the research gaps in the literature, then research model and hypotheses are suggested. Section 3 describes development of the measurement instrument. In section four, results are presented and discussed. Implications and directions for further research are mentioned at the end of this paper.

LITERATURE REVIEW AND HYPOTHESES

SCM aims at improving the sourcing for raw materials, the production and the distribution of products/services to customers (Fredendall and Hill, 2000; Hugos, 2011). The successful implementation of SCM practices provides opportunities to improve operational performance along the supply chain (Harrison and New, 2002).

In the literature, the adoption of SCM practices has been widely conducted. Yet, there is a large degree of overlap in the use of SCM practices and quality management practices. In other words, the taxonomy between them is unclear.

According to Talib et al. (2011), they can be classified based on "primary integration." While quality management practices mainly concentrate on the internal integration, e.g. executives and employees, SCM practices take into account internal processes of an organization and linking these with the external operations of members in the entire supply chain. Hence, combination with the extensive literature review, a set of relevant SCM practices have been identified (see Table 1). The classification adopted in this study (Flynn et al., 1995) assumes two main categories:

- **Core practices:** defined as technique- and methodology-oriented practices for supply chain, such as process control and improvement.
- **Support practices:** such as supplier management, customers focus and top management support, which are people- and culture-oriented practices and create an environment that supports effective use of the core SCM practices.

Table 1: Description of SCM practices.

SCM practices	Description
Process control and improvement	Use of fool-proof for process design, statistical techniques, automation, preventive equipment. Clarity of work or process instructions. Identification of problem easily. *(Forker, 1997; Kaynak, 2003; Saraph et al., 1989)*
Top management support	Offer of innovation and continuous improvement policies. Provision of necessary resources for processes. Promotion of partners' involvement in firm's activities. Participation of top management in supply chain improvement process. Review of supply chain issues in top management meetings. Responsibility for operational performance. *(Flynn et al., 1995; Kaynak, 2003; Saraph et al., 1989)*
Customer focus	Determination of customers' needs and wants. Use of information from customers in designing products and services. Understanding of products or services by employees. Commitment in satisfying customers. Relationship between company's goals and customers' expectations. *(Lakhal et al., 2006)*
Supplier management	Reliance on a few suppliers. Selection of suppliers based on quality. Development of long-term relationship with suppliers. Clear of the specifications provided to suppliers. Assessment of suppliers' capabilities and performance. *(Li et al., 2005)*

The relation of these practices to operational performance has received attentions in previous studies. However, the results have not been fully consistent. For instance, in the relationship between process management and performance, the direct effect of process management on performance has been identified in several studies (Feng et al., 2006; Fening et al., 2008; Kaynak, 2003; Kaynak and Hartley, 2008; Prajogo and Brown, 2004; Sila and Ebrahimpour, 2005; Terziovski, 2006; Zu, 2009). However, according to Tarí et al. (2007), they have an indirect relationship (Tarí et al., 2007). Conversely, Flynn et al. (1995) argued that process management has a negative direct relationship with performance, or even they are not associated (Powell, 1995; Samson and Terziovski, 1999).

According to Kaynak (2003), furthermore, if a research model does not explore the relationships among practices, it cannot be considered comprehensive. In other words, studies need to identify the direct and indirect impact of SCM practices on operational performance at multiple levels. However, by using of multiple regression approach (Adam et al., 1997; De Cerio, 2003; Fening et al., 2008; Flynn et al., 1994; Samson and Terziovski, 1999; Zehir and Sadikoglu, 2010) or correlation (Powell, 1995; Tabachnick and Fidell, 2012), this issue cannot be fully addressed.

Therefore, to explore the relationship among selected SCM practices and the operational performance as well as to have a comprehensive research model, a structural model is proposed (Figure 1).

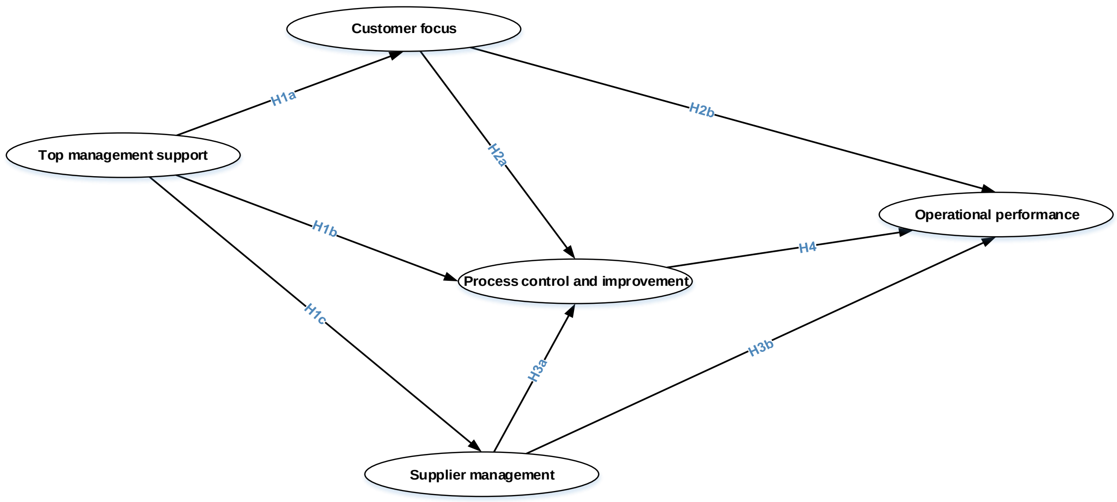

Figure 1: Research model

These relationship will be investigated by using SEM, which is an adequate approach to test the direct and indirect effect (Bollen, 1989). In the following sections, hypotheses suggested in the research model will be developed.

Top management support. The support of top management is the main motivation that drives companies towards an effective and successful implementation of SCM (Abraham et al., 1999; Ahire and Dreyfus, 2000; Ahire and O'Shaughnessy, 1998).

In most companies, customer satisfaction is the key driver of all activities. Therefore, customers' needs must be properly addressed not only by top managers but by all employees also (Lakhal et al., 2006). Top management support is essential to ensure that necessary resources are provided to carry out market studies to determine customers' needs and wants as well as making all efforts to meet them (Kaynak, 2003).

Additionally, in the SCM perspective, customer involvement in firm's activities plays an important role in the success of the whole supply chain (Robinson and Malhotra, 2005). Top management can promote customer involvement from the earlier stages of development until the commercialization stage (Flynn et al., 1995). Top management, further to define companies' mission and goals, creates the working environment in which all employees are encouraged to focus on addressing customer requirements (Ahire and Ravichandran, 2001). Thus, we suggest the following hypothesis:

H1a: Top management support is positively related to customer focus.

Top management sets up policies which encourage innovations and continuous improvement in an organization. For instance, the support for initiatives in the use of standard component, modular design of component parts makes design activities simpler. The effectiveness of design is improved as a result (Kaynak, 2003; Kaynak and Hartley, 2008; Ou et al., 2010). In manufacturing activities, moreover, top management invests machines, equipment, etc., to increase level of automation as well as enhance implementation of preventive equipment maintenance and fool-proof of process design. This minimizes probability of employee errors and reduces variance in processes (Flynn et al., 1995; Forker, 1997; Kaynak, 2003; Lakhal et al., 2006; Saraph et al., 1989; Sila and Ebrahimpour, 2005). Thus, the following hypothesis is suggested:

H1b: Top management support is positively related to process control and improvement.

As traditional approaches, supplier management is seen as a mere administrative activity that mainly focuses on supplier selection. In this activity, price is the main criterion to evaluate suppliers. This can result in poor quality materials or even delayed orders. In new perspective, supplier management refers to not only selection of quality suppliers, but development of long-term relationship with suppliers and assessment of suppliers' performance also (Li et al., 2005). These activities only implement successfully if they receive support from top management (Kaynak, 2003; Kaynak and Hartley, 2008; Sila and Ebrahimpour, 2005; Singh, 2008; Zu et al., 2008). Top management actively participates in this process and selection will be based on review of more demanding criteria, e.g. quality, reliability of delivery activities and service. It ensures that firm has a reliable and high quality suppliers (Flynn et al., 1995; Trent and Monczka, 1999). Moreover, effective supplier management is considered a strategic area by top managers promoting higher levels of integration and collaboration (e.g. design, production, marketing, sales and customer service) with key suppliers. Thereby, communication, relationship, and cooperation among parties in the supply chain are improved (Ellram, 1995). Thus, we propose the following hypothesis:

H1c: Top management support is positively related to supplier management.

Customer focus. Customer focus is considered a key element for successful enterprises. All activities such as the development of new product/services, production, marketing, distribution and after-sales services should be concentrated on customer requirements. Each department and every employee should share customer-focused vision alike (Ahire and O'Shaughnessy, 1998; Ahire and Ravichandran, 2001; Flynn et al., 1995; Forza and Filippini, 1998; Lakhal et al., 2006; Nair, 2006; Sila and Ebrahimpour, 2005)

The implementation of customer focus practice helps companies to better understand customer expectations and market opportunities (Lakhal et al., 2006). Based on that, firms can be active in planning for purchasing, production, delivery, etc. For instance, firms can balance supply and demand, reducing variance in processes (Lee et al., 1997). In production activities, by understanding customer's demand, company could coordinate effectively machines, equipment and human resources to minimize process variances, reduce downtime and lead-time. Furthermore, employees knowing attributes of products/services can minimize errors and suggest improvements. Consequently, the effectiveness of processes and operational performance are improved. Finally, in the delivery stage, better shipment plans could be devised in order to reduce rate of late deliveries. Moreover, since customer's needs and wants are well identified, company can focus on value added activities and be able to eliminate or, at least reduce, defect rates, scrap, rework, returns, etc. (Dow et al., 1999; Fening et al., 2008; Lakhal et al., 2006; Rahman and Bullock, 2005; Samson and Terziovski, 1999; Zehir and Sadikoglu, 2010). Hence, we suggest the following hypothesis:

H2a: Customer focus is positively related to process control and improvement.

H2b: Customer focus is positively related to operational performance.

Supplier management. As referred earlier, cooperation between a company and key suppliers is a basic and critical SCM practice. Buyers collaborate with suppliers to ensure that input materials meet standards and quality requirements in order to produce quality products (Chen and Paulraj, 2004; Kaynak, 2003; Kaynak and Hartley, 2008; Li et al., 2005; Ou et al., 2010; Robinson and Malhotra, 2005; Vickery et al., 2003). High quality inputs, provided at the right time with the required quantity, helps firm to avoid downtime incidents, to reduce variance in processes and the rate of damaged materials (Flynn et al., 1995; Forza and Filippini, 1998). Moreover, effective supplier management can cut off inventory, waste and safety inventory level (Easton and Jarrell, 1998; Yeung, 2008).

From a supply chain perspective, suppliers are involved in firm's activities (Robinson and Malhotra, 2005). They can suggest the most appropriated components or parts for designing new products (Hoegl and Wagner, 2005), and help purchasers buying inputs that can be used most efficiently in manufacturing processes (Flynn et al., 1995; Forza and Filippini, 1998; Shin et al., 2000; Tan, 2001; Trent and Monczka, 1999). In addition, Vonderembse and Tracey (1999) showed that a good relationship with suppliers is useful for reducing order-time and rate of late orders. Hence, we suggest the following hypotheses:

H3a. Supplier management is positively related to process control and improvement.

H3b. Supplier management is positively related to operational performance.

Process control and improvement. Process control and improvement refers the use of statistical techniques, increasing automatic level of processes and fool-proof in designing process (Flynn et al., 1995; Forker, 1997; Kaynak, 2003; Saraph et al., 1989). These activities are helpful in decreasing process variance (Flynn et al., 1995) and minimizing chances of employee errors (Forker, 1997; Kaynak, 2003; Saraph et al., 1989). As a consequence, rate of damaged materials and late delivery, lead-time, unnecessary costs are reduced (Ahire and Dreyfus, 2000, Anderson et al., 1995), output increases and uniformity of products is higher (Anderson et al., 1994; Forza and Flippini, 1998). Furthermore, the use of preventive equipment maintenance make manufacturing process smoothly by improving reliability of equipment and restricting disruption in production (Ho et al., 1999). The relation of process control and improvement to operational performance is founded in the studies of Ahire and Dreyfus (2000); Forza and Filippini (1998). Hence, the following hypothesis is proposed:

H4: Process control and improvement is positively related to operational performance.

Operational performance. Operational performance refers to the ability of a company in reducing management costs, order-time, lead-time, improving effectiveness of using raw material and distribution capacity (Heizer et al., 2008). Operational performance has an important meaning to firms, it helps to improve effectiveness of production activities and to create high quality products (Kaynak, 2003), leading to increased revenue and profit for companies.

RESEARCH METHODOLOGY

In this section the validation methodology of the conceptual model is described: (1) Identification and development of initial instrument, (2) personal interviews and Q-sort, (3) large-scale data collection and (4) large-scale analysis.

Identify and develop the initial instrument. The effective measurement instrument should cover all content domain of constructs (Parasuraman, 1991), measurement items of each construct should converge with other items statistically (Garver and Mentzer, 1999). In other words, two constructs which are similar in theory, are also the same in practical and vice versa. Constructs should have high level of reliable, short and easy to use (Li et al., 2005).

Based on a comprehensive literature review and definition of SCM practices in table 1, the scales of constructs were developed (table 2). A seven-point Likert scale was employed with a score of 1, indicating “strongly disagree”, and 7, representing “strongly agree”, to extract the different attitudes of respondents.

Personal interview and Q-sort. A structural interview of academicians with experience in the SCM area was conducted. These discussions were recorded, analyzed before to perform some improvements in the model. Q-sort method, then, was applied with the participation of some managers to assess initial construct validity, reliability and unidimensionality.

In the process of Q-sort method, some managers, who are working in the garment industry, were invited to review the scales of constructs in order improve their overall quality. Based on the feedback from experts, items were adjusted, and then, the official questionnaire was established.

Large-scale data collection. Target population in this study is Vietnam-based garment industry companies. The target respondents include presidents, vice presidents, directors, managers and coordinators who have information and experience in SCM. In the list of General Statistics Office in 2008, there are 3.174 garment enterprises. Contact information of companies was searched from website of *nhungtrangvang.com.vn*, which provides address, email, phone, etc. of companies in Vietnam. A total of 2.147 out of 3.147 garment enterprises were selected. The link of the official questionnaire was sent to these 2147 firms via email addresses. In order to increase the response rate, an electrical postcard was sent after the initial mailing to remind non-respondents. Depending on their requirements, a copy of questionnaire was mailed by post-office or the link of survey was sent to their email. One month later, the survey link, once again, was emailed. To encourage the cooperation of respondents, the survey results would be sent to them. A total of 246 questionnaires were received, resulting in the response rate of 11.5%. This is a significant rate with the method of email survey (Tse et al., 1995).

An estimate of non-response bias with T-test procedures was conducted in order to test the difference in items between early and late respondents (Armstrong and Overton, 1977). Results showed that no significant differences on the average scores of all observed items were found (internal confidence of 99%). It means that non-response bias exists between early and late respondents.

These 246 questionnaires were checked before analyzing in order to reduce errors in data entry process and detect missing values. After filtering data, there were 179 valid questionnaires, which were used for the next steps.

In addition, independent and dependent variables were obtained from the same respondent in each firm. This could lead to the presence of common method variance (CMV). Harman’s single-factor test was calculated to test this existence (Podsakoff et al., 2003). Unrotated factor analysis was performed with all observed items. If only one factor emerges, in other words, if a general factor could explain most of covariance in all variables, it is rational to conclude that a significant CMV is existed. Results indicated that eight factors was appeared, however, when the number of items are too much, this way of testing is not really exact (Podsakoff et al., 2003). Therefore, in this case, items in each of the independent construct (SCM practices) were factor analyzed with items in the dependent construct’s scale (operational performance). For each case, the results of factor analysis showed that two and more than two factors were emerged, meaning that there is no significant CMV.

Most of respondents are presidents, directors, vice directors, managers, etc. who had more than 5 years of working experience in the current company. Among them, 32.4% are retailers, 40.2% from manufacturing companies, 14.5% from distribution centers, fabric firms account 10.6% and the remaining are design-related companies. Approximately 26.8% of the firms had 10 or fewer employees, 35.8% of the firms employed between 10 and 49 workers, 19.6% of the firms had from 50 to 249 employees, and 17.8% of the firms had more than 250 employees.

Large-scale data analysis process. Firstly, Cronbach's Alpha coefficient was used for evaluating reliability of each construct (Antony et al., 2002). Cronbach's Alpha coefficient is a statistical test about the consistent degree to which observed items in a construct are correlated. Additionally, to improve Cronbach's Alpha coefficient, items which are low in item – total correlation coefficient will be deleted. Coefficient of item – total correlation expresses correlation among an item and the average score of other items in the same construct. Thus, the higher this coefficient is, the higher the correlation among items are and reliability of this construct is high at the result (Hair et al., 1995; Nunnally, 2010).

Then, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted to assess unidimensionality and validity of constructs, including: convergent validity, discriminant validity and criterion-related validity.

Additionally, the distribution of observed items is the normal distribution. Most of Kurtosis and Skewness range from (-1, +1), which is in acceptant range (Kline, 1998). Thereby, the method of ML (Maximum Likelihood) is appropriate to estimate parameters in the research model (Muthen and Kaplan, 1985).

If measurement items are unidimensional, reliable and valid, the analysis of structural equation model is carried out to test the hypotheses developed in the research model. In contrast, the process will turn back to literature review to redefine the constructs as well as the measurement instrument.

RESULTS

Test results of the measurement instrument. The measurement items were calculated Cronbach's Alpha and EFA with the support of SPSS (**S**tatistical **P**ackage for the **S**ocial **S**ciences) in advance. Extraction method used in EFA was Principal component – rotation method of Varimax. The breakpoint is at Eigenvalue ≥ 1 for all constructs in theory model. The results, in the table 2, indicated that two items were deleted because they do not get the target value. The remaining items have the coefficient of item-total correlation range from 0.578 to 0.784 (greater than 0.35), the minimum of Cronbach's Alpha is 0.791 (greater than 0.7), factor loadings range from 0.722 to 0.871 (greater than 0.4), Eigenvalue is greater than 1, the average variance extracted is greater than 50.

Then, CFA was carried out by AMOS software. After removing 3 items which do not get the target values, the measurement model including four constructs of SCM was tested with the following results: $\chi 2/df = .927$ (less than 3.0), Root Mean Square Error of Approximation (RMSEA) = .000 (less than 0.08), Akaike's Information Criterion (CAIC) = 320.734 < CAIC for Saturated Model (841.484) and CAIC for Independent Model (1452.991), Parsimony Goodness-of-Fit Index (PGFI) = .686 (greater than 0.5), Parsimony Normed Fit Index (PNFI) = .769 (greater than 0.5), Comparative Fit Index (CFI) = 1.000 (greater than 0.9), indicating that the measurement model is appropriate with the collected data (Bollen, 1989; Byrne, 1998; Carmines and McIver, 1981; Hair et al., 1995; Jaccard and Wan, 1996; Joreskog and Sorbom, 1993).

For the dependent construct, $\chi 2 = 6.977$, $p = .222$ (>0.05); df = 5; $\chi 2/df = 1.395$ (<3.0); GFI = .985, TLI = .988, CFI = .994 (>0.9); RMSEA = .047 (<0.08), CAIC = 68.723 < CAIC for Saturated Model (92.811) and CAIC for Independent Model (369.104), indicating that the measurement model of the dependent construct is appropriate with the collected data.

Standardized Regression Weights of all items are greater than 0.6 (the minimum value is 0.656) and significant ($p<0.05$). The composite reliability of all items ranges from .751 to .893, greater than the acceptant level of 0.6 and the average variance extracted ranges from 50.2% to 60.8% (>50%) (Table 2). In addition, the correlation coefficient between pairs of constructs ranges from .471 to .632 in the significant level of $p = .000$ (Table 3). In other words, constructs have discriminant validity (Steenkamp and van Trijp, 1991). Likewise, each SCM practices has high and positively related to operational performance, indicating that constructs have criterion-related validity (Chen and Paulraj, 2004; Kaynak, 2003; Li et al., 2005). It is concluded that scales of constructs have unidimensionality, reliability and validity (Bollen, 1989; Byrne, 1998; Carmines and McIver, 1981; Hair et al., 1995; Jaccard and Wan, 1996; Joreskog and Sorbom, 1993).

Table 2: Test results of measurement instrument

		Cronbach's Alpha and EFA with SPSS					CFA with AMOS		
Constructs	**Observed items**	**Factor loadings**	**Item – total correlation**	**Eigenvalue**	**Variance extracted**	**Cronbach's Alpha**	**Standardized Regression Weights**	**Composite reliability**	**Variance extracted**
Process control and improvement	Use of statistical techniques.	.803	.647	2.721	68.014	.843	.708	.844	.575
	Use of automatic processes.	.847	.710				.798		
	Use of fool-proof for process design.	Deleted					Deleted		
	Use of the preventive equipment maintenance.	.803	.649				.727		
	Clarity of work or process instructions.	.845	.706				.796		
Top management support	Offer of innovation and continuous improvement policies.	.761	.640	3.429	57.142	.85	.739	.809	0.514
	Provision of necessary resources for processes.	.800	.686				.726		
	Promotion of partners' involvement in firm's activities.	.761	.639				.693		
	Participation of top management in supply chain improvement process.	.749	.625				.708		
	Review of supply chain issues in top management meetings.	.740	.615				Deleted		
	Responsibility for operational performance.	.722	.593				Deleted		
Customer focus	Determination of customers' needs and wants.	.802	.623	2.461	61.517	.791	.75	.751	.502
	Use of information from customers in designing products and services.	.771	.583				.681		
	Understanding of products or services by employees.	.798	.617				.692		
	Commitment in satisfying customers.	.766	.578				Deleted		
	Relationship between company's goals and customers' expectations.	Deleted					Deleted		
Supplier management	Reliance on a few suppliers.	.839	.740	3.502	70.039	.893	.802	.893	.608
	Selection of suppliers based on quality.	.822	.717				.774		
	Development of long-term relationship with suppliers.	.826	.723				.765		
	Clear of the specifications provided to suppliers.	.826	.723				.777		
	Assessment of suppliers' capabilities and performance.	.871	.784				.837		
Operational performance	Reduction of management costs.	.768	.626	3.08	61.594	.844	.656	.868	.517
	Reduction of lead-time.	.780	.643				.670		
	Reduction of order-time.	.793	.661				.764		
	Reduction of rate of damaged materials.	.827	.705				.779		
	Reduction of rate of late delivery.	.754	.612				.697		

Table 3: Test results of correlation among constructs

	1	2	3	4	5
1. Customer focus	1				
2. Supplier management	.512	1			
3. Top management support	.480	.471	1		
4. Process control and improvement	.563	.569	.549	1	
5. Operational performance	.632	.523	.476	.619	1

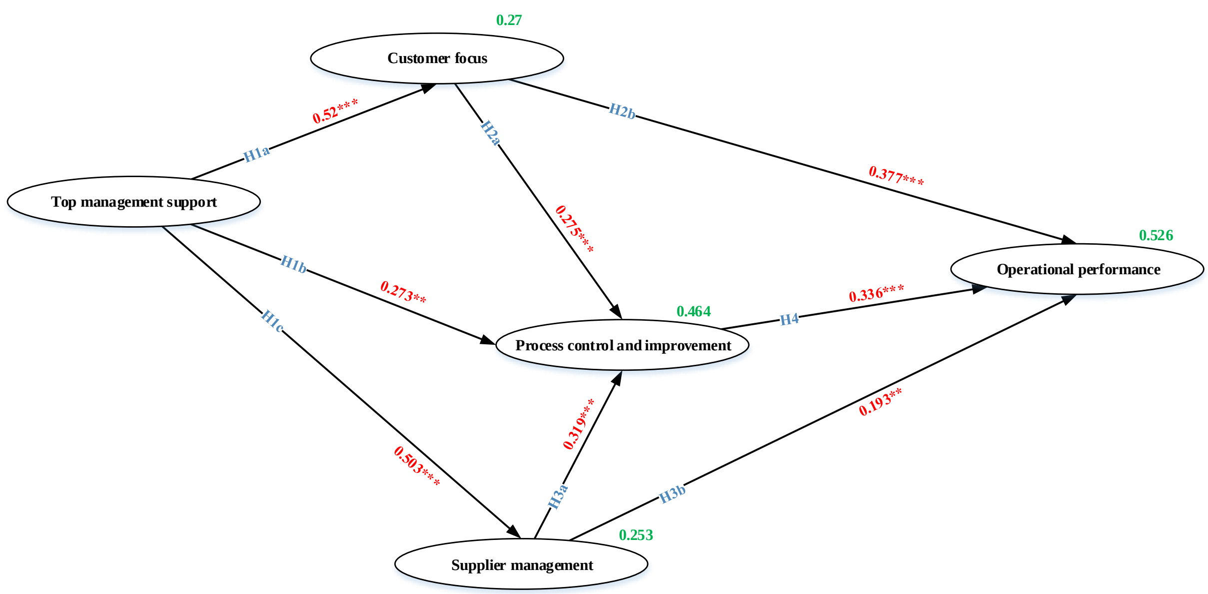

Figure 2: Test results of SEM

The R^2 for operational performance explained by the SCM practices is 0.526, indicating that the SCM practices can explain a large amount of variance in operational performance. Therefore, it can be said that SCM practices suggested in this study have important role in improving operational performance.

DISCUSSION

The empirical results in this study provide an evidence to consider SCM practices as reliable predictors for operational performance. The interactions among SCM practices and the relation of these practices to operational performance were also proved. The next part will present further discussion about the role of each practice in the SCM implementation and the improvement of operational performance.

Firstly, the practice of customer focus is directly related to operational performance and indirectly through the relationship with process control and improvement. -

Customers are those who bring benefits for enterprises, so they are an important factor that any firms and supply chains want to find out and satisfy their requirements. When global trends have changed from offering what company can produce into selling what customers need and want, garment industry is no exception. Being an industry in which designs and materials frequently change seasonally, it requires enterprises to catch up customers' demand promptly. In the global value chain, the most essential factor to approach the design segment is to master customers' fashion interest.

The successful implementation of customer focus practice helps companies to better understand customer expectations and market opportunities. Thus, firms can balance supply and demand, coordinate effectively machines, equipment and human resources to minimize process variances and increase operational performance.

This correlation helps to understand the weakness of Vietnam garment industry. The export model of Vietnam mainly based on CMT (cut - make - trim) processing contract, in which, customers decide what kind of input materials are to be used, while the oversea distributors/ vendors choose all distribution channels. Hence, most of companies have no chance to communicate with their end-users and do not know what customers' expectations are. Consequently, Vietnamese garment enterprises only work at cutting & sewing stage - the lowest benefit and value-added segment.

Additionally, the relation of top management support to customer focus indicated that customer focus is a mediating factor in the relationship between top management support and operational performance. Specifically, top management creates the organizational culture and provides necessary resources to determine customer demand that will result in increasing operational performance.Next, the practice of supplier management is directly related to operational performance as well as indirectly through the relationship with process control and improvement. In addition, supplier management is a mediating factor in the relation of top management support to operational performance. These are supported by studies of Easton and Jarrell (1998); Yeung (2008) and Vonderembse and Tracey (1999).

Nowadays, buying quality materials at a reasonable price becomes more and more difficult. To increase the effectiveness of purchasing, supplier management plays an extremely important role (Easton and Jarrell, 1998; Yeung, 2008). Different from the traditional view, many suppliers are chosen to have the cheapest price. Supplier management practice relies on a few suppliers and develops the long-term relationship with them. As a result, firm will have the stable supply, reduce the variance in price and processes as well as improve operational performance. The ineffective implementation of supplier management practice decreases the competitive advantage of garment enterprises in Vietnam. It is the fact that export orders are often delayed, due to the delayed import of materials. In addition, when there is a shortage of materials in market, some suppliers delayed shipments and took this opportunity to increase selling price. That's why, so far, only some leading firms have the ability to implement FOB contracts, a higher export method against CMT, that garment enterprises, themselves, can use materials which are procured somewhere without any directions from buyers, or be able to produce garments based on their own design, with no prior commitment of any kind from foreign buyers. The main cause is that Vietnamese garment enterprises have no reliable suppliers in quality materials and delivery time.

The study also confirms the relation of top management support to supplier management. It means that supplier management is a mediating factor in the relationship between top management support and operational performance. We can explain briefly this as follows. Top management are those selecting qualified suppliers and providing the best condition for them to participate in daily activities. This helps to increase efficiency of supplier management that will result in improving operational performance.

The relationship between process control and improvement and operational performance is supported in this study. When an organization can control and improve its processes effectively, manufacturing processes operate smoothly. Process variance and chances of employee errors are also minimized. Consequently, operational performance is improved. In addition, process control and improvement is also proved to have relationship with support practices, top management support, customer focus and supplier management. It indicated that the role of process control and improvement is as a mediating factor in the relation of the support practices and operational performance. The support practices create an environment supporting effective adoption of process control and improvement that will result in increasing operational performance.

This study, once again, proved role of the support SCM practice – top management support. The implementation of this practice can create environment to support for other SCM practices including supplier management, customer focus, process control and improvement, and indirectly improve operational performance. Specifically, the relationship among top management support, supplier management among customer focus provides an evidence about the role of top management support in building the relationship of partners in supply chain, Supplier – Firm – Customer. Top management support plays a role as "an adhesive" connecting members together. In addition, top management support can also maximize the capacity of supply chain through quality policies and objectives which mobilize participation of all employees in order to (1) determination of customers' needs and wants (2) assessment and selection of suppliers (3) improvement of production processes. Therefore, their support could create a good environment helping companies to improve their operational performance.

CONCLUSIONS AND IMPLICATIONS

This study explores the relationship among SCM practices and operational performance in a transitional economy. SCM practices, including: process control and improvement, top management support, customer focus and supplier management, should be implemented as an integration system rather than independent practices, in which they interact with each other to improve operational performance (Flynn et al., 1995; Kaynak, 2003). The results of this study help to understand the weaknesses of the Vietnam garment industry and are supported by previous studies in other countries (Flynn et al., 1995; Kaynak, 2003; Lakhal et al., 2006; Tarí et al., 2007; Zu, 2009; Zu et al., 2008)

According to the results, SCM practices suggested in this study could explain 52.6% variance of operational performance. This is an remarkable rate because not only SCM practices suggested in this study, operational performance is also impacted by others, such as operational environment, capital, technology, equipment, human resource, information, etc. Each of above practices has a certain impact, and not any is the unique one to effect on operational performance. As a consequence, enterprises which have investment resource for equipment investment, technological innovations will be able to remarkably improve operational performance by implementing these SMC practices. In other words, in the same conditions of finance, technology, equipment, environment, etc. those that can well address these SCM practices will have higher operational performance. For the purpose of improving operational performance at Vietnamese garment companies, some following proposals are suggested:

- It is necessary to focus on customers who should be considered as the "heart" of all activities. The efforts of companies should concentrate on how to satisfy their customers. To do so, companies need to determine what customers' needs and wants are by accessing networks of distribution center, wholesale, retail, etc., and use these information in designing products and services. It is important to assure employees, especially who contacts directly to customer, to understand the products or services of company clearly. Moreover, enterprises need to promote marketing activities and trade promotion, establish networks to collect the feedbacks from customers, understand what their expectations are and participate in the activities which create more benefits in the global apparel value chain.

- Choosing a few suppliers who have high quality and are certified. Companies should set up an effective information network to communicate with suppliers, make clear specifications provided to suppliers and enhance the relationship with supplier as strategic partners. It is useful to help in decreasing amount of inspection, review, or checking for incoming quality at company's plant. For foreign suppliers, instead of negotiating individually, enterprises should cooperate, based on Textile and Apparel Association to deal with suppliers about quality, price, etc.
- Firms need to strengthen in controlling and improving processes in order to improve operational performance by using statistical techniques, preventive equipment maintenance, and increasing automatic level of processes preventive equipment (Forker et al., 1997; Kaynak, 2003; Saraph et al., 1989).
- Last but not least, top managers act as a driver of implementing the other practices. Operational performance will be increased if top managers participate in supply chain improvement process, provide necessary resources for processes and promote partners' involvement in firm's activities (Forker, 1997; Kaynak, 2003). Top management has to be pioneers in implementation of innovation and continuous improvement policies along the supply chain. (Kaynak, 2003). It is equally important that these goals and policies need to be clear and provided fully to employees (Forker, 1997; Kaynak, 2003; Kaynak and Hartley, 2008).

The improvement of operational performance leads to the augment on revenue and profit for company. Employee income will increase and their living conditions also. Consequently, their loyalty to company enhances as well. Government budget is also increased via tax.

Finally, the proposed structural equation model analyzing the relationship among SCM practices and operational performance as well as its validation using the Vietnam garment industry provided valuable insights both from theoretical and practical perspectives. However, there are some limitations that can guide academics to new lines of future research: (i) to extend the scope of the survey to include different countries and new situations, so results can be generalized and (ii) to explore additional factors that can further explain operational performance, such as operational environment, capital, technology, human resource, etc.

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The role of quality management practices in operational performance: An empirical study in a transitional economy

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ABSTRACT:

Purpose. This research was conducted to recognize quality management (QM) practices which have relationship with operational performance.

Design/methodology/approach. Based on the extensive literature review, a set of quality management practices were identified and a conceptual model was built to explore their relationship with operational performance. An empirical testing at Vietnamese garment enterprises was carried out.

Findings. The results of this research showed that four main practices including top management support, human resource management, reporting and analysis of quality data, product/service design and process management are directly and indirectly related to operational performance. In addition, 57.1% variance of operational performance was explained by the QM practices above mentioned.

Research limitations/implications. Within the scope of this study, there are some aspects that haven't been yet considered: (i) there are many other factors that might also have impact on operational performance which are not incorporated in this study, such as, external environment, capital, technology, equipment, information flow, oursourcing, etc., (ii) generalized ability of results would be higher if extending the sample scope to other industries and other countries. These imply directions for further research.

Practical implications. To increase operational performance, the QM practices should be applied simultaneously and the structural model was used in this study could play as "a guideline" to orient for the implementation of these practices.

Originality/value. This study tried to address some issues that have not been fully examined in the literature. Not only fill these voids, the research model presented the relationship among QM practices and operational performance, along with the measurement instrument validated in this study also provided some insights to the theory system of QM and operational performance. It is also a valuable contribution for the next empirical studies, especially for countries having the transitional economy as Vietnam.

Keywords: Quality Management, Quality Management practices, Operational performance, garment industry, transitional economy, Vietnam.

Article Classification: Research paper

INTRODUCTION

As competition among firms becomes fierce, it is required that managers need to identify practices which improve capacity and competitive advantage. In organizational context, operational performance brings advantages in all aspects (Demeter, 2014; Prajogo et al., 2012; Samson and Terziovski, 1999). Increased operational performance leads to a cost reduction (Heizer et al., 2008), improved product/service quality (Samson and Terziovski, 1999) financial performance (Kaynak, 2003; Kaynak and Hartley, 2008; Ou et al., 2010) and customer satisfaction (Ou et al., 2010). It is useful to gain and maintain competitive edge (Reed et al., 2000). But how can we improve operational performance?

Related to this issue, a lot of academic studies were carried out. Flynn et al. (1995) took into account the relationship between quality management (QM) and operational performance. He is known as one of the pioneers to suggest the improvement of operational performance by QM practices. Flynn divided QM practices into two groups: (1) core QM practices and (2) infrastructure QM practices. Several empirical studies were conducted after Flynn's study and proved the importance of QM practices in operational performance.

As we know, investment on research projects able to leverage the performance of the industrial sector plays an important role in the economy of countries. This is particularly relevant in the Vietnam garment sector, which is one of industries with larger social and economical impact, whereas operational performance is still very low. Thus, carrying out a study to help garment industry to improve operational performance is one of main objectives of this study.

According to Vietnam Textile and Apparel Association, characteristics of Vietnam garment industry are a labor-intensive industry, high production costs, ineffective in design and manufacturing and low product quality as well. To improve operational performance of garment sector, hence, based on the extensive literature review, the practices of top management support, human resource management, reporting and analysis of quality data, product/service design and process management are suggested.

The importance of these practices have been partly recognized and applied in some companies. However, this implementation is not widespread. Pershap, it is the main reason leading to low operational performance. To verify this, this study will examine the relationship between the QM practices and operational performance. We aim at providing further insight into this subject in order to create an understanding on the way to a more efficient industry.

The structure of this paper is organized as follows: after the introduction, QM practices used in this research are presented. Research model and hypotheses, then, are suggested. Section 3 describes development of the instrument measurement. Next, results are presented and discussed. Implications and directions for further research are mentioned at the end of this paper.

BACKGROUND AND RESEARCH MODEL PROPOSAL

Five of the QM practices investigated in this study – top management support, human resource management, reporting and analysis of quality data, product/service design and process management have been documented in both measurement studies and the studies that have investigated the relationship between QM practices and various dependent variables, as shown in Table 1.

In the literature, the classification of these practices still remains unclear. It is important because this classification acts as "an orientation" that the relationships among practices are identified. In this study, based on the taxonomy of Flynn et al. (1995), the QM practices are grouped into two sectors: (1) core QM practices which are technique- and methodology-oriented practices such as reporting and analysis of quality data, product/service design; process management, (2) and support QM practices such as top management support; human resource management which are people- and culture-oriented practices and create an environment that supports effective use of the core QM practices.

Table 1: QM practices

QM practices	**Description**
Reporting and analysis of quality data	The collection of quality data. Display of quality data, control charts… at work stations. Delivery feedback of quality data to employees. Availability of quality data. Use of quality data in employees' tasks. *By (Forker, 1997)*
Product/service design	Use of modular design of component parts. Use of standard components. The simplification of products. Review of new product/service design. Clarity of product/service specifications. *By (Kannan and Tan, 2005)*
Process management	Use of fool-proof for process design, statistical techniques, automation, preventive equipment. Clarity of work or process instructions. Identification of problem easily. *By (Forker, 1997; Kaynak, 2003; Saraph et al., 1989)*
Top management support	Offer of innovation and continuous improvement policies. Provision of necessary resources for processes. Promotion of partners' involvement in firm's activities. Participation of top management in quality improvement process. Review of quality issues in top management meetings. Responsibility for operational performance. *By (Flynn et al., 1995; Kaynak, 2003; Saraph et al., 1989)*
Human resource management	The relationship between human resource objectives and strategic. The role of environment on the development of all employees. Responsibility in employees' tasks. Promotion in the motivation of employees. Training program for employees timely. The measurement methods of employee satisfaction. The effectiveness of employee problem resolution program. Involvement in determining training needs. *By (Adam, 1994; Choi and Eboch, 1998; Park et al., 2001; Powell, 1995; Samson and Terziovski, 1999)*

The relationship between QM practices and operational performance receives much attention in the literature. However, results have shown to have low consistency. Some authors employed the same dimensions to test the relationship between QM practices and operational performance but they obtained different results. For instance, in the relationship between process management and performance, the direct impact of process management on performance has been proved in several studies (Feng et al., 2006; Fening et al., 2008; Kaynak, 2003; Kaynak and Hartley, 2008; Prajogo and Brown, 2004; Sila and Ebrahimpour, 2005; Terziovski, 2006; Zu, 2009). However, according to Tarí et al. (2007), they have an indirect relationship (Tarí et al., 2007). Conversely, Flynn et al. (1995) argued that process management has a negative direct influence on performance, or even they are not associated (Powell, 1995; Samson and Terziovski, 1999).

An explanation to these contrasting scenarios can be given by the use of different data analysis techniques. By using multiple regression (Adam et al., 1997; De Cerio, 2003; Fening et al., 2008; Flynn et al., 1994; Samson and Terziovski, 1999; Zehir and Sadikoglu, 2010) or correlation (Powell, 1995), it is restrictive to test the relationships among constructs, especially, indirect effects (Kaynak, 2008).

Otherwise, Kaynak (2003) suggested that future research should take into account the the interaction among QM practices that is able to indicate the indirect relationship between QM practices and operational performance. However, it has not been yet properly addressed in the literature. In fact, the empirical studies testing this interaction are still limited (Dow et al., 1999). Therefore, to fill these voids, the following structure equation model is proposed (Figure 1).

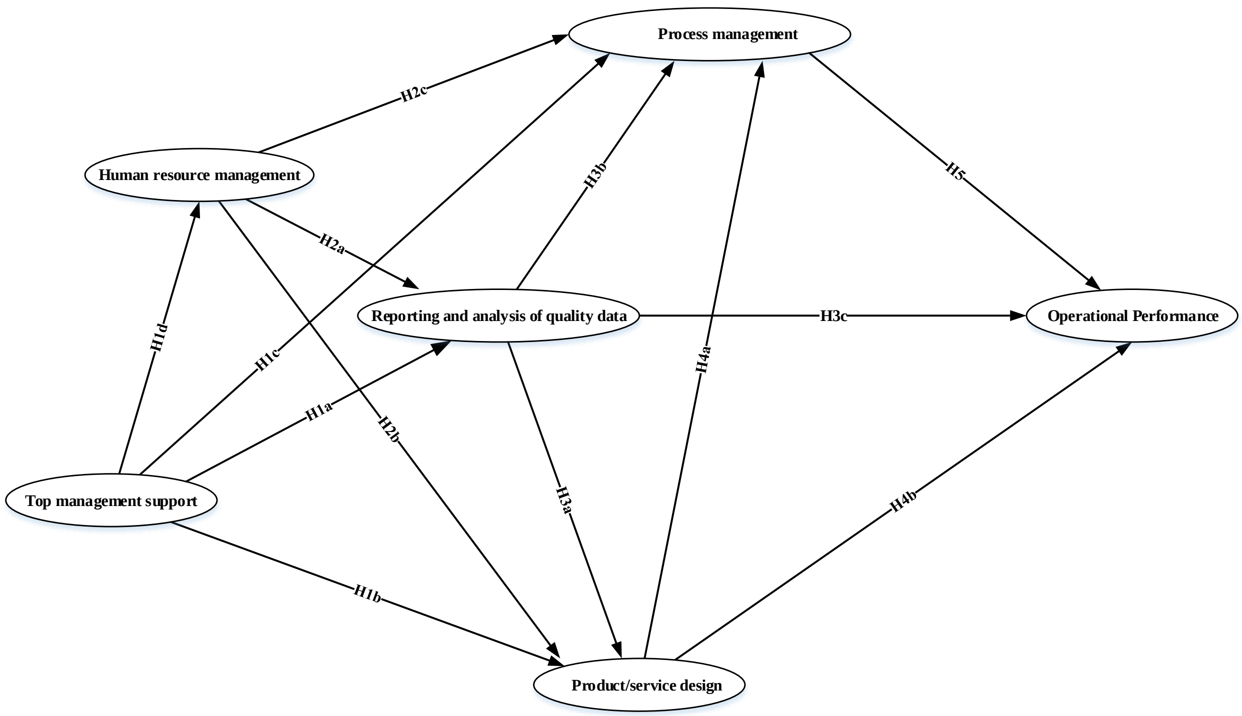


Figure 1: Research model

The relationships in figure 1 will be tested by applying Structural equation modeling (SEM). It is one of modern and complex methods, however, it gets the highest accurate in the quantitative research (Bollen, 1989). In the next part, hypotheses on the paths were developed.

Top management support. As stated by previous studies of Ahire and O'Shaughnessy (1998), Anderson et al. (1995), Flynn et al. (1995), Kaynak (2003), Shin et al. (2000), top management support plays an extremely important role in QM implementation. By impacting on other QM practices, it can improve operational performance. For instance, in order to increase the effectiveness in the use of quality data, top management provides the necessary resources in collecting quality data and ensures that they are always available in work stations. Moreover, by supporting to display quality data in control charts at employee's work stations, it would be easier to spot existing issues in the manufacturing processes. The relation of top management support to reporting and analysis of quality data is well established in the literature (Flynn et al., 1995; Kaynak, 2003; Lakhal et al., 2006; Sila and Ebrahimpour, 2005). Hence, we suggest the following hypothesis:

H1a: Top management support is positively related to reporting and analysis of quality data.

Nowadays, products become increasingly complex and differentiated, so design for new products/ services needs to integrate more information and techniques. A design team from different departments, known as cross-functional team, could help improving design process through overall consideration of organization's issues. Top management mobilizes human resource of departments for the team and creates good conditions in their tasks. In the traditional perspective, moreover, design and manufacturing activities mainly took place within a firm and even considered as technological secrets. However, as competition moves from firms to supply chains, key suppliers and customers need to be involved in these activities in order to increase the competitive advantage of supply chain (Petersen et al., 2003). Support of top management is a prerequisite for this integration (Kaynak and Hartley, 2008).

Top management offers policies which encourage innovations and continuous improvement in design and production. For instance, the support for initiatives in the use of standard component, modular design of component parts makes design activities more simple. The effectiveness of design is improved as a result (Kaynak, 2003; Kaynak and Hartley, 2008; Ou et al., 2010). In addition, supports for continuous improvement in manufacturing activities, such as, by increasing level of automation and using statistical techniques, fool-proof of process design and preventive equipment maintenance can minimize chances of employee errors and reduce variance in processes (Flynn et al., 1995; Forker, 1997; Kaynak, 2003; Lakhal et al., 2006; Saraph et al., 1989; Sila and Ebrahimpour, 2005). Hence, the following hypotheses are suggested:

H1b: Top management support is positively related to product / service design.

H1c: Top management support is positively related to process management.

Additionally, top management creates an environment conducive to the development of all employees and promotes their motivation. By empowering, employees could make their own decisions in their tasks. Top management, moreover, supports employees to involve in determining training needs and have training program to improve quality-related skills and knowledge for employees. There are some studies that found a positive relation of top management support to human resource management (Kaynak and Hartley, 2008; Ou et al., 2010; Sila and Ebrahimpour, 2005; Singh, 2008; Tarí et al., 2007). Hence, the following hypothesis is proposed:

H1d: Top management support is positively related to human resource management.

Human resource management. Human resource is considered as the most important resource in any firms and it is a key factor on the success of companies. This is always right even when a company has high technological level (APO, 2000). Human resource management refers to create a good environment for employees that are trained and empowered to deliver their tasks (Adam, 1994; Choi and Eboch, 1998; Park et al., 2001; Powell, 1995; Samson and Terziovski, 1999).

In daily activities, employees are required to interact with quality data. An effective training program helps employees know how to collect and use quality data in their tasks (Ahire and Dreyfus, 2000; Ho et al., 1999; Kaynak, 2003), such as display quality data, control charts, etc., at their work stations (Forker, 1997). In addition, empowerment makes employees more active, easier in cooperation with other departments to collect quality data. In contrast, human resource management is not effective if employees do not receive quality data accurately and timely. In the studies of Kaynak (2003), Kaynak and Hartley (2008) and Ou et al. (2010), the relation of human resource management with reporting and analysis of quality data is proved. So, the following hypothesis is proposed:

H2a : Human resource management is positively related to reporting and analysis of quality data.

Employees are those who transfer market and consumer needs into designs. Training programs are to ensure that employees have knowledge and skills to design products/services as required. In addition, empowerment allows employees freely in creating innovations. Consequently, the effectiveness of product/ service design is improved. Hence, we suggest the following hypothesis:

H2b: Human resource management is positively related to product/service design.

Quality-related training programs help employees know how to use quality improvement tools, fool-proofing for process design, the preventive equipment maintenance, etc. (Ahire and Dreyfus, 2000; Ho et al., 1999). As a result, employees could reduce unnecessary or excess motions, errors as well as process variance (Sila and Ebrahimpour, 2005; Tarí et al., 2007; Zu et al., 2008). Hence, the following hypothesis is given:

H2c: Human resource management is positively related to process management.

Reporting and analysis of quality data. For an effective design, it is required to consider a wide range of information about customer needs, raw materials, supplier capacity, production and distribution processes, etc. Therefore, quality data collected timely and accurately could improve design efficiency and support cross-functional teams in their tasks (Flynn et al., 1995; Iii, 1998). The relationship between reporting and analysis of quality data and product/service design is found in the previous studies of Kaynak (2003), Kaynak and Hartley (2008) and Ou et al. (2010). Hence, we suggest the following hypothesis:

H3a: Reporting and analysis of quality data is positively related to product/service design.

Quality data displayed in control charts, histograms, etc., could help organizations to easily and timely identify issues in processes (Ho et al., 1999), allowing employees to have corrective actions quickly before products are made. It ensures that production processes are operated smoothly (Flynn et al., 1995; Ho et al., 1999). Kaynak (2003), Kaynak and Hartley (2008) and Ou et al. (2010) also showed the relation of reporting and analysis of quality data to process management in their studies. Hence, the following hypothesis is offered:

H3b: Reporting and analysis of quality data is positively related to process management.

In addition, available quality data provides historical information about: (1) customers, (2) supplier quality, (3) distributors, (4) manufacturing process. These information is useful for reducing order-time and rate of late delivery, improving quality of inputs, detecting potential problems faster, making operating activities smoothly and reducing lead-time and other expenses as well (Kaynak, 2003; Kaynak and Hartley, 2008; Ou et al., 2010). Hence, we propose the following hypothesis:

H3c: Reporting and analysis of quality data is positively related to operational performance.

Product/service design. Practice of product/service design refers to simplify products, reduce component parts per product and increase the level in the use of standard components (Chase et al., 2006; Kannan and Tan, 2005). Reduction of component parts per product and high level of standardization make manufacturing processes more effective, reduce process complexity and variance (Ahire and Dreyfus, 2000; Flynn et al., 1995). Employees quickly get acquainted with their works that makes low rate of errors, lead-time is shorter and output is increased (Tan, 2001). The cost of repair and rework also is significantly reduced (Ahire and Dreyfus, 2000; Anderson et al., 1995). Moreover, simple components and products make delivery easier, rate of late delivery is decreased as a result. Hence, the following hypotheses are given:

H4a: Product/service design is positively related to process management.

H4b: Product/service design is positively related to operational performance.

Process management. Process management refers the use of statistical techniques, increasing automatic level of processes and fool-proof in designing process (Flynn et al., 1995; Forker, 1997; Kaynak, 2003; Saraph et al., 1989). These activities are helpful to decrease process variance (Flynn et al., 1995) and minimize chances of employee errors (Forker, 1997; Kaynak, 2003; Saraph et al., 1989). As a consequence, rate of damaged materials and late delivery, lead-time, unnecessary costs are reduced (Ahire and Dreyfus, 2000, Anderson et al., 1995), output increases and uniformity of products get higher (Anderson et al., 1994; Forza and Flippini, 1998). Futhermore, the use of preventive equipment maintenance make manufacturing process operate smoothly by improving reliability of equipment and restricting disruption in production (Ho et al., 1999). The relation of process management to operational performance is founded in the studies of Ahire and Dreyfus (2000); Forza and Filippini (1998). Hence, the following hypothesis is proposed:

H5: Process management is positively related to operational performance.

Operational performance. Operational performance refers to the ability of a company in reducing management costs, order cycle time – meet orders, improving raw material efficient use and distribution capacity (Heizer et al., 2008). Operational performance has an important meaning to firms, it improves effectiveness of production, creates high quality products, customers are more satisfied, leading to increased revenue and profit for companies (Kaynak, 2003; Kaynak and Hartley, 2008; Ou et al., 2010).

DEVELOPMENT OF THE MEASUREMENT INSTRUMENT

The scales of QM practices and operational performance were validated in 4 steps: (1) Identify and develop the initial instrument, (2) personal interview and Q-sort, (3) large-scale data collection and (4) large-scale analysis.

Identify and develop the initial instrument. The effective measurement instrument should cover all content domain of constructs (Parasuraman, 1991), measurement items of each construct should converge with other items statistically (Garver and Mentzer, 1999). In other words, two constructs which are similar in theory, are also the same in practical and vice versa. Constructs should have high level of reliable, short and easy to use (Li et al., 2005).

Based on an extensive literature review and definition of QM practices in table 1, the scales of constructs were developed (table 2). A seven-point Likert scale was employed with a score of 1, indicating "strongly disagree", and 7, representing "strongly agree", to extract the different attitudes of respondents.

Personal interview and Q-sort. A structural interview of academicians who have a lot of experiences in this area was conducted. These discussions were recorded, analyzed, modified and added some items, variables. Q-sort method, then, was applied with the participation of some managers to assess initial construct validity, reliability and unidimensionality.

In the process of Q-sort method, some managers, who are working at garment companies, were invited to review the scales of constructs in order to indicate which items need to keep, modify, drop or add. Based on the feedback from experts, items were adjusted, and then, the official questionnaire was established.

Large-scale data collection. The target population in this study is Vietnam-based companies which are working in garment industry. The target respondents are Presidents, Vice presidents, Directors, Managers, Coordinators who have information and experience in QM. In the list of General Statistics Office in 2008, there are 3.174 garment enterprises. Contact information of companies was searched from website of *nhungtrangvang.com.vn*, which provides address, email, phone... of companies in Vietnam. A total of 2.147/ 3.147 garment enterprises were collected. The link of the official questionnaire was sent to these 2,147 firms via email addresses. In order to increase the response rate, an electrical postcard was sent after the initial mailing to remind non-respondents. Depending on their requirements, a copy of questionnaire was mailed by post-office or the link of survey was sent to their email. One month later, the survey link once again was emailed. To encourage the cooperation of respondents, the survey results would be sent to them. A total of 246 questionnaires were received, resulting in the response rate of 11.5%. This is a significant rate with the method of email survey (Tse et al., 1995).

An estimate of non-response bias with T-test procedures was conducted in order to test the difference in variables between early and late respondents (Armstrong and Overton, 1977). Results showed that no significant differences on the average scores of all observed items were found (in the internal confidence of 99%). It means that non-response bias exists between early and late respondents.

These of 246 questionnaires were checked before analyzing in order to reduce errors in data entry process and detect missing values. After filtering data, there were 179 valid questionnaires, which were used for the next steps.

In addition, independent and dependent variables were obtained from the same respondent in each firm. This could lead to the presence of common method variance (CMV). Harman's single-factor test was calculated to test this existence (Podsakoff et al., 2003). Unrotated factor analysis was performed with all observed items. If only one factor emerges, in other words, if a general factor could explain most of covariance in all variables, it is rational to conclude that a significant CMV is existed. Results indicated that eight factors was appeared. However, when the number of items are too much, this way of testing is not really exact (Podsakoff et al., 2003). Therefore, in this case, items in each of the independent construct (QM practices) were factor analyzed with items in the dependent construct's scale (operational performance). For each case, the results of factor analysis showed that two and more than two factors were emerged, meaning that there is no significant CMV.

Most of respondents are presidents, directors, vice directors, manager, etc., who had more than 5 years of working experience in the current company. Among them, 32.4% are retailers, 40.2% of manufacturing companies, 14.5% of distribution centers, fabric firms account 10.6% and the remaining is design-related companies. Approximately 26.8% of the firms had 10 or fewer employees, 35.8% of the firms employed between 10 and 49 workers, 19.6% of the firms had from 50 to 249 employees, and 17.8% of the firms had more than 250 employees.

Large-scale data analysis process. Firstly, Cronbach's Alpha coefficient was used for evaluating reliability of each construct (Antony et al., 2002). Cronbach's Alpha coefficient is a statistical test about the consistent degree to which observed items in a construct are correlated. Otherwise, to improve Cronbach's Alpha coefficient, items which are low in item – total correlation coefficient will be deleted. Coefficient of item – total correlation expresses correlation among an item and the average score of other items in the same construct. Thus, the higher this coefficient is, the higher the correlation among items are and consequently, the reliability of this construct is high (Hair et al., 1995; Nunnally, 2010).

Then, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted to assess unidimensional and validity of constructs, including: convergent validity, discriminant validity and criterion-related validity.

Additionally, the distribution of observed items is the normal distribution. Most of Kurtosis and Skewness range from (-1, +1), which is in acceptant range (Kline, 1998). Thereby, the method of ML (Maximum Likelihood) is appropriate to estimate parameters in research model (Muthen and Kaplan, 1985).

If measurement items are unidimensional, reliable and valid, the analysis of structural equation model is carried out to test the hypotheses developed in the research model. In contrast, the process will turn back to literature review to redefine the constructs as well as the measurement instrument.

RESULTS

Test results of the measurement instrument. Cronbach's Alpha and EFA were calculated with the support of SPSS (**S**tatistical **P**ackage for the **S**ocial **S**ciences) in advance. Extraction method was used in EFA is principal component – rotation method of Varimax. The breakpoint is at Eigenvalue ≥ 1 for all constructs in theory model. The results, in the table 2, indicated that six items were deleted because they could not get the target value. The remaining items have the coefficient of item-total correlation range from .462 to .775 (greater than 0.35), the minimum of Cronbach's Alpha is 0.748 (greater than 0.7), factor loadings range from .683 to .904 (greater than 0.4), Eigenvalue is greater than 1, the average variance extracted is greater than 50.

Then, CFA was carried out by AMOS software. After removing 4 items which do not get the target values, the measurement model including five constructs of QM is tested with the following results: $\chi2$ = 163.058; p = .132 (greater than 0.05); df = 144; $\chi2$/df = 1.132 (less than 3.0); GFI = .911, TLI = .985, CFI = .987 (greater than 0.9); RMSEA = .027 (less than 0.08), indicating that the QM measurement model is appropriate with the collected data (Bollen, 1989; Byrne, 1998; Carmines and McIver, 1981; Hair et al., 1995; Jaccard and Wan, 1996; Joreskog and Sorbom, 1993).

For the dependent construct, $\chi2$ = 6.977, p = .222 (>0.05); df = 5; $\chi2$/df = 1.395 (<3.0); GFI = .985, TLI = .988, CFI = .994 (>0.9); RMSEA = .047 (<0.08), indicating that the measurement model of the dependent construct is appropriate with the collected data.

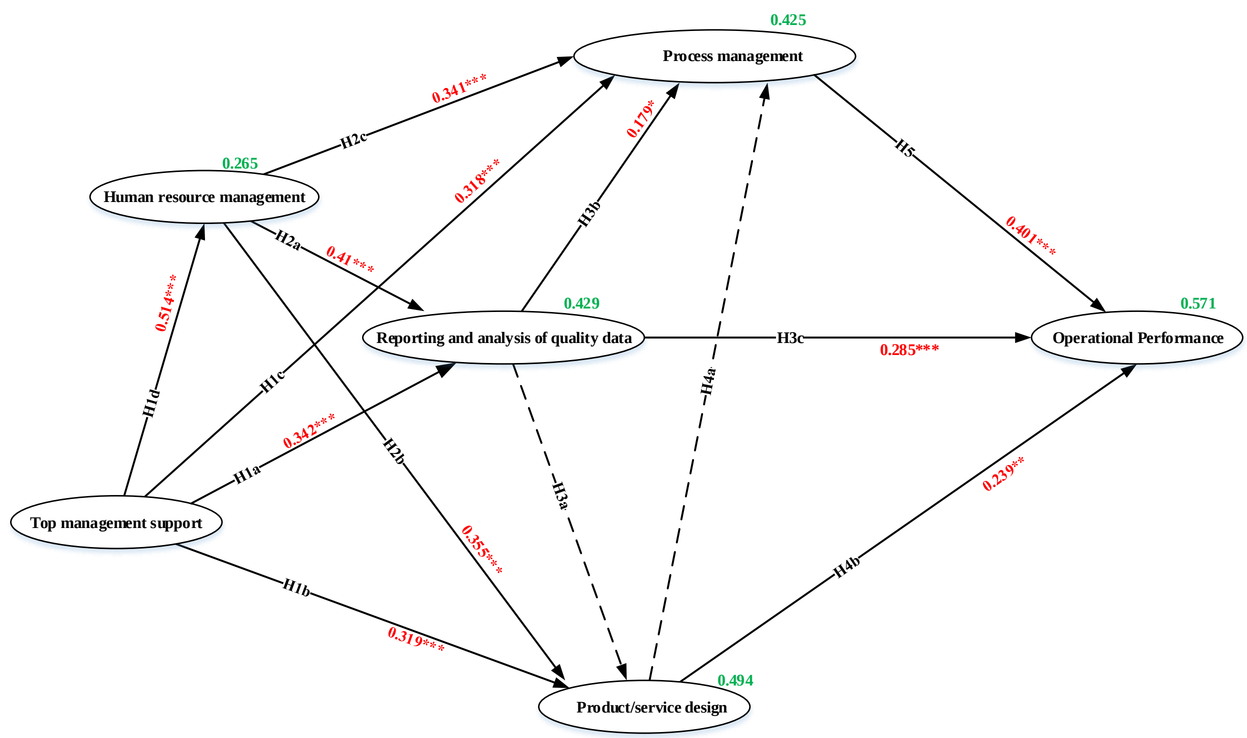
Standardized Regression Weights of all items are greater than 0.6 (the minimum value is .656) and significant (p<0.05). The composite reliability of all items ranges from .721 to .872, greater than the acceptant level of 0.6 and the average variance extracted ranges from 51,1% to 69.5% (>50%) (Table 2). In addition, the correlation coefficient between pairs of constructs ranges from .417 đến .648 in the significant level of p = .000 (table 3). In other words, constructs have discriminant validity (Steenkamp and van Trijp, 1991). Likewise, each QM practices has high and positively related to operational performance, indicating that constructs have criterion-related validity (Chen and Paulraj, 2004; Kaynak, 2003; Li et al., 2005) (table 3). It is concluded that scales of constructs have unidimensional, reliability and validity (Bollen, 1989; Byrne, 1998; Carmines and McIver, 1981; Hair et al., 1995; Jaccard and Wan, 1996; Joreskog and Sorbom, 1993).

Table 2: Test results of measurement instrument

Constructs	Observed items	Cronbach's Alpha and EFA with SPSS					CFA with AMOS		
		Factor loadings	Item – total correlation	Eigenvalue	Variance extracted	Cronbach's Alpha	Standardized Regression Weights	Composite reliability	Variance extracted
Reporting and analysis of quality data	The collection of quality data.	.879	.731	2.387	79.562	.871	.810	.872	.695
	Display of quality data, control charts... at work stations.	.893	.757				.840		
	Delivery feedback of quality data to employees.	.904	.775				.850		
	Use of quality data in employees' tasks.	Deleted					Deleted		
	Availability of quality data.	Deleted					Deleted		
Product/service design	Use of modular design of component parts.	.721	.504	2.287	57.167	.748	Deleted	.721	.564
	Use of standard components.	.683	.462				Deleted		
	The simplification of products.	Deleted					Deleted		
	Review of new product/service design.	.825	.634				.775		
	Clarity of product/service specifications	.787	.576				.726		
Process management	Use of statistical techniques.	.803	.647	2.721	68.014	.843	.713	.844	.575
	Use of automatic processes.	.847	.710				.792		
	Use of fool-proof for process design.	Deleted					Deleted		
	Use of the preventive equipment maintenance.	.803	.649				.757		
	Clarity of work or process instructions.	.845	.706				.769		
Top management support	Offer of innovation and continuous improvement policies.	.761	.640	3.429	57.142	.850	.723	.809	.514
	Provision of necessary resources for processes.	.800	.686				.734		
	Promotion of partners' involvement in firm's activities.	.761	.639				.703		
	Participation of top management in quality improvement process.	.749	.625				.707		
	Review of quality issues in top management meetings.	.740	.615				Deleted		
	Responsibility for operational performance.	.722	.593				Deleted		
Human resource management	The relationship between human resource objectives and strategic.	.782	.669	3.548	59.135	.862	.735	.862	.511
	The role of environment on the development of all employees.	.744	.624				.661		
	Promotion in the motivation of employees.	.79	.679				.728		
	Involvement in determining training needs.	.768	.653				.730		
	Training program for employees timely.	.804	.697				.765		
	Responsibility in employees' tasks.	.721	.600				.660		
	The measurement methods of employee satisfaction.	Deleted					Deleted		
	The effectiveness of employee problem resolution program.	Deleted					Deleted		
Operational performance	Reduction of management costs.	.768	.626	3.080	61.594	.844	.656	.868	.517
	Reduction of lead-time.	.780	.643				.670		
	Reduction of order-time.	.793	.661				.764		
	Reduction of rate of damaged materials.	.827	.705				.779		
	Reduction of rate of late delivery.	.754	.612				.697		

Test results of hypotheses. The theoretical model was tested by method of Structural Equation Modeling (SEM) with the support of AMOS 5.0 software (Byrne, 1998). Test results of the structural model showed that $\chi^2 = 259.797$ (p = .193 > 0.05); df = 241, $\chi^2/df = 1.078$ (<3.0); TLI = .989, CFI = .990 (>0.9); RMSEA = .021 (<0.8), indicating that the structural model is an appropriate fit with the collected data.

Figure 2 describes the SEM results of relationships among QM practices and operational performance. Parameters on the arrows are Standardized Regression Weights and P-value. Test results indicated that all paths in the model, with the exception of the paths pertaining to H3a and H4a, are supported by the collected data (Standardized Regression Weights (β) ranges from .179 to .514 at the significant level, p<0.035).



*Notes: *p<0.1; **p<0.05; ***p<0.01*

Figure 2: Test results of SEM

The R^2 for operational performance explained by the QM practices is 0.571, indicating that the QM practices can explain a large amount of variance in operational performance. Therefore, it can be said that QM practices suggested in this study have important role in improving operational performance.

DISCUSSION

This study determines the multidimensionality of QM constructs (Adam et al., 1997; Ahire and O'Shaughnessy, 1998; Anderson et al., 1995; Das et al., 2000; Dow et al., 1999; Flynn et al., 1995; Forza and Filippini, 1998; Kaynak, 2003; Kaynak and Hartley, 2008; Mohrman et al., 1995; Powell, 1995; Rungtusanatham et al., 1998; Samson and Terziovski, 1999; Shin et al., 2000). QM is identified as a multidimensional construct including different practices: top management support, human resource management, reporting and analysis of quality data, product/service design and process management. Operational perforamance will be improved remarkably if these practices are implemented as an integrated system instead of independent practices. In this system, they interact with each other and improve operational performance. The interaction among QM practices and the relationship between those and operational performance are presented as follows:

- The support practices consisting of top management support and human resource management are directly related to the core practices: reporting and analysis of quality data, product/service design and process management. The support practices create an environment that supports effective use of the core quality management practices. In particular, by maintaining the support and commitment of top management, encouraging the participation of employees in quality activities throughout empowerment and training program, an organization could create studied- and cooperated-based environment that can improve the efficiency of reporting and analysis of quality data, product/service design and process management.
- Reporting and analysis of quality data is both directly related to operational performance and indirectly through the relationship with process management. Quality data, which is collected and displayed in control charts, histograms, etc., and timely delivered to employees, is useful to identify problems in production processes. Based on them, preventive solutions and innovations are offered and operational performance is improved as a consequence. In addition, the relation of the support QM practices to reporting and analysis of quality data indicated that reporting and analysis of quality data is a mediating factor in the relationship between the support QM practices and operational performance.
- Product/service design is directly related to operational performance. By reviewing new product/service designs before they are produced and making clear specifications (Kannan and Tan, 2005), employees know clearly about products and what they need to do. They quickly get acquainted with their works that drives to low rate of errors, shorter lead-time and improve output. The cost of repair, rework also is significantly reduced. In addition, the relation of the support QM practices to product/service design indicated that product/service design is a mediating factor in the relationship between the support QM practices and operational performance.
- The relationship between process management and operational performance is supported in this study. When an organization can manage its processes effectively, manufacturing processes operate smoothly. Process variance and chances of employee errors are also minimized. Consequently, operational performance is improved. In addition, process management is also proved to have relationship with the support QM practices and reporting and analysis of quality data. It indicated that the role of process management is as a mediating factor in the relation of the support QM practices and reporting and analysis of quality data to operational performance.
- Human resource management is directly related to reporting and analysis of quality data and process management.

In Vietnam, garment is a labor-intensive industry (5% in the total of national workforce). Productivity and product quality are almost decided by direct labors. Human resource management throughout training programs and empowerment can enhance work performance of employees. Specifically, an effective training program helps employees know how to collect and use quality data and quality improvement tools in their tasks. In addition, empowerment makes employees more active, easier in their tasks, e.g. cooperation with other departments to collect quality data or even suggest continuous improvement initiatives at their workplace. It is useful to improve the efficiency of quality data and business processes.

To improve efficiency of QM practices and operational performance, therefore, it is necessary to build up a high quality human resource which needs to be considered as the most important factor to gain competitive advantage. In doing so, based on the research results, some following solutions are proposed.

- Human resource objectives should be integrated into firm's strategies.
- Companies need to organize training programs timely and employees are involved to determine training needs.
- Firms pay attention to create a work environment conductive to the development of employees and empower for them in their tasks.

In addition, the research results indicated the relation of top management support to human resource management. It proves the mediating role of human resource management in the relationship between top management support and other QM practices.

- Top management support plays the driving force for the implementation of other QM practices. It indirectly improves operational performance throughout paying attention to (1) training programs and create a good environment for employees, (2) collection and use of quality data, (3) effectiveness of product/service design, and (4) process management. The research results showed that successful implementation of top management support practice required the participation of top management actively in the quality improvement process. Top management, who has responsibility for quality performance, needs to create quality-related policies and objectives as well as conveys them to employees.

In an enterprise, top management could be Board of Directors. Widenly, it could be associations or governments in an industry or in a country. Therefore, the support of top management could create a good environment helping companies to improve their operational performance.

The relationship among product/service design and other practices, including reporting and analysis of quality data and process management is not supported by data in this study. The reason can be that Vietnamese garment enterprises, currently, mainly work at cutting & sewing stages - the lowest value-added segment in global apparel value chain. Others, such as design, input materials and distribution, etc., are nominated by customers. The use of quality data in the design process, therefore, is not concerned. And the passive attitude in design activities leads to the lack of attention in the establishment of cross-functional teams, in the use of standard components and modular design of component parts to improve process. Thus, in the context of Vietnam garment industry, product/service design is not related to reporting and analysis of quality data and process management. This result is contradictory with the studies of (Kaynak, 2003; Kaynak and Hartley, 2008; Ou et al., 2010). Hence, future research should test this result in different contexts to consolidate the statements about relationship among them.

CONCLUSION

This research project aimed at exploring the relationships between QM practices and operational performance. A conceptual model was developed and an empirical study was carried out to validate the model. The results showed that operational performance is impacted by QM practices under two groups: support practices (including: top management support, human resource management) and core practices (including: reporting and analysis of quality data, product/service design and process management). These factors interact with each other to improve operational performance, so it's better if these practices are implemented as an integration system rather than independent. Therefore, in order to improve operational performance, practitioners and researchers could not simply choose some practices mentioned in this study to apply in their context. These practices should be applied simultaneously and the structural model was used in this study could play as a "guideline" to the implementation of QM practices.

It was noted that operational performance is not only impacted by QM practices as suggested in this study, but also by many factors such as: external environment, capital, technology, equipment, information flow, etc. However, QM practices suggested in this study could explain 57.1% variance of operational performance, which is a remarkable value. Enterprises which have limitations in resources for equipment investment and technological innovations could still improve operational performance remarkably by the implementation of these QM practices. In other words, in the same conditions of finance, capital, technology, equipment, information, etc., firms which could implement QM practices successufully will have higher operational performance.

Finally, the proposed research model is also a valuable document for next empirical studies, especially for countries having the transitional economy as Vietnam.

Within the scope of this study, there are some aspects that haven't been yet considered including a wider sample, which extends to other industries and countries, will allow the generalization of the main findings. Also, it will be more comprehensive if future researches incorporate other critical factors such as external environment, capital, technology, equipment, information flow, oursourcing, etc. These imply directions for further research.

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An extensive structural model of supply chain quality management and firm performance

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ABSTRACT:

Purpose. This study was carried out to create a research model investigating the impact of supply chain quality management (SCQM) practices on firm performance.

Design/methodology/approach. Based on a comprehensive literature review, the practices were suggested. These SCQM practices will be analyzed and categorized into 4 dimensions: upstream (supplier assessment, supplier quality management), downstream sides of a supply chain (customer focus), internal process (product/service design, process management and logistics) and support practices (top management support, human resource management, information and supply chain integration). The measurement instrument of firm performance was developed including three aspects: operational performance, customer satisfaction and financial performance.

Findings. A conceptual framework and a structural model were proposed as well as the development of hypotheses on the paths.

Research limitations/implications. It is necessary to test the rationality of this model by empirical studies in different contexts.

Originality/value. The research considers integration of quality and supply chain management still remains limited in the literature. Therefore, it is necessary to have a more focused approach in assessing quality management issues within the internal and external supply chain contexts. This study concentrates on the practices which improve quality aspects of supply chain, known as SCQM practices. Proposed structural model in this paper not only fills the voids in the literature but contributes a parsimonious conceptual framework for theory building in SCQM and firm performance. It also expects to offer a useful guidance for measuring and implementing SCQM practices as well as facilitate further studies in this field.

Keywords: Quality management, Supply chain management, Supply chain quality management practices, firm performance.

Article Classification: Conceptual paper

INTRODUCTION

As competition moves beyond a single firm into the supply chain, organizations began to realize that it is not enough, if they only pay attention to improve performance within their own company. According to Li et al. (2006), the development and implementation of Supply chain management (SCM) can maximize customer value and gaining a competitive advantage in the marketplace and getting a good profit as well. Thus, SCM becomes increasingly important.

The concept of SCM has attracted the attention from academicians and business managers. Many organizations have started recognizing that SCM is the main factor to create a sustainable competitive edge for their products and/or services in an increasingly crowded marketplace.

In supply chain, quality plays an important role. Establishment of a quality-based culture can improve operational performance, customer satisfaction, financial performance, etc. along the supply chain (Kaynak and Hartley, 2008).

Several researchers have suggested to integrate quality and supply chain management. However, this implementation still remains limited (Robinson and Malhotra, 2005). Therefore, it is necessary to have a more focused approach in assessing quality management issues within the internal and external supply chain contexts.

This study will concentrate on the practices which improve quality aspects of supply chain, known as supply chain quality management (SCQM) practices. Also, a structural model will be proposed to investigate the relationship between SCQM practices and performance.

Examining these relationships is very important because it allows us to understand deeply how SCQM practices impact on performance in supply chain. And this study also expects to offer the useful guidance for measuring and implementing SCQM practices as well as facilitate further researches in this field.

The structure of this paper is as follows: the next section is literature review that previous studies concerning SCQM are documented. In section 3, the SCQM practices and firm performance were described. Then, research model and hypotheses are suggested. Implications and directions for further research are mentioned at the end of this paper.

LITERATURE REVIEW

This section is separated into 2 parts. Firstly, various definitions of SCQM are documented. Then, an appropriated one is suggested. Next, empirical studies are reviewed to explore research gaps in the literature.

Definitions of SCQM. There are some previous studies to define SCQM in different perspectives. According to Ross (1998), it is the participation of all members in a supply chain to improve all processes, products, services, and work cultures, etc. It will result in increasing productivity, competiveness and customer satisfaction.

Kuei et al. (2001) defined SCQM in the three following equations:

1. SC = a suppliers – manufacturers – customers network;
2. Q = meeting market demands correctly, and improving operational performance, customer satisfaction, financial performance; and

3. M = facilitating, encouraging the quality processes and activities, increasing trust for supply chain quality.

SCQM is the coordination, integration and optimization of quality activities among members in a supply chain. It manages product quality and processes effectively in order to gain competitive advantage, customer satisfaction and market share (Robinson and Malhotra, 2005).

SCQM is an SCM extension that is designed to help firms to establish a competitive supply chain through application of quality management practices (Kuei et al., 2008).

In sum, SCQM is the orientation, coordination and implementation of all activities taking place in supply chain smoothly. It is helpful to improve operational quality and product quality as well as to increase customer satisfaction.

Research gaps. There are some empirical studies to investigate the impact of SCQM on firm performance. However, they still remain some limitations that need to further explore. Based on extensive literature review, the research gaps are indicated, including:

- Lack of a research model covers upstream, internal process and downstream activities.
- Role of information has not yet fully examined.
- The inconsistency is in results of previous studies.
- The mutual interaction among practices has not been taken into account.
- Various dimensions of firm performance have not yet evaluated simultaneously.

For more detail, these research gaps will be discussed as follows.

SCQM has a significant impact on firm performance throughout practices along the entire supply chain that cover upstream, internal process and downstream activities (Kaynak and Hartley, 2008). It, however, has not been sufficiently examined in the literature. Some of previous studies focused only on the upstream side of the supply chain (Akamp and Müller, 2013; Hollos et al., 2011; Kumar et al., 2014; Wu et al., 2010). While others investigated the impact of downstream on performance (Danese and Romano, 2011; Mokhtar, 2013; Mukerjee, 2013). Vachon and Klassen (2006) examined integration between upstream and downstream. Conversely, other authors tested effects of internal process on performance (Adam et al., 1997; Ahire and Dreyfus, 2000; Ahire and O'Shaughnessy, 1998; Anderson et al., 1995; Choi and Eboch, 1998; Powell, 1995; Samson and Terziovski, 1999; Saraph et al., 1989). In sum, each study showed some different perspectives in a wide picture about relationship between SCQM practices and firm performance.

According to Kaynak and Hartley (2008), the implementation of SCQM is not only internal practices, which are contained within an organization, but external practices, which cross organizational boundaries integrating a company with its customers and suppliers, are also examined (figure 1).

In the study of Romano and Vinelli (2001), performance of two different supply chains in garment industry was investigated. One is a traditional chain with no formal integration, and the other has involvement of upstream and downstream partners in activities of the focal firm. The study found that the supply chain which has integration and cooperation among members is better able to meet expectations of customers.

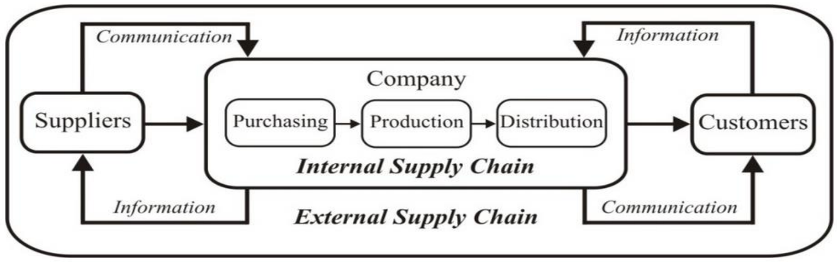

Figure 1: Internal and External Supply Chain

On the other hand, for this successful integration, information plays an extremely important role (Ding et al., 2014; Inderfurth et al., 2013; Qrunfleh and Tarafdar, 2014; Wu et al., 2014; Zhou et al., 2014). Lack of information or distorted information passed from one end of the supply chain to the other, can create significant problems, including, but not limited to, excessive inventory investment, poor customer service, lost revenues, misguided capacity plans, ineffective transportation, and missed production schedules. These are not deliberate attempts to sabotage the performance of fellow supply chain members. Rather, distorted information throughout the supply chain will result in bullwhip effect (Handfield and Nichols, 2008). A further study which covers four major dimensions of SCQM including: internal process, upstream, downstream and information is essential to provide more macro guidance for quality integration in whole supply chain network.

Additionally, in QM or SCM literature, the results of previous studies are inconsistent in order to consolidate the statement of the influence of SCQM practices on firm performance (Kaynak and Hartley, 2008). For instance, in the relationship between customer focus and performance, the direct impact of customer focus on performance is supported by Prajogo and Brown (2004), Feng et al. (2006), Fening et al. (2008), Terziovski (2006), Samson and Terziovski (1999), Lakhal et al. (2006), Dow et al. (1999). However, according to Tarí et al. (2007), Zu (2009), Su et al. (2008), customer focus indirectly effects on performance through the relationship with other practices. Also, Rahman and Bullock (2005) pointed out that there are indirect and direct relationship between them. Otherwise, between process management and performance, the direct influence of process management on performance have been identified in several studies (Feng et al., 2006; Fening et al., 2008; Kaynak, 2003; Kaynak and Hartley, 2008; Prajogo and Brown, 2004; Sila and Ebrahimpour, 2005; Terziovski, 2006; Zu, 2009). However, Tarí et al. (2007) argued that they have an indirect relationship. Conversely, Flynn et al. (1995) proved that process management has negative direct impact on performance, or even they are not associated as the studies of Powell (1995), Samson and Terziovski (1999).

Also, it is more important that these investigations are mainly to concentrate on the directly relationships, there is a lack of examining interactions among SCQM practices (Dow et al., 1999). According to Kaynak (2003), it is not comprehensive if a research model does not show relationship among practices. In other words, further studies need to identify the direct and indirect impact of SCQM practices on firm performance at multiple levels.

So far, few studies have considered the effect of SCQM practices on various dimensions of firm performance. Most of them are to focus on the relationships between SCQM practices and a single performance measure, such as: financial performance (Li et al., 2006), operational performance (Bayraktar et al., 2009; Devaraj et al., 2007; Fawcett et al., 2007; Wong et al., 2011), supplier/buyer performance (Shin et al., 2000), customer satisfaction (Power et al., 2001), etc.

It is hoped that by addressing diversified aspects of SCQM practices simultaneously as well as examining the direct and indirect impact of these practices on various firm performance, this study will provide a parsimonious conceptual framework for theory building in SCQM and firm performance.

IDENTIFICATION OF SCQM PRACTICES AND FIRM PERFORMANCE

Methodology. SCQM practices were documented based on extensive literature review in both areas of QM and SCM. Then, they were divided into four groups: upstream, internal process, downstream and support practices. The next step was to refine these practices that the similar ones were deleted. It is hope that the remaining practices will cover four above aspects.

Traditionally, firm performance was primarily evaluated by financial indicators such as sales revenue, market share, return on investment or return on sale. (Li et al., 2006). It is not comprehensive because firm performance is also reflected by other goals. In 1993, Kaplan and Norton introduced balanced scorecard including four different perspectives of performance indicators: financial, customer, internal processes and innovation and learning. Based on them, the measurement scales for firm performance were designed.

SCQM practices. As discussed, a comprehensive implementation of SCQM needs to cover four major dimensions including: upstream, internal process, downstream and information.

Based on an extensive literature review, the most relevant SCQM practices are identified (see Table 1). The classification adopted in this study (Flynn et al., 1995) assumes three main categories:

- Upstream: supplier management consists of supplier assessment and supplier quality management.
- Downstream: customer focus.
- Internal process: product/service design, process management and logistics.

Moreover, to ensure that activities in the entire supply chain are performed smoothly, the practices of human resource management, top management support, supply chain integration and information, known as support practices, are suggested.

Table 1: Description of SCQM practices.

SCQM practices		Description
Supplier management	Supplier assessment	Formal supplier assessment system. Clear metric for measuring supplier performance. Monitoring closely supplier performance. Comparison with other suppliers. (Prajogo et al., 2012)
	Supplier quality management	Reliance on a few suppliers. Supplier selection based on quality. Use of certified suppliers. Reliance on supplier process control. Communication with suppliers about quality considerations. Conformity of required quality attributes by suppliers. Clarity of specifications to suppliers. Decrease in amount of inspection for incoming quality. (Li et al., 2005)
Customer focus		Determination of customers' needs and wants. Understanding of products or services by employees. Use of information from customers in designing products and services. Commitment to satisfy customers. (Lakhal et al., 2006)
Internal process	Product/service design	Use of modular design of component parts. Use of standard components. Simplification of products. Review of new product/service design. Clarity of product/service specifications. (Kannan and Tan, 2005)
	Process management	Use of fool-proof for process design. Use of statistical techniques. Use of automatic processes. Auto-control inspection. Use of the preventive equipment maintenance. Clarity of work or process instructions. Identification of problem's location. (Forker, 1997; Kaynak, 2003; Saraph et al., 1989)
	Logistics	Selection of facility location. Response to anticipated delivery dates. Response to desired quantities. Modification of order size. Response to delivery times for specific customers. (Stank et al., 2001)
Human resource management		Employee development objectives based on strategic objectives. Effectiveness of employee problem/grievance resolution program. Measurement of employee satisfaction. Work environment. Empowerment. Promote of employee motivation. Training programs. Involvement in determining training needs. (Adam, 1994; Choi and Eboch, 1998; Park et al., 2001; Powell, 1995; Samson and Terziovski, 1999)
Top management support		Offer of innovation and continuous improvement policies. Provision of necessary resources for processes. Promotion of partners' involvement in firm's activities. Participation of top management in supply chain quality improvement process. Review of supply chain quality issues in top management meetings. Perception of importance of supply chain quality improvement. Responsibility for firm performance. (Flynn et al., 1995; Kaynak, 2003; Saraph et al., 1989)

Supply chain integration		Development of a long-term relationship. Participation in company's activities. Participation in activities of trade partners. Share of knowledge about core business processes. Share of improvement benefits, risks and rewards. Joint problem-solving. Participation in continuous improvement programs. Support for trade partners to improve product quality. Common goals. Evaluation relationship periodically. (Vanichchinchai and Igel, 2010)
Information	Information Sharing	Share of proprietary information. Announcement about issues affecting company's business. Share of business knowledge about core business processes. Information exchange to establish business planning. Announcement about events or changes. Face-to-face planning/communication. (Li and Lin, 2006; Li et al., 2006; Li et al., 2005)
	Information quality	Exchange of relevant information. Exchange of timely information. Exchange of accurate information. Exchange of complete information. Exchange of confidential information. (Cao and Zhang, 2011; Li and Lin, 2006; Li et al., 2005)
	Information Management	Data collection about trade partners' activities. A common standard for information sharing. Evaluation of formal and informal complaints and satisfaction. Information sharing among functions. Important information transmission to employees. Use of information to improve key processes, products and services. (Vanichchinchai and Igel, 2010)
	Information technology	Direct computer-to-computer links. Inter-organizational coordination based on electronic links. Use of information technology-enabled transaction processing. Electronic mailing capabilities. Use of electronic transfer of purchase orders, invoices, and/or funds. Use of advanced information systems to track and/or expedite shipments. (Prajogo et al., 2012)

Firm Performance. Firm performance is defined as how a firm achieves its market goals, and also its overall goals (Yamin et al., 1999). This study defines the set of measures for firm performance according to the four dimensions of balance scorecard. In which, financial perspective is measured by financial performance, customer satisfaction represents for customer perspective and finally, operational performance consists of internal processes, innovation and learning. Detail description of each dimension is in table 2.

Table 2: Description of firm performance dimensions

Dimensions of firm performance	Description
Customer satisfaction	Response to customer standards. Customer evaluation to firm performance. Continuity to use firm's product/service. Recommendation of firm's product/service to others. (Bozarth et al., 2009; Taylor and Baker, 1994)
Financial performance	Material acquisition costs. Non-quality costs. Warehousing costs. Manufacturing unit costs. Cost of carrying inventory. Logistics costs. Transportation costs. Sales revenue. Market share. Return on investment. Return on sale. (Beamon, 1999)
Operational performance	Delivery of inputs on-time. Material inventories. Quality inputs. Inspection of incoming materials/components/products. Set-up time. Lead-time. Inventory levels. Rate of defect products. Level of utilization at plant. Product/service quality. Rate of new product development. Level of absenteeism. Employee's productivity. (Beamon, 1999)

From above, the conceptual framework is suggested in figure 3.

STRUCTURAL MODEL AND HYPOTHESES

From literature review, we can see that previous studies suffered incomplete consideration of SCQM dimensions as well as insufficient examination of the direct and indirect impact of these practices on various firm performance. This study will try to fill this void by proposing a comprehensive framework covering all suggested dimensions and developing related hypotheses as follows.

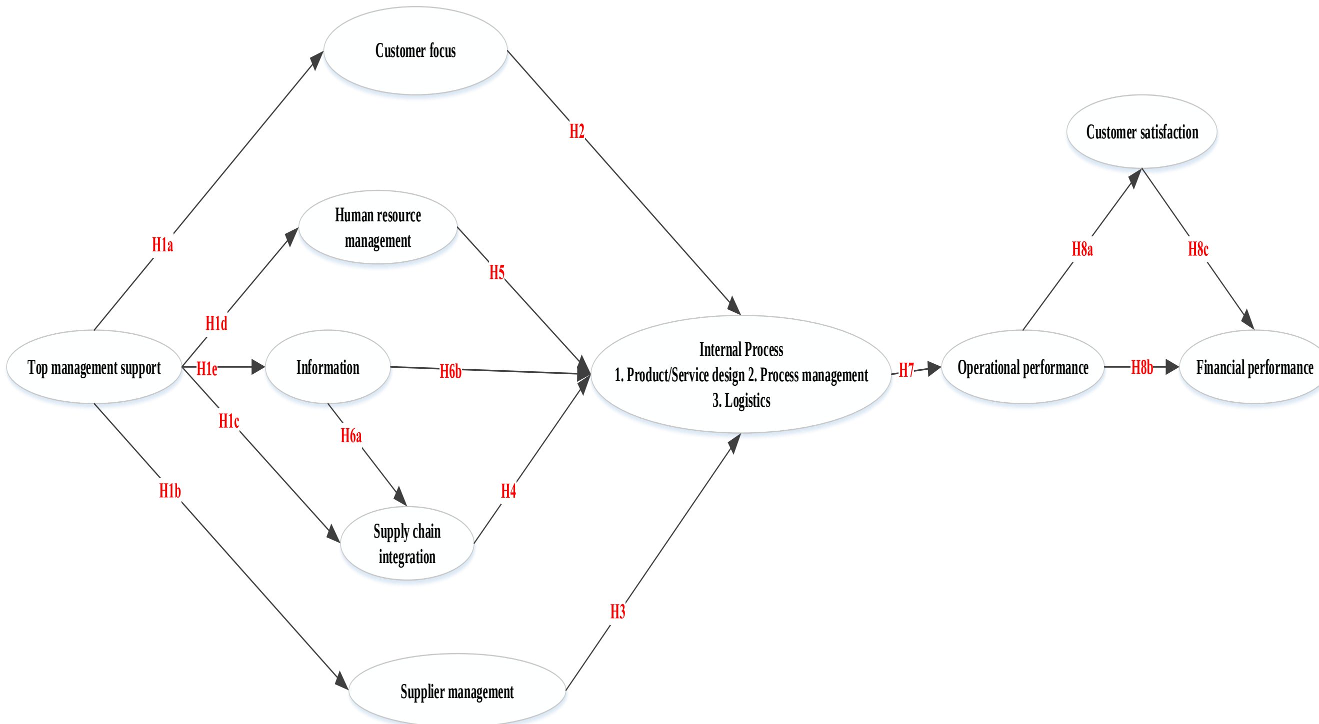

Figure 2: Structural model

Figure 2 describes the proposed structural model. In this model, internal process, supplier management and information are presented as second-order latent constructs. The structural relationships are depicted by arrows and will be discussed as follows.

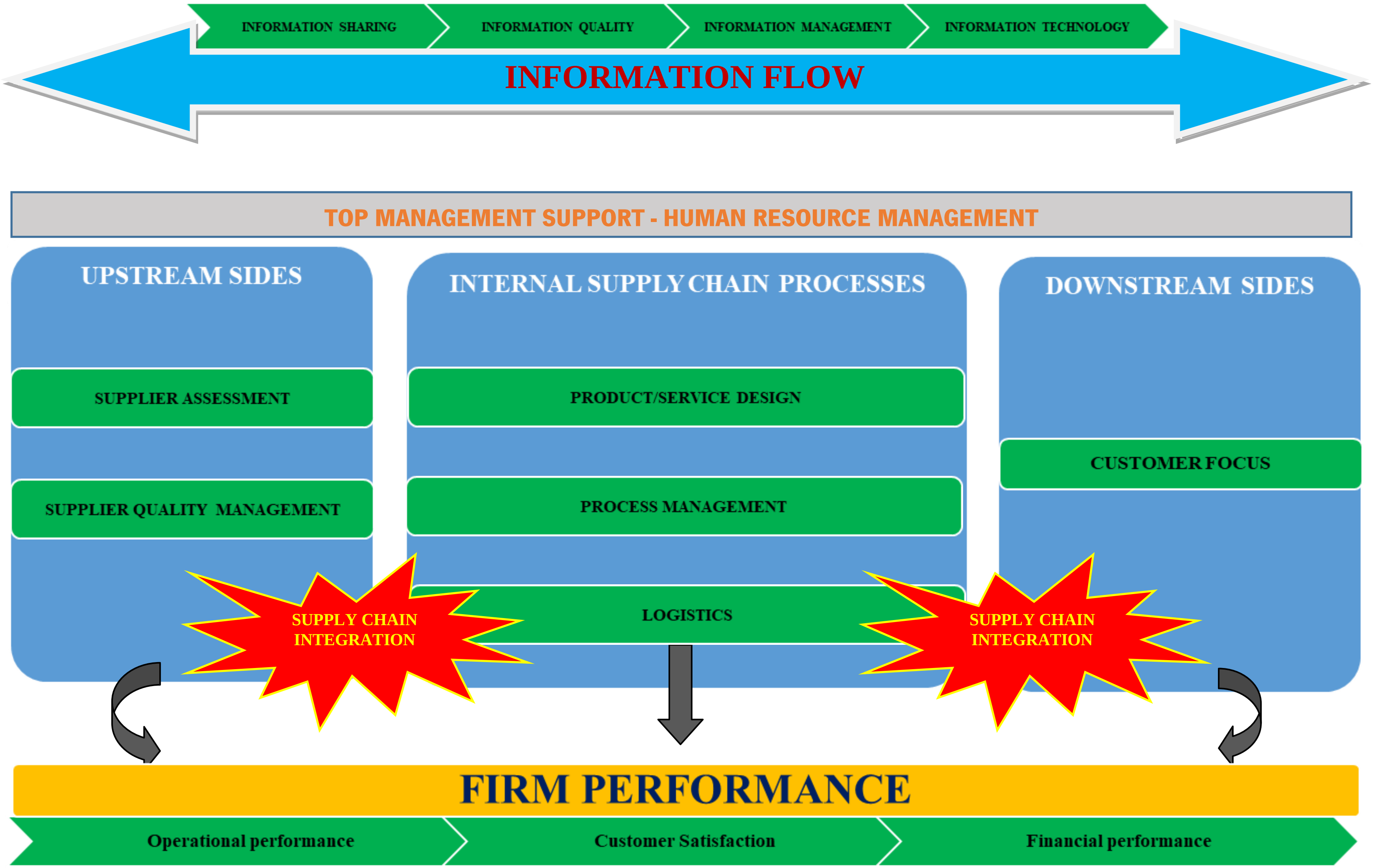

Figure 3: Conceptual framework

Top management support. The support of top management is the main motivation that drives companies towards an effective and successful implementation of SCQM (Abraham et al., 1999; Ahire and Dreyfus, 2000; Ahire and O'Shaughnessy, 1998).

In any companies, customer satisfaction is the key driver of all activities. Therefore, customers' needs must be properly addressed not only by top managers but all employees also (Lakhal et al., 2006). Top management support is essential in ensuring that necessary resources are provided to carry out market studies to determine customers' needs and wants as well as making all efforts to meet them (Kaynak, 2003).

Additionally, in the SCM perspective, customer involvement in firm's activities plays an important role in the success of the whole supply chain (Robinson and Malhotra, 2005). Top management can promote customer involvement from the earlier stages of development until the commercialization stage (Flynn et al., 1995). Top management, further to define companies' mission and goals, creates the working environment in which all employees are encouraged to focus on addressing customer requirements (Ahire and Ravichandran, 2001).

As traditional approaches, supplier management is seen as a mere administrative activity that mainly focuses on supplier selection. In this activity, price is the main criterion to evaluate suppliers. This can result in poor quality materials or even delayed orders. In new perspective, supplier management refers not only to the selection of quality suppliers, but to the development of long-term relationship with suppliers and assessment of suppliers' performance also (Li et al., 2005). However, to ensure that this implementation is successful, it is necessary to have support from top management (Kaynak, 2003; Kaynak and Hartley, 2008; Sila and Ebrahimpour, 2005; Singh, 2008; Zu et al., 2008). Top management actively participates in this process and selection will be based on review of more demanding criteria, e.g. quality, reliability in delivery activities and service. It ensures that firm has a reliable and high quality suppliers (Flynn et al., 1995; Trent and Monczka, 1999). Moreover, effective supplier management is considered as a strategic area by top managers promoting higher levels of integration and collaboration (e.g. design, production, marketing, sales and customer service) with key suppliers. Thereby, communication, relationship, and cooperation among parties in the supply chain are improved (Ellram, 1995). Hence, we propose the following hypotheses:

H1a: Top management support positively impacts on customer focus.

H1b: Top management support positively impacts on supplier management.

H1c: Top management support positively impacts on supply chain integration.

Top management creates an environment conducive to the development of all employees and promotes the motivation of employees. By empowering, employees could make their own decisions in their tasks. Top management, moreover, supports employees to involve in determining training needs and have training program to improve quality-related skills and knowledge for employees. There are some studies that found a positive relation of top management support to human resource management (Kaynak and Hartley, 2008; Ou et al., 2010; Sila and Ebrahimpour, 2005; Singh, 2008; Tarí et al., 2007). Hence, the following hypothesis is proposed:

H1d: Top management support positively impacts on human resource management.

To operate a supply chain smoothly, information needs to be shared among partners. However, this leads to a concern that information disclosure is as a loss of power (Mason-Jones and Towill, 1997). Thus, to ensure that information practice is applied successfully, top management support has a significant role. They are those who can decide types of shared information and extent to which critical and proprietary information is communicated to supply chain partners as well as transmitted to employees within their company. Moreover, the accuracy, timeliness, adequacy, and credibility of information exchanged are also determined by top management. Furthermore, top management makes decisions to invest necessary facilities to apply information technologies in daily activities. Hence, we suggest the following hypothesis:

H1e: Top management support positively impacts on information.

Customer focus. Customer focus is considered as a key element for successful enterprises. All activities such as the development of new product/services, production, marketing, distribution and after-sales services should be concentrated on customer requirements. Each department and every employee should share customer-focused vision alike (Ahire and O'Shaughnessy, 1998; Ahire and Ravichandran, 2001; Flynn et al., 1995; Forza and Filippini, 1998; Lakhal et al., 2006; Nair, 2006; Sila and Ebrahimpour, 2005).

The implementation of customer focus practice helps companies to better understand customer expectations and market opportunities (Lakhal et al., 2006). Based on them, firms can be active in planning for design, purchasing, production, delivery, etc. For instance, firms can balance supply and demand, reducing variance in processes (Lee et al., 1997). In production activities, by understanding customer's demand, company can coordinate effectively machines, equipment and human resources to minimize process complexity and variance.

Furthermore, employees know attributes of products/ services which bring benefits for customers can enhance the efficiency of their jobs. As a result, errors are minimized as well as improvements in design, production, delivery, etc., are also suggested. Moreover, since customer's needs and wants are determined, firms concentrate their efforts on responding them. It is helpful to increase productivity of internal process (Dow et al., 1999; Fening et al., 2008; Lakhal et al., 2006; Rahman and Bullock, 2005; Samson and Terziovski, 1999; Zehir and Sadikoglu, 2010). Hence, the following hypothesis is proposed:

H2: Customer focus positively impacts on internal process.

Supplier Management. The successful implementation of supplier management ensures that input materials meet standards and quality requirements in order to produce quality products (Chen and Paulraj, 2004; Kaynak, 2003; Kaynak and Hartley, 2008; Li et al., 2005; Ou et al., 2010; Robinson and Malhotra, 2005; Vickery et al., 2003). High quality inputs, provided at the right time with the required quantity, helps firm to avoid downtime incidents, to reduce variance in processes and the rate of damaged materials (Flynn et al., 1995; Forza and Filippini, 1998). Moreover, effective supplier management can cut off inventory, waste and safety inventory level (Easton and Jarrell, 1998; Yeung, 2008). Hence, we suggest the following hypotheses:

H3. Supplier management positively impacts on internal process.

Supply chain integration. From a supply chain perspective, integration of trade partners in firm's activities can increase the efficiency of internal process (Robinson and Malhotra, 2005). For instance, suppliers can offer the most appropriated components or parts for designing new products (Hoegl and Wagner, 2005), and help purchasers buy inputs that can be used most efficiently in manufacturing processes and delivery (Flynn et al., 1995; Forza and Filippini, 1998; Shin et al., 2000; Tan, 2001; Trent and Monczka, 1999).

In another perspective, by participation on cross-functional design teams, contribution of new ideas, selection of ideas and features for further product/ service development or choosing components for new products, etc., customer involvement directly increases the effectiveness of product/ service design (Ulwick and Teitelbaum, 2005). In activities of production and distribution, moreover, suggestions of customer is a base to identify underlying issues.

Furthermore, Flynn et al. (2010) proved that share of knowledge about core business processes among members in supply chain improves the operations in internal process of each firm. Hence, the following hypothesis is offered:

H4. Supply chain integration positively impacts on internal process.

Human resource management. Human resource is considered as the most important resource in any firms, it is also a key factor deciding the success of companies. This is right even when a company has good technologies and equipment. Because all activities in a firm always require human interaction (APO, 2000). Human resource management refers to create a good environment for employees that they are trained and empowered to implement their tasks (Adam, 1994; Choi and Eboch, 1998; Park et al., 2001; Powell, 1995; Samson and Terziovski, 1999).

Employees are those who transfer market and consumer needs into designs. Quality-related training programs ensure that employees have knowledge and skills to design products/services as required. In addition, it also helps employees know how to use quality improvement tools, such as, statistical techniques, fool-proofing for process design, etc. in their daily tasks (Ahire and Dreyfus, 2000; Ho et al., 1999). Employees could reduce unnecessary or excess motions and process complexity (Sila and Ebrahimpour, 2005; Tarí et al., 2007; Zu et al., 2008). Moreover, empowerment allows employees actively suggest innovations at their plant. Hence, we suggest the following hypothesis:

H5. Human resource management positively impacts on internal process.

Information. For integration of members within the supply chain, information systems plays an important role (Zhao et al., 2002). According to Stein and Sweat (1998), supply chain partners who exchange information regularly are able to work as a single entity. Together, they can understand the needs of the end customer better and hence, can respond to market change quicker. Many researchers have suggested that the key to the seamless supply chain is making available undistorted and up-to-date marketing data at every node within the supply chain (Childerhouse and Towill, 2003). Moreover, by taking the data available and sharing it with other parties within the supply chain, the negative impact of the bullwhip effect on a supply chain can be also reduced or eliminated (Yu et al., 2001). On the other hand, Bayraktar et al. (2009) agrued that relevant information is transmitted timely to employees can improve efficiency of internal activities.

With the growing popularity of e-business and e-supply chain, information technology is a crucial factor in a successful organization and its supply chain. By using direct computer-to-computer links, electronic links or electronic mailing capabilities, etc., information technology can increase communication among members in supply chain network as well as departments in a firm. Effectiveness of internal process is also enhanced by applications of advanced information systems in transaction processing, electronic transfer of purchase orders, invoices, funds or track and expedite shipments (Prajogo et al., 2012). Hence, we proposed the following hypotheses:

H6b. Information positively impacts on supply chain integration.

H6b. Information positively impacts on internal process.

Internal process. Internal process refers to all activities in a firm. This concept, therefore, is considered as a second-order latent construct including 3 practices: product/service design, process management and logistics. The successful implementation of internal process throughout three these practices has a significant impact on operational performance.

Product/service design refers to simplify products, reduce component parts per product and increase the level in the use of standard components (Chase et al., 2006; Kannan and Tan, 2005). Reduction of component parts per product and high level of standardization make employee's tasks easier. They quickly get acquainted with their works that makes low rate of errors, lead-time is shorter and output is increased (Tan, 2001). The cost of repair and rework is also significantly reduced (Ahire and Dreyfus, 2000; Anderson et al., 1995). Moreover, simple components and products make delivery easier. As a result, rate of late delivery is decreased.

Process management refers the use of statistical techniques, increasing automatic level of processes and fool-proof in designing process (Flynn et al., 1995; Forker, 1997; Kaynak, 2003; Saraph et al., 1989). These activities are helpful in decreasing process variance (Flynn et al., 1995) and minimizing chances of employee errors (Forker, 1997; Kaynak, 2003; Saraph et al., 1989). Consequently, output increases and uniformity of products is higher (Anderson et al., 1994; Forza and Flippini, 1998). Furthermore, the use of preventive equipment maintenance make manufacturing process smoothly by improving reliability of equipment and restricting disruption in production (Ho et al., 1999). The relation of process management to operational performance is founded in the studies of Ahire and Dreyfus (2000); Forza and Filippini (1998).

One of logistics implementation refers to select facility location close to suppliers and customers as well as modify order size (Stank et al., 2001). It ensures that distribution activities are fast and more effective. As a consequence, rate of late delivery and damaged materials in transportation are minimized (Kenneth et al., 2008). All above, the following hypothesis is recommended:

H7. Internal process positively impacts on operational performance.

Firm performance. Operational performance refers to the ability of a company in reducing management costs, order-time, lead-time, improving effectiveness of using raw material and distribution capacity (Heizer et al., 2008). Kaynak (2003) indicated that a high operational performance firm is able to produce quality products/services that increase customer satisfaction (Choi and Eboch, 1998; Ou et al., 2010), revenue and profit for companies (Ahire and Dreyfus, 2000; Kaynak, 2003; Kaynak and Hartley, 2008; Yeung, 2008).

Furthermore, since unnecessary costs are reduced, firms are able to offer lower prices for their products/services. Consequently, market share and sales revenue are also increased (Maani et al., 1994). Moreover, improving efficiency in the use of machines, equipment, warehouses, etc. will increase return on assets (Kaynak, 2003). Otherwise, as a firm has ability to offer high quality products/ services, higher price can be charged, which, can increase return on sales (Kaynak, 2003). Last but not least, a high quality product/ service offered at the low price will make customer more satisfied (Choi and Eboch, 1998). Hence, two following hypotheses are proposed:

H8a. Operational performance positively impacts on customer satisfaction.

H8b. Operational performance positively impacts on financial performance.

According to Buchanan and Gillies (1990), customers who are content with products/services of a company are less likely to switch to competitors, thereby, market share is maintained. Moreover, they tend to be less price sensitive or even willing to pay at a higher price, this can result in increasing sales and return on sales. Likewise, a satisfied customer will introduce to other potential customers. As a consequence, market share is increased.

H8c. Customer satisfaction positively impacts on financial performance.

CONCLUSION

This paper proposed a structural model to consider the integration between quality and supply chain management which is still limited in the literature. Based on extensive literature review, the research gaps in previous studies were indicated. Those are: (i) lack of integration among internal process, upstream and downstream side of SCQM, (ii) role of information in this integration is not emphasized, (iii) insufficient examination of various dimensions of firm performance and (iv) the causative links among SCQM practices. These things lead to detract from benefits of the SCQM implementation in previous results (Li et al., 2006).

Proposed structural model in this study not only fills the above voids but contributes a parsimonious conceptual framework for theory building in SCQM and firm performance. It covers diversified aspects of SCQM practices and firm performance as well as presents the direct and indirect effects of these practices on various firm performance simultaneously. Investigating these relationships is very important because it allows us to understand deeply how SCQM practices impact on performance in supply chain. And we also expects that research models suggested in this paper can offer a useful guidance for measuring and implementing SCQM practices as well as facilitate further studies in this field. For future researches directions, it is necessary to test the rationality of these models by empirical studies in different contexts.

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Application of Statistical Process Control to Evaluate the Effectiveness of Replacing Ordinary Plumbing Fixtures in an Educational Institution

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ABSTRACT

Water conservation is a theme of great importance and it is directly associated to quality of life. Within this context, water saving plumbing fixtures are options for consumption reduction. This study will assess whether the replacement of ordinary taps with water saving plumbing fixtures in a university campus is effective. With this goal, CUSUM control charts (Cumulative Sum) and the EWMA chart (Exponentially Weighted Moving Average) were applied. These charts are suitable to monitor processes subject to small changes, and the decision concerning the statistical control state is based on information accumulated from previous samples and not only on the last of them. With these charts, it is possible to identify the moment in time in which a change in the process occurs. The study was divided into two stages: measuring before the intervention and after the replacement of ordinary taps with water saving devices. Both CUSUM and EWMA charts indicate that after the equipment replacement there is a reduction in water consumption.

Keywords: Water consumption, CUSUM, EWMA.

Article Classification: Case study

INTRODUCTION

Water is an important natural, finite and vulnerable resource, and its use should not compromise its availability, both in quantity and in quality. Efficient water usage is therefore essential for the planning and management of water demand in various industries (Lee and Tansel, 2013).

On college campuses, efficient water usage is a recurring tool for promoting environmental sustainability. According to Marinho, Gonçalves and Kiperstok (2014), in addition to water savings and economic resource conservation, efficient water usage also leads to technological and behavioral innovation in the educational environment.

Therefore, for new buildings, it is essential that water saving hydro-sanitary equipment be used to reduce consumption. It is within this context that this paper seeks to contribute to research that involves the efficient use of water in buildings. It will propose the use of statistical process control charts to analyze whether the replacement of conventional equipment for more efficient equipment is effective in reducing water consumption.

Until recently, the traditional paradigm of the use of control charts was for industrial processes. However, the number of reported applications in areas outside conventional production systems has extended to other areas and increased in recent years (Maccarthy and Wasusri, 2002; Samohyl, 2009), including the monitoring of water parameters (Henning et al., 2014), detection of bioterrorism, public health, space surveillance and operational strategies in finance, among others (Frisen, 2011).

The control chart is a method of detecting unusual causes that, acting in a process, cause high variability in output (the result of the process). Some control charts, such as the cumulative sum (CUSUM) control chart and the Exponentially Weighted Moving Average (EWMA) control chart still allow you to detect trends and changes in level, i.e., by means of a control chart, it is possible to evaluate trends in the process (Montgomery, 2008). For this reason, they are increasingly used in epidemiology to assist in both the understanding and evaluation of the stability of processes, and identify changes that indicate improvement or worsening of health conditions (Woodall; Adams and Benneyan, 2012). Thus, as in epidemiological studies, this is a problem of detecting a change in a process. According to Han (2010)

> One statistical methodology for dealing with health care surveillance is from the sequential change point detection problem. In the classical sequential change detection problem, one monitors the sequence of observations Y_1, Y_2,... from the process of a system. Initially, the process is under the in-control state (normal state). At some unknown time ν, the process goes to an out-of-control state (abnormal state). The problem is to detect a change in the process state quickly while controlling the false alarm rate. Motivated by engineering applications, the classical problem assumes that observations are independent and that the distributions in the process are known. The problem has been solved using several popular methods including Shewhart's chart, Roberts' EWMA, Page's CUSUM, and the Shiryaev Roberts procedure. (2010, p. 01)

From this point of view, determining when a change has occurred, control charts are a natural choice for this purpose. The difference in the proposed application lies in the fact that the state considered out of statistical control results in an improvement in the process, as it indicates the reduction of water consumption. CUSUM techniques have already been implemented by Barrat et al. (2007) and Chelani (2011) to assess the implementation of regulatory measures related to motor vehicles on air quality. Here, we assume the approach proposed by Lucas (1985), where the CUSUM control chart is recommended for detection of problems and improvements. These considerations have motivated the choice of these procedures (CUSUM and EWMA) to assess the impact of replacing conventional hydro-sanitary equipment with water saving devices.

Several studies have been conducted about efficient water usage based on the use of water-saving devices, each with its own characteristics and methods. Descriptive and graphic measurements, regression models and multivariate statistical methods appear as statistical techniques to analyze the reduction of water consumption (Ilha et al, 2010; Lombardi, 2012; Barberán et al, 2013; Pedroso, 2008; Willis et al, 2011; Willis et al, 2013). Until now, there is no record of studies covering the proposed application.

CONTROL CHART OVERVIEW

Statistical process control (SPC) is the use of statistical methods in all stages considered critical or very important in the development a product or process. According to Samohyl (2009), the main idea of SPC is that better processes with less variability provide better quality levels in production output. And as it deals with improving processes, this means not only better quality but also lower costs. Standing out among the tools of SPC, there are control charts.

There are several parameters that allow for the categorization of control charts. You can separate them, for example, according to the number of control limits: unilateral or bilateral charts. You can also categorize them according to the number of variables to be controlled by a single chart: Charts for individual variables or for multiple variables.

They can be further broken down by the memory type of the chart: Shewhart charts use only the result of the current sample, and so are classified as control charts without memory. But the EWMA (exponentially weighted moving average) and CUSUM (cumulative sum) control charts use the results of previous samples, and are known as control charts with memory (Montgomery, 2008).

The basic mode of operation of control charts is to improve processes by understanding and learning the variations attributed to them. Through control charts, casual variations of a process can be distinguished from the so-called special ones. That way, you can detect when a process leaves a predictability condition (under statistical control) and starts to behave in an unpredictable way (out of statistical control). When a variation caused by a special cause is found, there is a unique opportunity to improve the process. At this point, the process should be investigated to find the root cause responsible for the unpredictability condition and, where possible, strategies must be developed to minimize or eliminate the effect of this cause (Hawkins and Olwell, 1998).

The process of operationalization of SPC can be separated into two phases: Phase 1 (setting the control limits) and Phase 2 (the control of the process itself). In Phase 1, the distribution of the process is not defined and it is expected that variations due to special causes will appear in the charts. These need to be identified and eliminated. It can be stated that during Phase 1, the control chart operates primarily as an exploratory analysis tool (Woodall, 2000). One of the most important results of this phase is the definition of the control limits. Phase 2 consists of the use of control charts, with samples being taken sequentially over time to detect changes in a process that was shown to be under control in Phase 1. Whenever any change occurs, a corrective action must be taken to restore control. At this stage, the decision to intervene in the process is based only on the values of the statistics and on the regions defined by the control limits.

Performance evaluation of a control chart is measured by how fast it detects changes in the process. The parameter used to evaluate such performance is the Average Run Length (ARL). The ARL is the average number of points to be allocated in the chart before it produces an out-of-control signal. For a good chart, the expectation is to have a high value for the ARL under control (ARL_0), that is, the probability of emitting a false alarm and sending a signal rapidly when a change actually occurred. ARL_0 is 370, which means that we admit that a false alarm can occur every 370 samples.

ADVANCED CONTROL CHARTS

The most widely used control charts are Shewhart charts. Their operational simplicity and proven added value are two aspects that explain their success. However, the traditional Shewhart control charts are not very efficient at detecting small changes in the quality characteristic being monitored. For cases where it is necessary to detect small changes, the recommendation is to use EWMA and CUSUM control charts (Montgomery, 2008).

These charts directly incorporate the whole sequence of information demarcating the cumulative sums of the deviations with respect to the target value (Alves and Samohyl, 2004; Souza et al, 2007). The decision on the state of statistical process control is based on the accumulated information from several previous samples. It is possible to signal small outliers more quickly, and to identify the moment in time that a change occurs in the process. By their very nature, the CUSUM and EWMA charts signal when there is a change in the process, be it an increase or a decrease in the quality characteristic.

CUSUM. The cumulative sum (CUSUM) control chart was proposed by Page (1954) and is recommended when there is interest in detecting small and constant change (Montgomery, 2008). According to Montgomery (2008), CUSUM control charts directly incorporate the whole sequence of information demarcating the cumulative sums of the deviations from the target value or nominal value. It is an advanced control chart developed for specific situations, but at the same time minimizes the occurrence of false alarms and missed detections (Samohyl, 2009).

The procedure for the creation of the cumulative sum chart is simple: given a cumulative sum chart for the mean of a process, if the process remains under control at the target value, the accumulated sum is a random path with a mean of zero. For example, assuming that we are monitoring the mean of a process for samples with $n > 1$ and μ_0 as the target value of the process mean and $\bar{x}_j$ as the mean of the jth sample, the CUSUM control chart is obtained by plotting the quantity (Equation 1) with respect to the sample *i*.

Equation (1):

$$C_i = \sum_{j=1}^{i} (\bar{x}_j - \mu_0) \, .$$

If the mean shifts, then an upward or downward trend (according to the shift) develops in the accumulated sum. According to Montgomery (2008), if the plotted points show a trend, it can be stated that the process mean has changed, and it is then necessary to search for some possible cause. In simpler terms, for the calculation, Equation 2 can be used.

Equation (2):

$$C_i = C_{i-1} + (\bar{x}_j - \mu_0) \, .$$

A series of negative cumulative sums C_i means that the observed readings are lower than the nominal values, showing a downward shift in the process mean. Similarly, a series of positive cumulative sums means that the observed readings are greater than the nominal values, showing an upward shift in the process mean. It is not yet a control chart, as it still lacks the statistical control limits.

A CUSUM works accumulating deviations from the mean μ_0 that are above or below the target, with the statistics C_i^+ and C_i^- respectively. These statistics are called the upper and lower one-sided CUSUMs, respectively, and are calculated according to Equations 3 and 4 (Montgomery, 2008).

Equation (3):

$$C_i^+ = \max[0, C_i^+ + x_i - (\mu_0 + k)].$$

Equation (4):

$$C_i^- = \min[0, C_i^- + x_i - (\mu_0 - k)].$$

The constant *k* is usually called the reference value or slack value. Equation 1 is sensitive to any deviation from the target value, even of small magnitude. All processes have some degree of variability and it is possible that very small variations are not of concern. So this "tolerance" with minor modifications is explicitly formalized in the CUSUM equations with the reference value *k*. This value is subtracted from positive deviations and added to negative deviations. In CUSUM charts for monitoring the mean, a common value, both in literature and in practice, is 0.5, meaning that it will not worry about variations of half a standard deviation in the process. According to Samohyl (2009), the reference value *k* helps to improve the ARL_1 of the process, as it allows the chart to be designed to detect specific changes.

WMA. The Exponentially Weighted Moving Average (EWMA) control chart is very effective against small changes in the process. Introduced by Roberts (1959), the EWMA control chart accumulates information successively, weighting the samples and giving greater weight to the most recent observations and less weight to the oldest observations, i.e., the weight given to samples decreases geometrically from the first to the last sample. In situations where the observations of the process are correlated, this chart is recommended, because it is a statistical tool that is easy to implement and very effective (Mastrangelo and Montgomery, 1995).

The control procedure based on the EWMA statistic (Zi) for monitoring the average value of a process is given by Equation 5

Equation (5):

$$Z_i = \lambda x_i + (1-\lambda) Z_{i-1}, \qquad i = 1,2,3,...,$$

where $0 \le \lambda \le 1$ and $x_j\,(j = 1,2,3,...,i)$ are observations of a quality characteristic used in process monitoring, and λ is the weighting constant or smoothing factor. This constant expresses how distant the memory of the chart is, and the initial value of this statistic (required with the first sample at i = 1) is the target of the process, so that $Z_0 = \mu_0$. The value of λ is determined by tables or charts based on the performance of the desired ARL. When $\lambda = 1$, the EWMA chart reduces itself to the Shewhart Chart, as well as $\lambda = 0$, $Z_0 = \mu_0$.

Let's say that $x_j\,(j = 1,2,3,...,i)$ are observations resulting from random, independent and normally distributed variables $X_j\,(j = 1,2,3,...,i)$ with the mean set at μ and standard deviation at σ, in other words $X_j \sim N(\mu, \sigma^2)$. In this procedure, the observations x_i, sequentially collected, can be either individual observations of the process or sample means obtained by a sampling plan. If we want the EWMA statistic for sample means, then $\bar{x}_i$ should be used instead of x_i in Equation 5. Thus, if the observations are independent random variables with variance σ^2, then the variance of z_i is given by Equation 6.

Equation (6):

$$\sigma_{Z_i}^2 = \sigma^2\left(\frac{\lambda}{2-\lambda}\right)\left[1-(1-\pi)^{2i}\right].$$

Once the value of the variance $\sigma_{Z_i}^2$ is obtained, the control limits of the EWMA chart are not fixed. They depend on *i*, and are usually obtained with the asymptotic value $\left(\frac{\lambda}{2-\lambda}\right)$ of the variance. As *i* increases, the variance approaches the asymptotic value. To monitor the process, observations are drawn on the EWMA chart whose control limits are obtained by Equations 7-9.

Equation (7):

$$UCL = \mu_0 + L\frac{\sigma}{\sqrt{N}}\sqrt{\left(\frac{\lambda}{2-\lambda}\right)\left[1-(1-\pi)^{2i}\right]};$$

Equation (8):

$$CL = \mu_0;$$

Equation (9):

$$LCL = \mu_0 - L\frac{\sigma}{\sqrt{N}}\sqrt{\left(\frac{\lambda}{2-\lambda}\right)\left[1-(1-\pi)^{2i}\right]};$$

where the factor L (Equations 7 and 9) is the extension of the control limits, namely, the number of multiples of the standard deviation in which the control limits are distant from the CL.

The choice of the parameters λ and *L* for the optimal planning procedure of an EWMA chart consists of the proper selection of this combination (λ , L) capable of providing the best ARL performance. When *L* = 3 (the usual 3σ limits), it works reasonably well, particularly with larger values of λ. However, when λ is small, for example, λ = 0.1, there is an advantage in reducing the amplitude of the control limits for the use of an *L* between 2.6 and 2.8. The process analyst should think about what the lowest value of λ should be to detect small shifts. Thus, if a small λ value is used, such as λ = 0.01, then L should be reduced, for example, *L* = 2. Another important aspect is the behavior of the control limits. Since $|1-\lambda|<1$, the sequence $(1-\lambda)^{2i}$ goes to zero and *i* goes to infinity. And the term $\left[1-(1-\pi)^{2i}\right]$ approaches the unit *i* making it large. This means that after the EWMA control chart has gone through different periods of time, the control limits have the asymptotic form and approach the fixed-position values, given by Equations 10-12.

Equation (10):

$$UCL = \mu_0 + L\frac{\sigma}{\sqrt{N}}\sqrt{\left(\frac{\lambda}{2-\lambda}\right)};$$

Equation (11):

$$CL = \mu_0;$$

Equation (12):

$$LCL = \mu_0 - L\frac{\sigma}{\sqrt{N}}\sqrt{\left(\frac{\lambda}{2-\lambda}\right)}.$$

Equations 10, 11 and 12 are simpler for performing the calculation. However, using Equations 7, 8 and 9 is highly recommended for small values of *i*. The control limits of the EWMA chart can be used to signal when an adjustment is necessary, and the difference between the target and the forecast of the average μ_{i+1} can be used to determine how much adjustment is needed (Montgomery, 2008).

METHODOLOGICAL PROCEDURES

This research is considered to be of an applied nature, since it is characterized by practical interest (Gil, 2010). In other words, its results are used immediately to solve problems of high consumption of drinking water in a university located in the state of Santa Catarina.

It has a quantitative approach, because it uses statistical resources and techniques, trying to demonstrate in numbers the knowledge generated by its application. After collecting the data, these data are analyzed by evaluating normality and autocorrelation. And then they are applied in advanced control charts.

The collected data are part of a larger project, where other devices (such as flush valves) were replaced, and other water consumption devices were adjusted. 15 water meters and 14 conventional mechanical taps were installed, which were later replaced by 14 more hydro-mechanical water efficient taps. The installation of water meters was performed in order to be able to measure the isolated consumption of each equipment group from a block of classroom facilities in the institution. Thus, we collected data from each water meter every day, always with an interval of 24 hours between each measurement, except Sundays, because it was not necessary to take the measurement since there is no access to the campus and hence no water consumption. The procedure was the same for all stages of the study. The values were recorded *in situ* and subsequently put into a spreadsheet.

The first period of data collection occurred in April and May 2011, during which the old, standard equipment was still in place. In other words, there were no replacements or adjustments before that time. For the second stage of data collection, the conventional mechanical taps were replaced with hydro-mechanical water efficient taps. Data were collected from May 2011 to July 2011. Values corresponding to periods in which there was a leak detected or pump problems were considered outliers, and removed from the dataset. Finally, for the analysis of the consumption of the taps, 70 days of valid data were considered, 35 days for Phase I and 35 days for Phase II and the generation of the control charts.

For data analysis, the software packages R (R Core Team, 2013) and qcc (Scrucca, 2004) were used. The qcc package is only for statistical process control, for generating Shewhart control charts for discrete and continuous variables and by attribute, as well as CUSUM and EWMA charts.

DISCUSSION AND RESULTS

Figure 1 shows the chart of the index of consumption over time (liters/user/day). There are 35 measurements for the period before the replacements (Phase I) and 35 for the period after the replacements (Phase II). If the equipment replacement was effective in reducing the consumption of water, it is expected that this trend (negative) would be detected by the chart in Phase II.

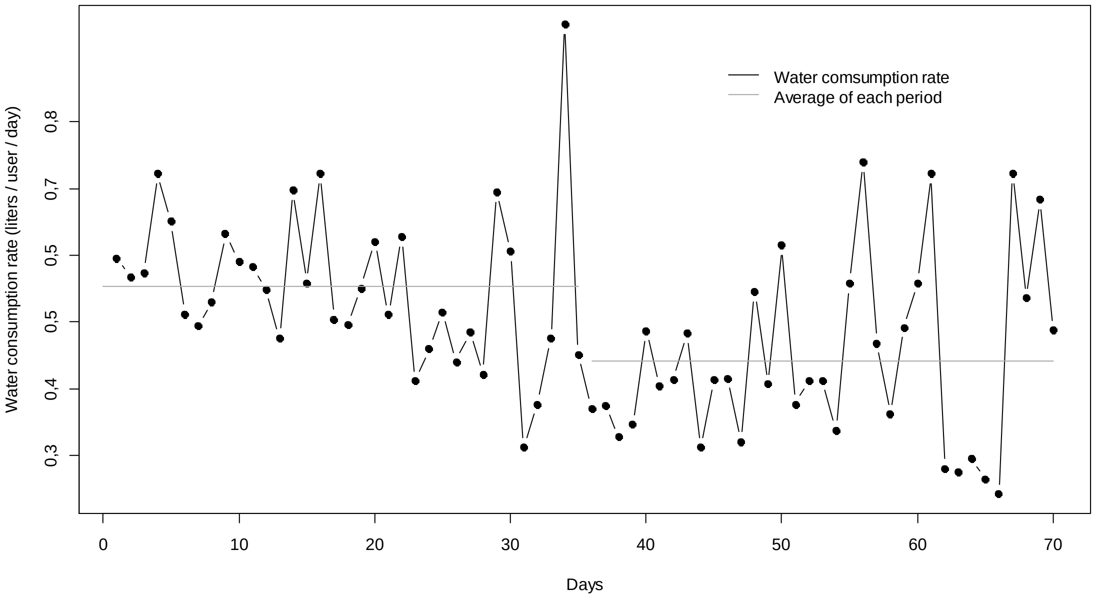

Figure 1 – Chart of index of consumption over time (liters/user/day)

In Phase I (prognosis), the necessary assumptions, normality and absence of serial correlation (Figure 2) were checked. Data normality was verified by graphical measures, like histograms (Figure 2a) using the Shapiro Wilk normality test, which confirms the assumption of normality (p-value = 0.13). The absence of autocorrelation was verified using the autocorrelation function chart (Figure 2b).

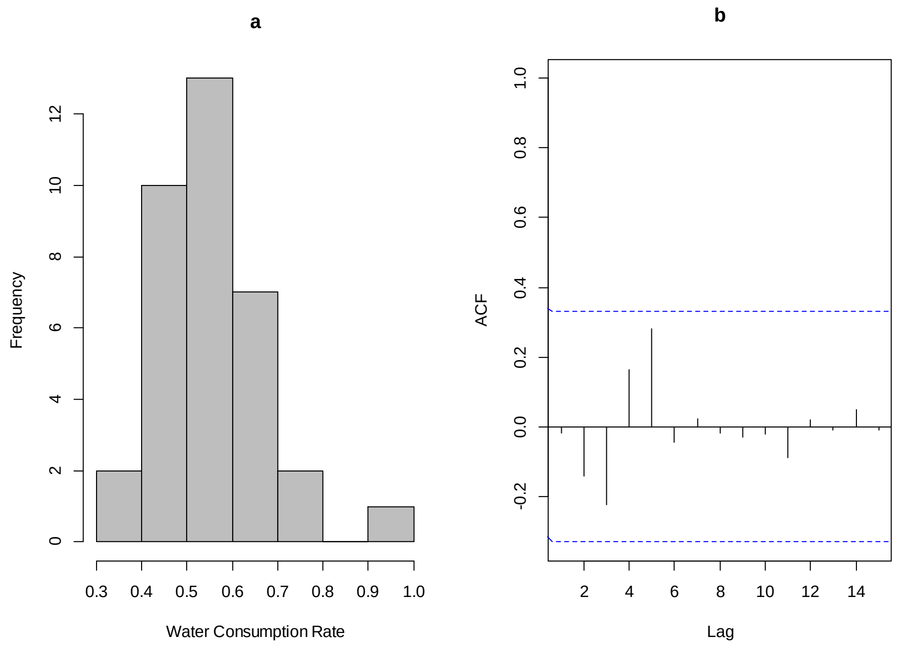

Figure 2 – Chart of index of consumption over time (liters/user/day)

Once the assumptions are met, it is possible to apply the CUSUM and EWMA control charts. Figure 3 shows the CUSUM chart. Note that in Phase I (Calibration Data), there are no samples where the control limits of the CUSUM control chart are exceeded, so the process is in statistical control. But in Phase II, the lower limit is exceeded in sample 39, not returning to the state of statistical process control. It should be noted that in sample 36, the first sample after replacing the taps, there is the beginning of a downward trend. Therefore, it can be concluded that the average consumption of water from the taps was reduced after the replacement of the equipment.

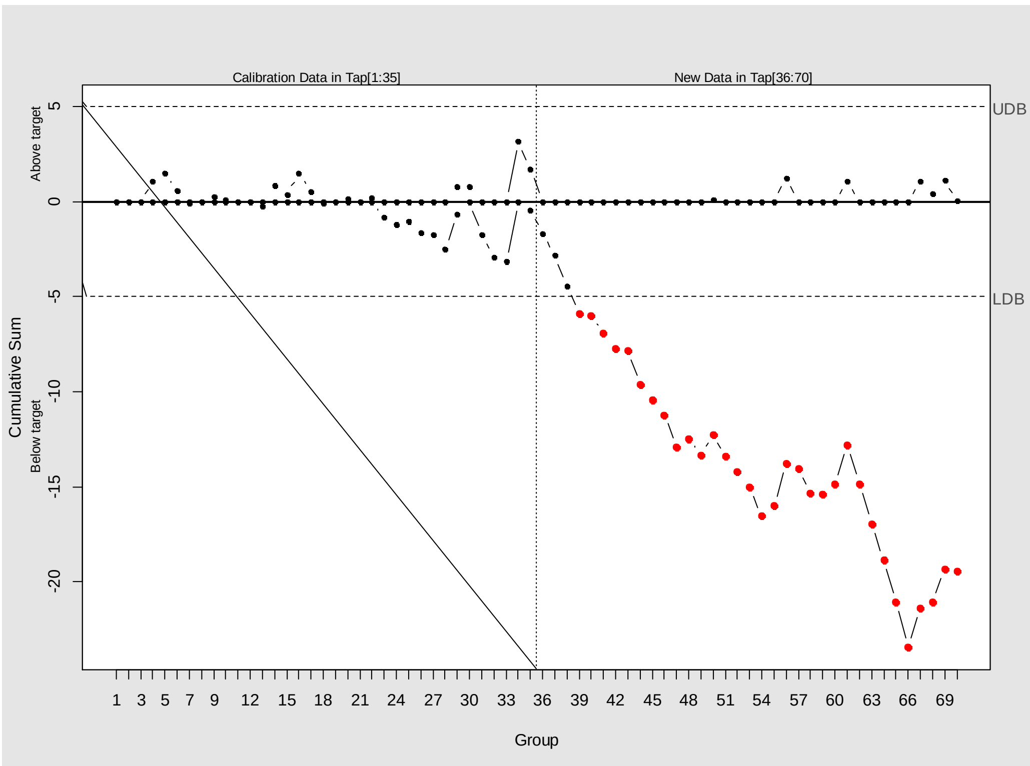

Figure 3 –CUSUM control chart

The EWMA chart can be seen in Figure 4. Note that none of the points of the curve exceeds the upper and lower control limits in Phase I, so the process is in statistical control. Thus until then, there is no change in the process mean. In Phase II, also at sample 39, the lower control limit is exceeded, confirming the aforementioned point.

Thus, the two charts indicate that in the second period there was a reduction in the rate of water consumption. This conclusion is confirmed by results from the literature, where the replacement of water saving equipment proved to be significant (Ilha et al, 2010; Lombardi, 2012; Barberán et al, 2013; Willis et al, 2013). Concerning the study itself, it also agrees with the results of Kalbusch and Ghisi (2012), who evaluated the energy consumption for the life cycle of two taps, one efficient and one conventional.

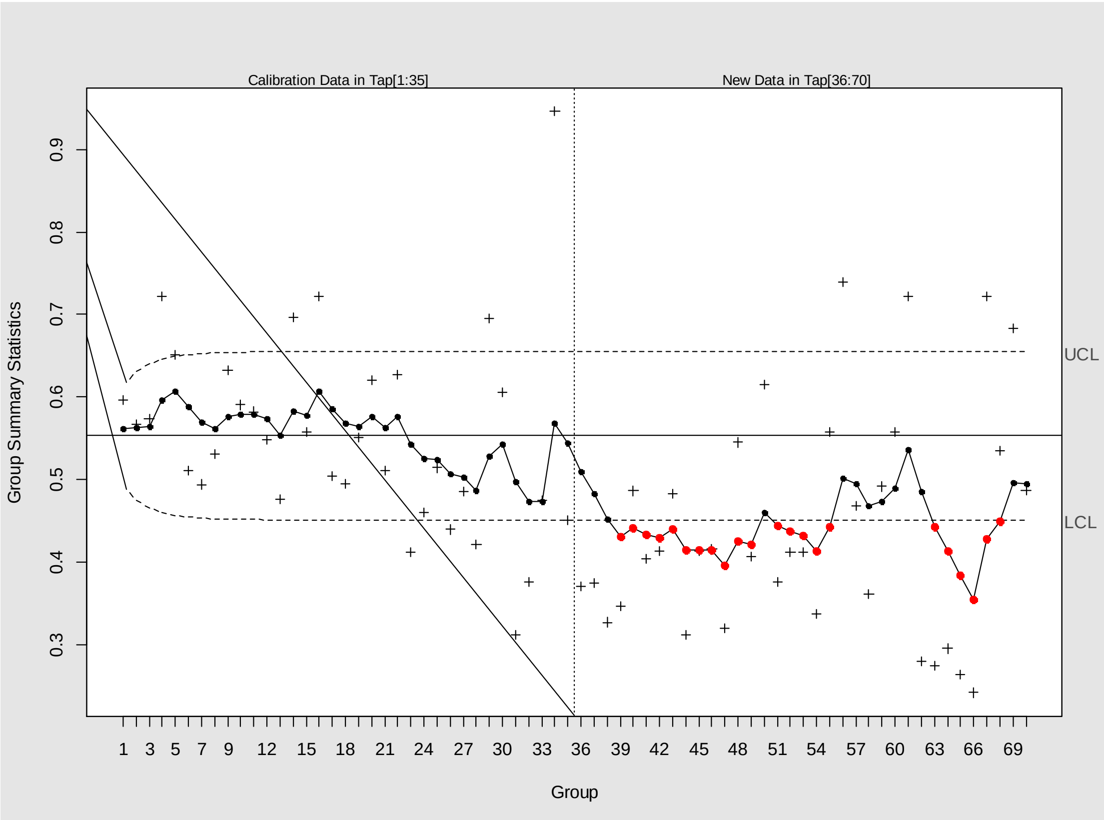

Figure 4 – EWMA control charts for the process data

The water efficient tap model showed lower energy consumption in the life cycle, and the step of using the taps showed dominant weight in the results. Thus, the water efficient tap is positioned as a viable choice compared to the conventional tap providing, according Kalbusch and Ghisi (2012), water and energy savings in the life cycle. From the point of view of the application of CUSUM and EWMA charts, they reflect what the literature says about sensitivity in the detection of change, signaling an out of statistical control state in the same sample.

CONCLUSION

This paper proposed the use of statistical process control charts to analyze whether the replacement of conventional equipment with more efficient equipment is effective in reducing water consumption. To this end, CUSUM and EWMA control charts were used.

The results from the application of both procedures indicate that this replacement was effective, and that the two procedures were equivalent with regard to detection sensitivity. Several studies have been conducted on efficient water usage based on the use of water-saving devices, each with its own characteristics and methods. It was found that there is a gap in studies regarding the implementation proposed in this paper.

This project does not end here, and there are many options for continuing the study. Also related to the issue presented here, nonparametric techniques should be addressed, since in real situations, it is not always the case that the assumptions of normality are met. To conclude, control charts can be studied with the aim of monitoring the index of consumption, as an alternative, for example, in the early detection of leaks.

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The utilization of Z and W charts for controlling service processes

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ABSTRACT

A lag still exists between SPC applications in services and in manufacturing. The causes for such a discrepancy are discussed, and an approach for integrating customer demands and technical aspects of a service as well as to define which characteristics to measure and monitor, is presented.

Services are very often characterized by a large number of characteristics, with relatively few observations. The current piece of research addresses a methodology based on Z and W charts, which is proposed for monitoring service features, when there are many characteristics to study. An example associated to service provision is presented to illustrate the computation of Z and W as well as its interpretation.

Purpose. This piece of research presents the utilization of non-traditional control charts, notably *Z* and *W* charts, in services frameworks.

Design/Methodology/Approach. The shortcomings of traditional control charts are exhibited when compared to *Z* and *W* control charts. An example illustrates how to utilize these charts, their ability to monitor several characteristics simultaneously, along with a continuous monitoring of process capability.

Findings. The proposed approach allowed the representation of several process characteristics in the same charts. Furthermore, the characteristics don't have to be collected with the same periodicity, which enhances the approaches' flexibility. The *Z* and *W* charts are dimensionless and can be applied whenever it is possible to estimate process parameters. Therefore, they proved to be an interesting approach to be utilized in phase 2 of SPC. As a major shortcoming, one notices the difficulty for identifying the existence of non-random patterns.

Originality/Value. The work was focused on the utilization of Z/W charts for controlling small productions in situations that allow process parameters' computation. The approach was based on the utilization of Z/W for samples, but can be extended to individual observations or even to the control of discrete variables. Furthermore, a methodology for capability analysis in real-time is also proposed.

Keywords: Service industry, SPC, Z charts, W charts

Article Classification: Research paper

INTRODUCTION

Regardless the benefits that come from Statistical Process Control (SPC) implementation, it is clear that primary application domain for SPC charts has been in process control and process improvement in manufacturing businesses (MacCarthy and Wasusri,2002). In fact, some authors (*e.g.* James, 2005) refer that SPC methodologies are not easily adapted to services.

Montgomery (1991) stresses two important features that pose some difficulties to the utilization of SPC in services:

i) Very often, a formal measurement system that defines which parameters to measure does not exist in services;

ii) In manufacturing environments it is usually visible the system to improve, while in services the processes might be hard to observe.

Nevertheless, it is also clear that in the last years applications of control charts have been reported in domains outside conventional production systems (MacCarthy and Wasusri, 2002). Among them, healthcare applications are becoming very popular (*e.g.*, Dzik et al., 2008; James, 2005; Lane et al., 2007; Pujar et al., 2010). Other specific approaches of SPC in services have also been published. For instance, Green Jr. et al. (2012) utilized statistical process control within an education services environment, Puga-Leal and Pereira (2007) proposed a methodology for process capability analysis in services and Wardell and Candia (1996) proposed an approach to monitor customer satisfaction survey data.

Furthermore, other non-standard applications of SPC have also been published as it is thoroughly illustrated by MacCarthy and Wasusri (2002).

Another important issue is the importance of obtaining *a match between service quality (the quality of what the operation delivers) and the quality of service as perceived by the customer* (Johnston and Clark, 2005). Parasuraman (2004) also refers the importance of translating user expectations into internal performance guidelines. This objective is somehow aligned with the objectives of QFD (Quality Function Deployment). In fact, among others, one of the objectives of QFD is to convert user's needs (or customer's demands) into quality characteristics. These characteristics are those in which SPC is usually focused, what reinforces the need of an adequate translation. The utilization of QFD principles in service environments continues to be an important research issue (*e.g.* Puga-Leal and Pereira, 2009; Androkinidis et al., 2009).

Traditional control charts are based on large data sets and focused on a single quality characteristic. Whenever a system requires several variables to be controlled, various documents have to be used, whose number increases as the number of quality characteristics increases. For coping with these frameworks, the statistical process control must be implemented through the utilization of alternatives to the Shewhart control charts. This approach is commonly known as statistical control of small productions ("short runs"). The *Z* and *W* control charts, as well as the Q control charts are the statistical techniques adequate for these purposes (Pereira and Requeijo, 2012). The *Z* and *W* charts are dimensionless and are applied whenever it is possible to estimate the parameters of the processes. On the other hand, whenever the data is insufficient for estimating process' parameters, Quesenberry (1997) proposes the use of Q charts. The implementation of these two types of control charts (Z/W and Q) allows that all characteristics are taken into account within the same document as well as it provides a quick way for controlling the stability (in-control) of all processes.

Furthermore, envisaging a continuous evaluation of processes' performance, the capability indices, Z_L, Z_U, Q_L, and Q_U (Pereira and Requeijo, 2012) can be presented, which enables the capability analysis in real time.

This piece of research illustrates the utilization of *Z* and *W* charts in a service framework associated to e-commerce, where two different variables are considered: time of navigation in the webpage and daily volume of sales.

TRANSLATION OF CUSTOMER REQUIREMENTS

An important decision regarding the implementation of SPC focuses on which characteristics must be measured and monitored (Mason and Antony, 2000). This difficulty is even more obvious in what regards non-standard applications of SPC, *i.e.*, those "that cannot be considered as conventional applications in manufacturing processes or production systems" (MacCarthy and Wasusri, 2002).

Quality Function Deployment can play an important role when dealing with the aforementioned difficulties. In fact, "the unique approach of QFD is its ability to integrate customer demands with the technical aspects of a service" (Andronikidis, 2009). Several authors have been using this approach in various services frameworks, such as law firms (Esteban-Ferrer and Tricás, 2012), after-sales services (Padkil et al., 2012) or healthcare (Azadi and Saen, 2013)

There are several strategies to implement QFD, but as mentioned by Panizzolo (2008) the keystone of the entire theory is the "House of Quality" (HOQ).

A detailed description of the QFD methodology is beyond the scope of this work. Nevertheless, a generic representation of the HOQ is presented in Figure 1

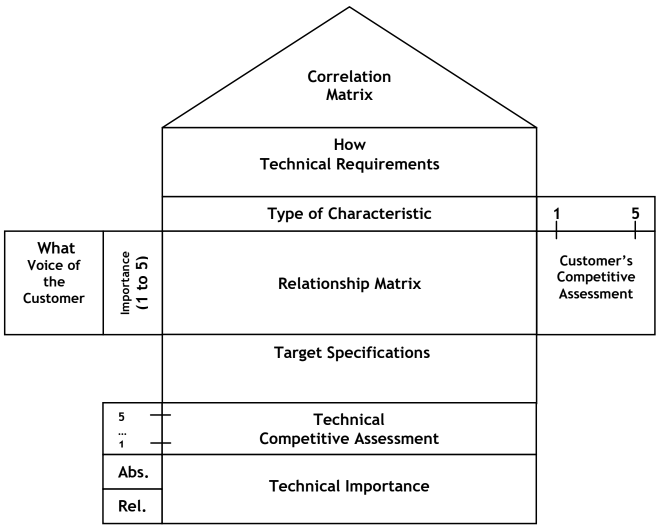

Figure 1 – House of Quality

The relationship between customer requirements and technical requirements is represented in the relationship matrix. The intensity of each relationship (weak △, medium ○ or strong ●), along with the importance given by customers to their own requirements, drives the computation of importance for each technical requirement. This importance constitutes a guideline to define which characteristics to measure and control. A short example of such computations will be presented along with the practical case.

METHODOLOGY

Figure 2 presents a methodology for decision support as regards the implementation of statistical process control.

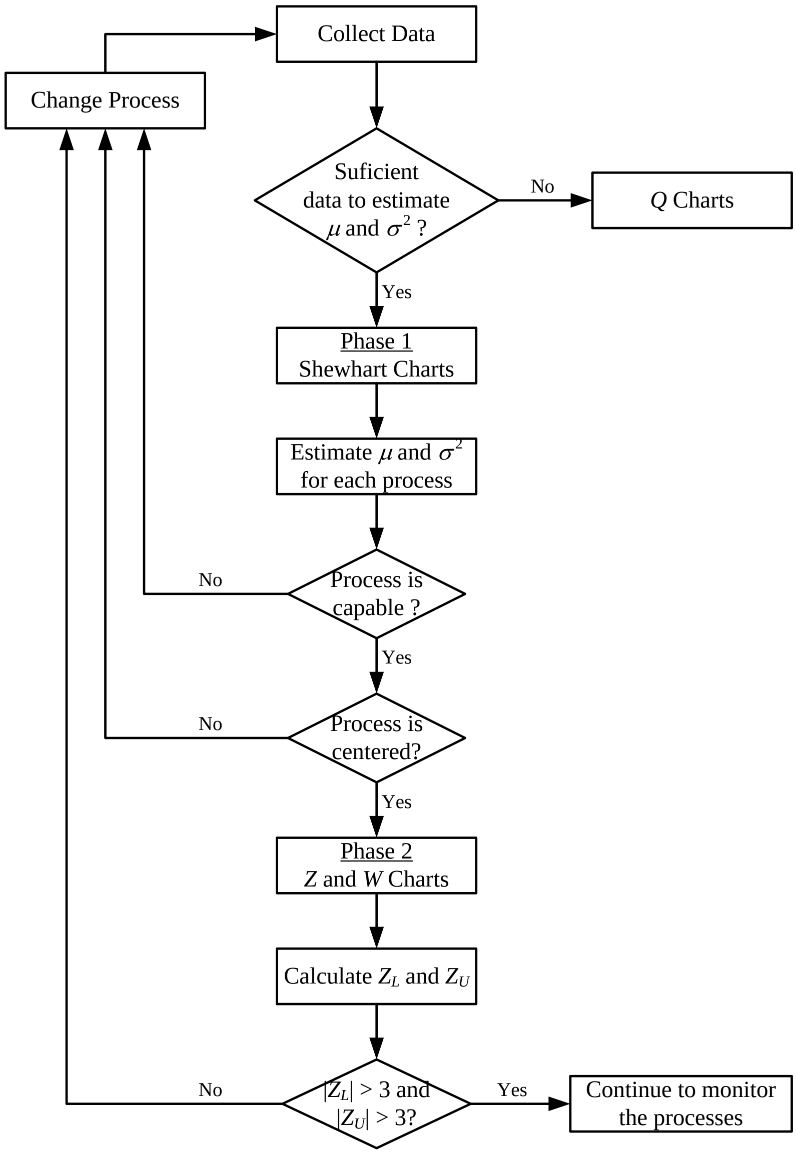

Figure 2 – Methodology for Statistical Process Control with large diversity of characteristics

SPC FOR A SIGNIFICANT AMOUNT OF DATA

When there are sufficient data for estimating processes' parameters, the phase 1 of SPC must utilize the Shewhart control charts applied to each process and quality characteristic. Usually, for continuous variables, $\overline{X}$ and R, $\overline{X}$ and S or X and MR control charts are utilized. Later, in Phase 2, Z and W control charts are implemented, focusing all characteristics in chronological order as regards the collection of observations.

Control chart analysis allows assessing whether or not the process is in a state of statistical control, i.e., all the variation comes from the common causes. The interpretation of Shewhart control charts is based on the identification of any non-random patterns, which is based on the rules established in ISO 7870-2:2013. The rules are as follows (figure 3) :

Rule 1- Any point outside the action limits;

Rule 2 – Nine consecutive points in zone C, or beyond zone C, in the same side of central line;

Rule 3 – Six consecutive points ascending or descending;

Rule 4 – Fourteen consecutive points increasing and decreasing alternately;

Rule 5 – Two out of three consecutive points in zone A, in the same side of central line;

Rule 6 - Four out of five consecutive points in zone B or A, in the same side of central line;

Rule 7 – Fifteen consecutive points in zone C;

Rule 8 – Eight consecutive points in both sides of the central line, without any in zone C.

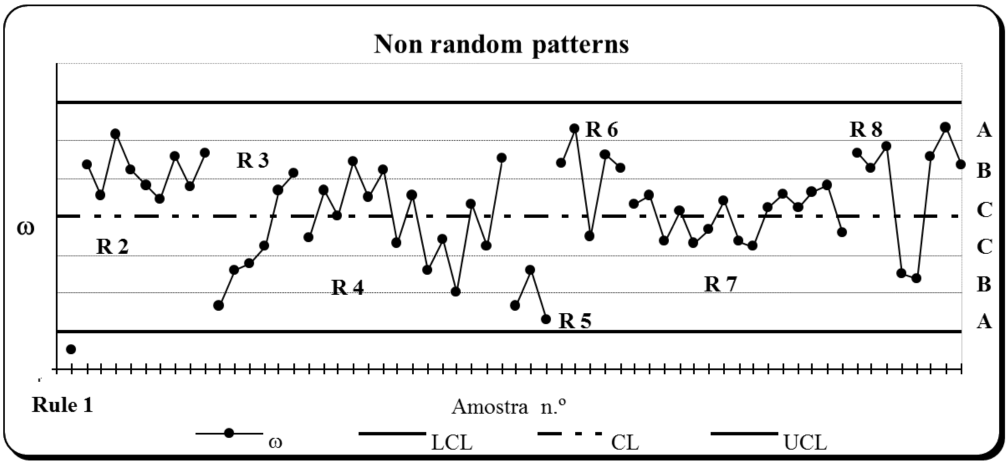

Figure 3 – Non-random patterns in control charts

Phase 1. In Phase 1, the analyst proceeds to the construction of the most appropriate Shewhart control chart for each product/characteristic. The upper control limit (UCL), the lower control limit (LCL) and the center line (CL) are determined in Phase 1 of the SPC, using the formulas shown in Table 1.

Table 1 – Limits of the Shewhart Control Charts (Phase 1 of SPC)

Chart	*LCL*	*CL*	*UCL*
$\overline{X}$ (Average)	$\overline{\overline{X}} - A_2\overline{R}$ or $\overline{\overline{X}} - A_3\overline{S}$	$\overline{\overline{X}}$	$\overline{\overline{X}} + A_2\overline{R}$ or $\overline{\overline{X}} + A_3\overline{S}$
S (Standard Deviation)	$B_3\overline{S}$	$\overline{S}$	$B_4\overline{S}$
R (Range)	$D_3\overline{R}$	$\overline{R}$	$D_4\overline{R}$
MR (Moving Range)	$D_3\overline{MR}$	$\overline{MR}$	$D_4\overline{MR}$

If the process is stable (statistically in-control) one proceeds to the estimation of the processes parameters using equations (1) and (2), where d_2 and c_4 are coefficients that depend on the sample size *n*.

$$\hat{\mu} = \overline{\overline{X}} \quad \text{or} \quad \hat{\mu} = \overline{X} \qquad (1)$$

$$\hat{\sigma} = \frac{\overline{S}}{c_4} \quad \text{or} \quad \hat{\sigma} = \frac{\overline{R}}{d_2} \quad \text{or} \quad \hat{\sigma} = \frac{\overline{MR}}{d_2} \quad (2)$$

The study of the capability for each process is carried out through the classical capability indices:

$$C_p = \frac{USL - LSL}{6\sigma} \qquad (3)$$

$$C_{pk} = min\left(C_{pkI}, C_{pkS}\right) \quad (4)$$

$$C_{pkU} = \frac{USL - \mu}{3\sigma} \quad \text{and} \quad C_{pkL} = \frac{\mu - LSL}{3\sigma} \qquad (5)$$

The utilization of equations (3) to (5) is restricted to quality characteristics that are Normally distributed. Therefore, Kolmogorov-Smirnov test is suggested to verify the Normality of data distribution.

If a process is out of control, the analyst should investigate the causes that led to this situation and make appropriate corrections. Furthtermore, corrections must also be made when the process is stable (in-control), but not capable.

Phase 2. After assuring stability and process capability (Phase 1), the statistical process control continues through monitoring. This procedure is commonly referred to as Phase 2 of the *SPC*. In Phase 2, the application of *Z* and *W* control charts may take place. These charts are based on *Z* and *W* statistics, which are obtained from the sample statistics $\overline{X}$ (or *X*) and *S* (or *R* or *MR*), respectively. Table 2 presents the transformed *Z* and *W* statistics for the different control charts. They refer to product/characteristic *j* at time *i*.

Assessing process performance is essential in Phase 2 of *SPC*, being required to define periodical analyses for accomplishing that objective. A real time approach is suggested, based on two normalized indices (Pereira and Requeijo, 2012).

Table 2: Transformed Z and W statistics

Chart	Statistic
$Z_{\overline{X}}$ Chart	$(Z_i)_j = \left(\dfrac{\overline{X}_i - \mu}{\sigma_{\overline{X}}}\right)_j$
Z_X Chart	$(Z_i)_j = \left(\dfrac{X_i - \mu}{\sigma}\right)_j$
W_S Chart	$(W)_j = \left(\dfrac{S_i}{\overline{\overline{S}}}\right)_j$
W_R Chart	$(W_i)_j = \left(\dfrac{R_i}{\overline{\overline{R}}}\right)_j$
W_{MR} Chart	$(W_i)_j = \left(\dfrac{MR_i}{\overline{\overline{MR}}}\right)_j$

The limits for *Z* and *W* control charts are:

$$\begin{aligned} UCL_X &= UCL_{\overline{X}} = +3 \\ LCL_X &= LCL_{\overline{X}} = -3 \end{aligned} \quad (6)$$

$$\begin{aligned} UCL_S &= B_4 \\ LCL_S &= B_3 \end{aligned} \quad (7)$$

$$\begin{aligned} UCL_R &= UCL_R = D_4 \\ LCL_R &= LCL_{MR} = D_3 \end{aligned} \quad (8)$$

The new normalized capability indices will be recorded in each time *r* in the *Z* control chart. They are defined for each *j* product/characteristic at instant *r* by equations (9) and (10). A process of the product/characteristic *j* is capable when it satisfies simultaneously the two conditions $(Z_U)_j > 3$ and $(Z_L)_j < -3$.

$$((Z_r)_L)_j = \left(\frac{LSL - \mu_r}{k\,\sigma_r}\right)_j \quad (9)$$

$$((Z_r)_U)_j = \left(\frac{USL - \mu_r}{k\,\sigma_r}\right)_j \quad (10)$$

The *k* value is usually 1.33 or 1.25 for bilateral specifications or unilateral specifications, respectively. The values μ_r and σ_r for the product/characteristic *j*, are estimated by equations (11) and (12) using data from the previous Phase 1 and also new data gathered during Phase 2.

$$\hat{\mu}_r = \overline{\overline{X}}_r \quad \text{or} \quad \hat{\mu}_r = \overline{X} \quad (11)$$

$$\hat{\sigma}_r = \frac{\overline{S}_r}{c_4} \quad \text{or} \quad \frac{\overline{R}_r}{d_2} \quad \text{or} \quad \frac{\overline{MR}_r}{d_2} \quad (12)$$

where:

$$\overline{\overline{X}}_r = \frac{1}{r}\left((r-1)\overline{\overline{X}}_{r-1} + \overline{X}_r\right) \ , \ r = 2,3,\ldots \qquad (13)$$

$$\overline{X}_r = \frac{1}{r}\left((r-1)\overline{X}_{r-1} + X_r\right) \ , \ r = 2,3,\ldots \qquad (14)$$

$$\overline{S}_r = \frac{1}{r}\left((r-1)\overline{S}_{r-1} + S_r\right) \ , \ r = 2,3,\ldots \qquad (15)$$

$$\overline{R}_r = \frac{1}{r}\left((r-1)\overline{R}_{r-1} + R_r\right) \ , \ r = 2,3,\ldots \qquad (16)$$

$$\overline{MR}_r = \frac{1}{r}\left((r-1)\overline{MR}_{r-1} + MR_r\right) \ , \ r = 3,4,\ldots \qquad (17)$$

Illustrative example. An illustrative example is presented within the framework of e-commerce. From the QFD's perspective, let's assume that three customer requirements are related with two technical requirements. Adopting the common QFD rules, the importance of each technical requirement is also computed (figure 4)

		Daily volume of sales	Time of navigation	....	
The prices are attractive	4	●	△		
I can find a large selection of articles	4	○	○		
The webpage is fast	3		●		
....					
		48	43		**Importance**

Figure 4 – Example of QFD relationships

Therefore, two different variables were selected for statistical control: *Time of navigation in the webpage* and *daily volume of sales.* The parameters associated to each characteristic were computed in Phase 1, utilizing 50 samples of five observations. The estimations are presented in Table 3. The company has established as desirable that the *time of navigation* must be above 6 minutes and that the *daily volume of sales* must not be lower than 1000€.

Table 3: Estimation of processes parameters

Variable	Average	Standard deviation
Time of navigation	12 minutes	1,4 minutes
Daily volume of sales	1520 €	100 €

Process monitoring was assured based upon daily information for the variable *daily volume of sales* and weekly information for the variable *time of navigation.*

Collected data refers to samples of 5 observations randomly selected from the available information

The data were collected along twenty five weeks of operations, corresponding to a total of thirty samples (25 regarding the *daily volume of sales* and 5 regarding the *time of navigation.*

The control charts corresponding to the 30 samples are represented in figures 5 and 6.

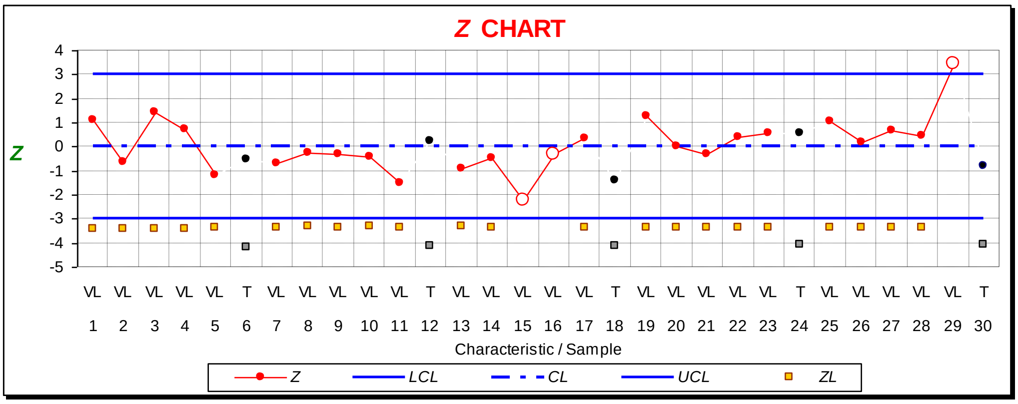

Figure 5 – Z chart for individual observations

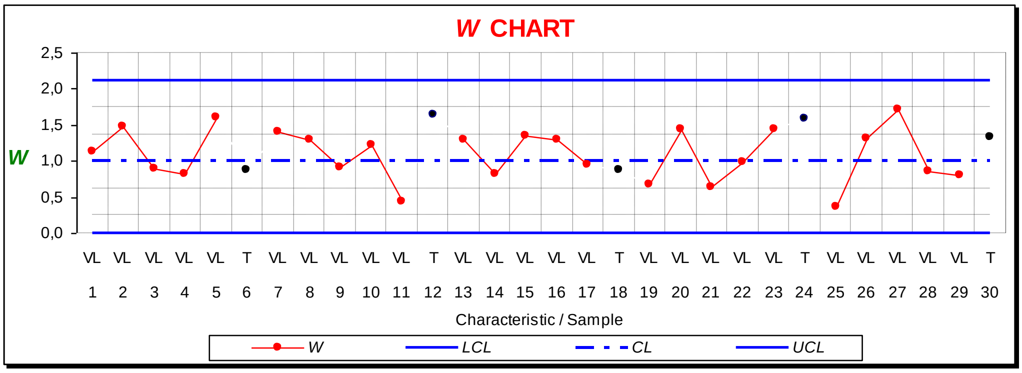

Figure 6 – W chart for moving range

The analysis of Z control chart reveals the existence of assignable causes on some samples (15, 16 and 29, rules 1 and 2) for the variable "*daily volume of sales*". As regards the characteristic "*time of navigation*", none special cause was detected.

The W chart, which monitors process variability, does not reveal any assignable cause for the analyzed characteristics.

A detailed analysis for the Z chart, as regards the *daily volume of sales,* shows that between samples 7 and 14 the daily volume of sales tend to be less than expected, which requires attention. After sample 19 those figures improve, suggesting that corrective actions launched in times 15 and 16 were effective.

As one can conclude from Z chart, both processes are capable as regards their technical specifications.

CONCLUSION

Services are very often characterized by simultaneous production and consumption. Therefore it becomes critical the ability to convert customer's demands into technical characteristics and selecting those which require controlling and monitoring. It was shown that QFD constitutes an interesting approach to address these issues.

It is well known that the utilization of Shewhart charts in phase 2 is questionable when several characteristics have to be controlled. A methodology based on Z/W charts was proposed as an alternative to overcome the shortcomings presented by the traditional SPC approach.

Although this piece of work was focused on the utilization of Z/W charts for samples, its utilization can be extended to Z/W charts for individual observations and moving ranges, as well as to the control of discrete variables (non-conforming fraction and defects per unit). Therefore, the proposed charts combine a large flexibility with a rational utilization of resources, thus constituting an effective alternative to the Shewhart charts as regards the control of services processes.

From a management perspective, the proposed methodology is quite rational and provides a holistic vision. In fact, several characteristics are represented in the same chart, which nevertheless can be interpreted through the traditional analysis of patterns, as described in the ISO 7870-2:2013 standard.

The *Z* and *W* control charts have advantages over traditional Shewhart charts, namely:

1. they allow statistical control of all quality characteristics in the same control chart,
2. they allow to study different characteristics together (*i.e.*, simultaneously).
3. they dramatically reduce the analysis time.

The use of capability indices Z_L and Z_U within the *Z* control charts allows the study of processes' capabilities in real time, thereby decreasing the probability of producing non-conforming units. Nevertheless, the Z charts also present some disadvantages, notably an increased difficulty for analyzing the existence of non-random patterns, which worsens as increases the number of products/quality characteristics to be checked.

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Total quality management and best practices to evaluate a management of change project

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ABSTRACT

Purpose. Evaluate a management of change project that has a challenge: to change the way the employees work in the organization so as to use "industrialization" methods and tools available in industrial contexts, in order to increase productivity and reduce costs in delivery.

Design/methodology/approach. Application of Total Quality Management principles and best practices.

Findings. It was verified that quality concepts can be applied in an environment where the product is change. In other words, whether controls, measurements, and communication can help advance the change process. Charts are used to show results.

Originality/value. Evaluation is of the greatest significance in organizations where management of change is carried out. Besides, the use of quality concepts and tools for such a purpose stands as a particular approach.

Keywords: Change, Communication, Data and Facts, Improvement, Total Quality Management.

Article Classification: Case study.

INTRODUCTION

Managing change within organizations is nowadays considered to be a vital factor when companies set out to achieve objectives that significantly upset the *status quo* (Hernandez and Caldas, 2001; Anderson and Anderson, 2009, 2001a; Watkins and Leigh, 2010). Any change that is necessary – either technical or organizational – and at the same time disturbing to the majority of people, e.g. adopting new design approaches, introducing new materials, using new software, changing the system, the way people work, or simply the office layout, etc., needs to be planned and structured so that people will be motivated to accept the intended future stage instead of being resistant to the change process, which certainly will have an impact on final results.

To be competitive, a company must have its products delivered on time with low costs and reduced effort. For this reason, it is important to have a well-defined process available to all the organization in order to increase productivity and reduce rework and associated costs. On the other hand, the organization needs to take care of its employees who carry all the knowledge and keep the organization alive and healthy. In such context, could quality concepts and practices be applied to manage the people who will effect the desired changes?

The purpose of this study is to evaluate an internal management of change project using principles of Total Quality Management (TQM) and also to analyze the best practices that could be applied in such project. The objectives of this internal project are to increase the engagement of practitioners, and make them aware of the importance of using a set of available tools and best practices, encourage them to change the way they work, and also to help create a collaborative work environment.

It is important to note, however, that the idea of using TQM principles, techniques and/or tools here is specifically related to the production of management of change products, and not to the implementation of quality or other management systems.

DEFINITIONS OF CONCEPTS

Some well-established concepts mentioned throughout the paper can be defined or summarized as follows:

- Quality is the degree to which a set of inherent characteristics fulfils requirements (ISO, 2005);
- Total Quality Management (TQM) is a set of systematic activities carried out by the entire organization to effectively and efficiently achieve the organization's objectives so as to provide products and services with a level of quality that satisfies customers, at the appropriate time and price (JUSE, 2014).
- Change is a shift between one state of being to another. A change can be an improvement (developmental change); it can occur to deal with a problem (transitional change), or it can mean survival: change or die. It can also mean breakthrough needed to pursue new opportunities (transformational change) (Anderson and Anderson, 2001b);
- The Shewhart-Deming Cycle, widely known as PDCA Cycle (Shewhart, W., (1939) 1986; Deming, W. E., 1982) is a concise pictorial description of administration;
- The Change Leader PDCA is an adaptation of the original cycle where it is necessary to think before speaking, to speak before acting, to act to provide care, and to assure that the change actually takes hold (Moran, 2012);
- The Pareto diagram technique, based on the "vital few" principle proposed by Italian engineer Vilfredo Pareto (1848-1923) while studying the distribution of wealth in human society (Juran et al, 1998), might as well be called a priority histogram and is one of the simplest and most widely employed quality techniques.
- The "what, how, why" or golden circle model is a simple and powerful technique for motivating people to accept new ideas. It is based on Sinek's (2009) realization that "people don't buy what you do; people buy why you do it".
- Best practices are "proven approaches, activities, methods or processes that produce better results than other approaches". They can also be said to be "proven activities or processes that have been successfully used by multiple organizations" (AXELOS, 2013)[*].

The authors are well aware of the fact that expressions such as "management of change" and "change management", allowed by the flexibility of the English language, may be considered to mean different aspects of change. The former, for instance, would refer to technical aspects only and the latter to people. Other expressions like "change leadership" are also widely used in this context. Sometimes it is even proposed that one should go "beyond change management" (Anderson, 2001). The authors would have preferred, as in this paper`s title and abstract, the expression "management of change" as encompassing all aspects of change, since nowadays, most often than not, people must change as a result of technological evolution. However, this text refers to a real company where the expression "change management" is current. Therefore, it will also be used throughout the rest of the paper.

CONTEXT

This paper deals with initiatives taken and actions carried out in a global organization that provides management consulting, technology services and outsourcing services in more than 120 countries, including a large Operation in Brazil since 1983. It refers to an internal initiative called "Industrialization Program", whose main objectives are saving hours and delivering a technological solution for the client with high quality. The focus of this initiative is to improve productivity and quality, and at the same time reduce costs from time of sale to the deployment phase of a project by using standard processes and solutions, reusing documentation, sharing best practices, optimizing solutions, and automating deliveries.

More specifically, this study focus on the IT Infrastructure area where the change management approach is applied.

1. Three business areas contribute tools, processes, procedures, and documentation that are used to help deliver the IT Infrastructure projects, as follows:
2. Data Centre Services (DCS) helps clients plan and implement data centre by providing some services such as data centre optimization, data centre automation, database optimization, server optimization, and storage transformation;
3. IT Service Excellence (ISE) helps clients plan and implement ITIL processes in their organizations;
4. Network Technology Services (NTS) helps clients understand and determine how to capitalize on network trends providing some services as network optimization, wireless and network service management.

In order to help achieve the industrialization objectives, all processes, tools, and best practices should be structured and available to all IT Infrastructure practitioners, as described below:

- *Delivery Methods for IT Infrastructure* includes processes, documentation and tools that could aid in the delivery of DCS, ISE, and NTS projects in a standardized and organized way;
- *Estimator tool* aids IT Infrastructure projects deliver accurate estimates based on experience and historical data;
- *Workbench tool*, a repository that is composed of projects' best practices, experiences and re-usable assets, serves as the knowledge management repository where it is possible to find contents on sales, delivery, and training subjects related to IT Infrastructure.

It should be considered that updating such methods and tools is quite expensive. For instance, *Delivery Methods* is a methodology divided in parts according to business areas. Each part takes six to seven months to be updated. Since Subject Matter Experts (SME) at high administrative levels must validate the content and documentation of each task (procedure) of a project's life cycle phase (Plan, Analyze, Design, Build, Test and Deploy), man-hour costs may run very high.

After any release of the "industrialized" methods and tools (*Delivery Methods*, *Estimators* and *Workbench*), the Change Management approach starts with internal marketing and communications (e-mails, videos, etc.), then training sessions are conducted to help practitioners understand what was updated and what is new (first phase). The second phase of the Change Management approach is to identify projects that could use and provide leverage to the "industrialization" methods and tools, and provide feedback to help improve them. These activities are carried out by the Change Management Project that is structured in three areas (towers), as illustrated in Fig. 1 and described below:

- Communications area is responsible for disseminating timely, accurate, and relevant information. This area is critical to ensure that all IT Infrastructure employees are aware of upcoming changes in the "industrialization" methods and tools, and how they impact them;
- Training area's purpose is to create a formal structure in which IT Infrastructure employees become familiar with updates and increase their speed to competency and proficiency;
- Mobilization area is responsible for identifying IT Infrastructure projects that deliver infrastructure solutions to clients, using *Delivery Methods*, *Estimator* and *Workbench* as projects progress, and collecting feedback on processes, procedures, and documentation.

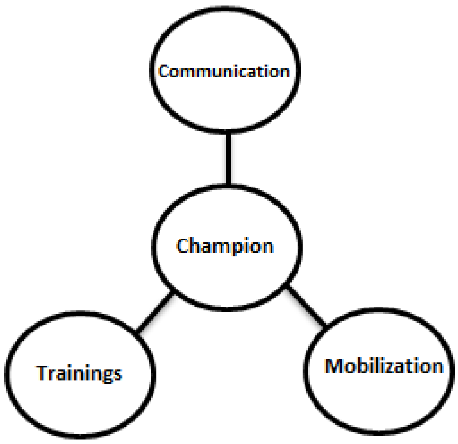

Figure 1 – Change Management Project's structure.

In addition, in order to help engage IT Infrastructure employees in the usage of infrastructure methods, estimators, and repository contents in each region, Champions are appointed. The IT Infrastructure Global Lead, who is the sponsor of this initiative, requests all Region Leads to nominate people that could help increase the usage of "industrialization" methods and tools; improve skills and knowledge as well as awareness and motivation among IT Infrastructure employees; help disseminate timely and accurate information about the industrialization tools; and be a key resource for Methods, Estimators and Workbench in each region, as illustrated in Fig. 2.

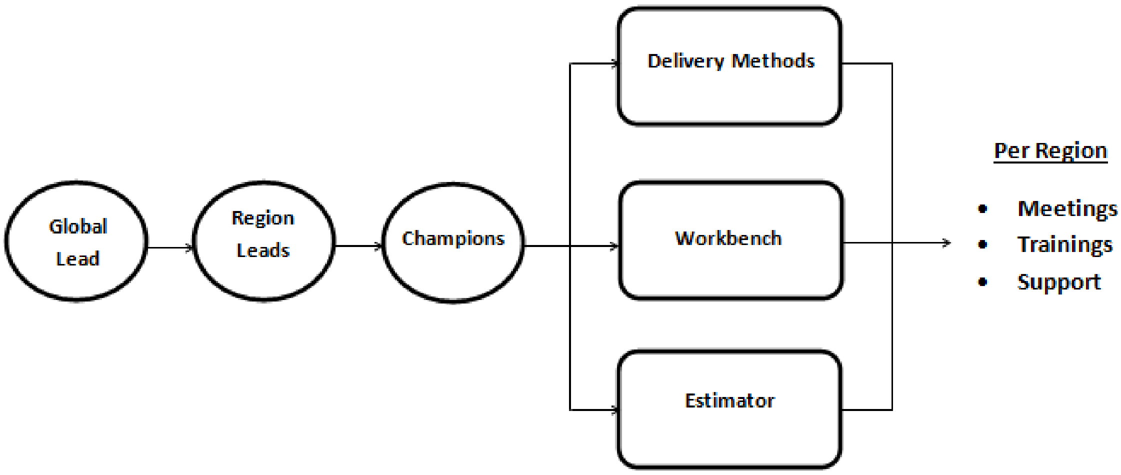

Figure 2 – Infrastructure Champions initiative.

The organization is segmented into three Geographical Units and several regions: North America (USA and Canada), EALA (ASG, Gallia, IGEM, Nordic, SPAI, UKI, Latin America) and APAC (ASEAN, ANZ, Greater China, India, Japan, South Korea). So, Region Leads nominate at least one Champion to take part in the Infrastructure Champions initiative. Figure 3 shows the percentage of IT Infrastructure employees per region.

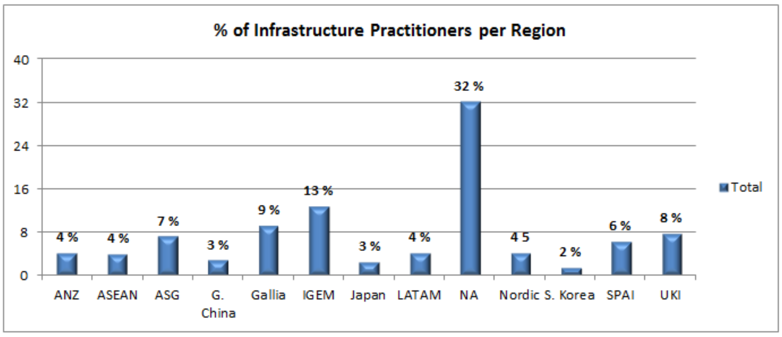

Figure 3 – Percentage of IT Infrastructure Practitioners per Region.

The Change Management Project is composed of a Project Manager, an Estimator Analyst, and a Change Management Analyst located in the USA. Also a Change Management Lead, a Workbench Lead, an Estimator Lead, a Change Management Analyst and a number of Programmers located in Brazil. Regardless of distance and time zones, this whole team has to maintain a good level of communication and help each other perform all activities with quality, and on time according to milestones defined for the current fiscal year.

EVALUATING THE CHANGE MANAGEMENT PROJECT

The word "principle" is employed in this paper meaning "a method of operating used in a certain instance" and not a fundamental law or a rule by which one lives. The various principles of TQM have been presented and explained in seminal works such as Ishikawa (1985), Imai (1986), Mizuno (1988), and Mizuno and Akao (1994). The evaluation of the Change Management Project was carried out in terms of ten selected TQM principles (Fontes, 2012) that are applicable to the matter in hand.

Treat the customer as your boss and benefactor. Bearing in mind the importance of clients' opinions, two types of surveys were carried out: one to evaluate the Workbench tool and the Service Desk, and another to understand the causes of non attendance by IT Infrastructure practitioners to virtual training sessions. Fig. 4 shows results from the type 1 survey related to Service Desk, and involving 56 respondents.

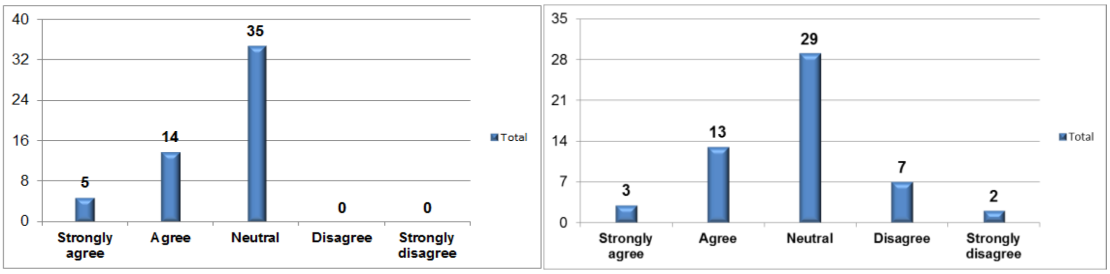

Figure 4 – (a) Support requests to Service Desk. (b) Issues settled by Service Desk.

Feedback provided by IT Infrastructure practitioners for the Service Desk is listed below in their own words:

- User desk is very good and reactive. Use of chat messages is good, sometimes I don´t always have the time to answer though;
- In terms, they helped me to "clean" bad package installations but the package installation issue remains;
- Reinstall is a time consuming solution to incidents;
- I promise to post bugs;
- No basis;
- Yes they can. But sometimes it was time consuming for me considering the use I make of it;
- It was an issue with the installation of the workbench and I had to re-install it.
- According to this survey, it was possible to know that:
- The IT Infrastructure employees have requested support recently;
- The issues were resolved by the service desk team, but some solutions were not the most suitable for the situation (e.g. reinstall the application);
- The user desk is able to resolve the issue.
- Two initial improvements were identified that should be considered to provide a service with more quality:
- Review the proposed time to resolve an issue in order to provide a better solution;
- Review the proposed time to close the issue after a response from the requestor so as to not impact the requestor´s work.

IT Infrastructure practitioners also provided feedback for the Workbench tool. Comments, in the region of a hundred, were analysed using Pareto`s Principle. Responses were grouped by "category" and "reasons". The analysis per "category" is illustrated in Fig. 5.

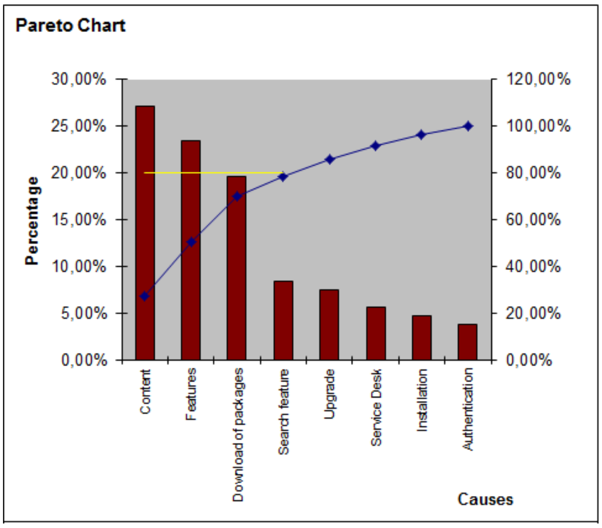

Figure 5 – Feedback received per "category

The causes grouped by "category" were prioritized, and as illustrated in Figure 5 it was necessary to treat 20% of the causes, i.e. content, features, download of packages, and search features in order to solve 80% of the identified problems and improve the Workbench application.

The analysis of feedback provided by IT Infrastructure practitioners helped the Workbench Lead to structure a plan that includes: prioritized causes; people in charge of solving problems; and deadlines for the conclusion of activities.

Respect and value human beings. This principle reminds us that organizations' resources are composed of hardware, software, as well as humanware. The main focus of the change management project is to improve humanware and social capital through training, dissemination of valuable information about industrialization tools – as a means of improving the productivity of IT Infrastructure employees – increasing external customer satisfaction, and cutting IT operational costs. Actions promoted to increase the awareness and motivation of employees include: global IT Infrastructure events; virtual trainings; web site and e-mail messages containing information about industrialization methods and tools.

All these actions need to be planned and performed periodically to maintain awareness and motivation among IT Infrastructure employees, and also to keep the humanware and the social capital alive in the IT Infrastructure area.

Constantly seek improvement. The essence of this principle is changing and keeping changes. One of the main challenges of the change management project is to change the way people work. There are two premises related to this challenge: people have been used to working in the same way for years; and people simply do not like to change, they are afraid of the unknown. However, people may change the way they work if they know the future state and its benefits, and have the sponsorship to make the change.

After increasing the awareness of IT Infrastructure employees through messages and training, the mobilization phase starts. The mobilization phase is very important to keep the industrialization methods and tools alive. Feedback is collected from IT Infrastructure projects that are using the process and documentation from the Delivery Methods, from projects that are using the Estimator tool to provide an assertive estimative and sell projects, and also from projects that are using the Workbench tool to get specific content, tools and best practices to improve their work. In the mobilization phase, the feedback received from an IT Infrastructure practitioner or Champion is sent to the Mobilization team. After an analysis, the improvement is delegated to the correspondent team (Estimator team, Methods team or Workbench team).

Another challenge of the change management project is to measure the success of the change, i.e. to measure how many hours the projects are saving using the industrialization methods and tools. These hours are related to the productivity of the projects in delivering solutions to their clients. The change management project is looking here for success stories from projects that have employed the industrialization methods and tools, so as to demonstrate to all the IT Infrastructure employees the benefits of changing the way they work. The benefits could be saving hours, reducing rework and time, using best practices and reusing documents instead of creating them from scratch. Without success stories, it is difficult for the IT Infrastructure employees to accept the change and trust results that may derive from the use of industrialization methods and tool.

At all levels and sections of the organization, involve everyone in all processes. This principle stresses the need for united efforts in order to achieve objectives. Bearing in mind the objectives of the intended change, which are to increase the usage of industrialization methods and tools and promote savings in projects' hours, effort, and costs, all the IT Infrastructure employees must be at the same page. Besides, they all must be aware of the benefits, and know the new future state. At this point, all efforts should be focused on having people achieve the same goals, and head in the same direction.

Increase communication within the organization. According to this principle, activities are performed to increase the communication in the organization, such as postcards, e-mail announcements, training, and global/regional events. In addition, there is also intense internal communication between the change management project team, Champions and managers of mobilized projects. Considering the role of Champions as regards this principle, they strengthen communication by writing articles related to Estimator, Methods and Workbench and releasing them in their regions (regional communication). Those articles can be written in their native languages, and this is an important factor wherever IT Infrastructure practitioners do not have a good knowledge of the English language, which is the only language used to create global communications in the company.

As for mobilized projects, the first contact is made by e-mail providing a brief description of the Industrialization Program initiative; mentioning the purpose of using the industrialization methods and tools available; and the importance of improving the latter. As a second step, meetings are scheduled in order to verify whether it would be possible to use industrialized methods and tools in the project. The first contact e-mail should be very objective, understandable and pleasant so as to create a good relationship with project managers and increase chances of scheduling a meeting where more details about the industrialization initiative will be presented and more information about the project gathered. At this point during evaluation, the Champion from North America informed that some project managers from his region had not understood the purpose of the meetings. Since contacts had only been made through phone or conference calls and by e-mails, were the language and content adequate to inspire people to use and adopt the industrialized methods and tools? As mentioned before, communication can be improved with the why (reason, beliefs), how (in what way, manner) and what (what is being offered) technique. Therefore, new messages had to be drawn up in order to improve communication with managers of projects that were candidates to use industrialization methods and tools.

Make decisions based on facts and data. This principle, formulated in its original form by Ishikawa (1985) and still considered nowadays a management core principle (FNQ, 2014; NIST, 2013), poses a considerable challenge to the change management project, i.e. to measure the success of the change. This means to measure how many people actually changed their way of working using the industrialization methods and tools. For this reason, key performance indicators (KPIs) were defined to measure the success of change and make assertive decisions based on facts and data. One of these KPIs is described below:

- KPI: Number of web hits.
- Description: number of people who accessed Delivery Methods per quarter.
- Reasons to measure: to verify whether the methodology was being used by IT Infrastructure employees. If not, to understand why not, and take actions in order to measure the speed of mobilization.
- Fig. 6 illustrates facts and data relating to Delivery Methods, where:
- FY11-Q1 – the Change Management Project started and some communication activities were performed (postcards about the IT Infrastructure Methodology);
- FY11-Q4 – few IT Infrastructure practitioners accessed Delivery Methods during this period because it was a vacation period (July and August);
- FY12-Q3 – it was the most productive quarter of the Change Management Project. Many activities were performed in all three towers (communication, trainings and mobilization). Champions also performed most of the activities in their regions aimed at engaging the IT Infrastructure practitioners to use the industrialized methods and tools.

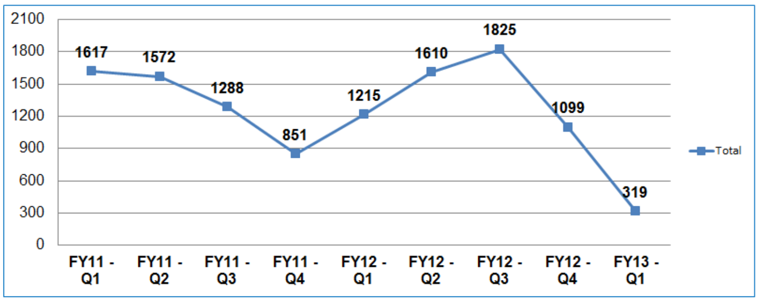

Figure 6 – Number of web hits for Methods.

Standardize the process. This principle states that processes should be standardized and should result from consensus involving all the stakeholders and all the employees. Considering these aspects:

- The industrialized methods and tools were developed based on a consensus involving all of IT Infrastructure SMEs who are designated to aid in the refreshment of the content and documentation;
- The industrialized methods and tools have been continuously updated according to an annual plan;
- All IT Infrastructure employees were submitted to training whose purpose was to disclose the latest updates and changes; clarify the integration; and help them get the maximum value from the Delivery Methods, Estimators, and Workbench;
- The KPIs were used to check the progress of the change management program.

Use PDCA. The customized PDCA cycle for Change Leaders was considered in the analysis of the Change Management Project as follows:

Plan - communication, training and mobilization activities were planned per year.

Do - activities were performed according to the previous planning, such as e-mail releases, training sessions, and presentations in global/regional events.

Check - activities performed by Champions were closely monitored by the Change Management Analyst from Brazil. In much the same way, all change management team's activities were closely monitored by the Project Manager and Change Management Lead to avoid unexpected issues and also to plan activities to be executed in the fiscal year.

Act - all the facts and data were collected and measured to check the development of change around the Globe. More attention was given to regions where there had been little engagement (for example, South Korea, G. China).

Encourage neatness, orderliness, cleanliness and self-discipline. This principle can be followed by employing the well and widely known 5-S technique (Carreira and Trudell, 2006) as applicable to the organization of the repository of documents that are used by the Change Management Project. This house keeping initiative allowed the change management team to better control and access said documents, and as a result more easily find accurate information without duplication.

Be methodical, patient and persistent. This principle is a reminder that the results of TQM are certain, but may take some time to come up. Therefore, patience and a positive attitude are required to reap the expected benefits. Accordingly, the Change Management Project is a continuous effort towards the objective of changing the way people use processes in the organization that started in 2011 and continues to this day, controls being kept and improved. The awareness about the industrialization tools is a constant concern that has contributed to the insertion of more content, samples, actual cases in trainings and communications. A timeline for 2014 establishing the main activities and accomplishments was created and will be followed throughout the year.

FINAL COMMENTS

The study showed that the TQM and best practices approach can be applied in a project that interacts with people and whose product is change. Instead of thinking about how a product was being developed (concrete), the main concern was how the change was being developed and deployed within the culture of the organization (abstract).

Despite changes in behaviour being essentially intangible, quality principles and concepts make it more tangible and perceptible by the affected people. Change is an ongoing process, and it is more and more necessary that people accept it as a natural process. Change brings hope, progress, challenge, motivation, strength, thinking, and courage to keep the current state and prepare for future states. After all, according to Heraclitus of Ephesus (540-475 BC): "There is nothing permanent except change" (apud Caminada Netto, 2012).

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LIPOR'S Value Chain

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ABSTRACT

Purpose. Consolidate the positive differentiation regarding quality management promoting internal and external recognition that the organization meets its customers' needs and comply with legal and regulatory requirements in all its activities, is the commitment of LIPOR.

The normative extension ISO 9001:2008 and the quality management system certification of the entire organization emerged with the integration of this standard in all LIPOR activity and answered the need to standardize management practices and optimization of different processes.

Approach. LIPOR used strategies that involved all the areas; in particular, an internal multidisciplinary working group was created, consisting of a member of each unit regarded as a link with the quality area.

Based on the value chain version designed in 2009 and drafted according to the concept introduced by Michael Porter in 1985, an internal reflection about the LIPOR's core business and about all activities developed within the organization was carried out.

Findings. Due to the positioning of LIPOR with its stakeholders, the value chain has been revised into a value chain that shows the macro processes in management processes and business processes.

This project resulted in quality increase in the organizational culture of the LIPOR through the involvement of team work in the redefinition of the value chain and in process documentation.

Value. Consequently, with the resetting of the value chain as a basic tool of management by process, it was possible to carry out a systematic analysis of LIPOR's activities.

Keywords: LIPOR, ISO 9001, Value Chain, Process, Competitive Advantage

Article Classification: Case study

INTRODUCTION

Management Systems. According to the ISO 9000:2005 standard, and associating the system definition, management system is the set of interrelated and interacting elements for the establishment of policies and goals to reach them (ISO 9000, 2005). This is a definition that organizations should always bear in mind throughout the development and implementation of a management system.

On the other hand, to lead and maintain in operation a successful organization processes need to be addressed and monitored systematically and transparently. The success of an organization can be consequence of implementing and maintaining a management system designed to continuously improve their performance, taking into account the needs of all stakeholders. The management of an organization includes, among other disciplines of management, quality management (ISO 9000, 2005).

The implementation of a management system requires the definition of a policy, e.g., a set of priorities and guidelines to which the entire organization is committed, to which all efforts are directed in the promotion of necessary changes (Cruz, 2005).

The policy promotes the alignment of the organization, both at the level of the management system and its processes, as individual activities of employees who only fulfil their function shown in goals, when translated into concrete challenges that generate action. This action must be targeted and aligned with the mission, vision and critical success factors of the organization, using the instruments and the tools to achieve something. It is not an end in itself (Cruz, 2005).

The implementation or redesign of a management system seeks to enhance the clarity, the flexibility to serve customers and allows the organization to focus on achievement and to maximize its potential. Thus, reference should be made to the customers' needs and on the assumption that the organization has to be focused on creating value for the customer (Cruz, 2005).

The Mission | What we do; The Vision | What we want, where we are going. The mission should demonstrate unequivocally what an organization does to create value for the customer, set out general purposes that provide guidelines for the future, serving as a behaviour guide to all employees. The mission should not be focused inwards the organization but outwards, i.e., on customers and their needs.

In short, this is the statement that in short describes what the organization does, what its business is, what its purpose is, and it should be able to reconcile the strategic and operational aspects (Iberogestão, 2003).

The implementation of a management system aims to support an organization in the process of change and improvement, providing tools that allow walking to a future State. The definition of where an organization wants to go translates your vision (Cruz, 2005).

The vision guides the action and the outcome of the reflection of the top management; the future state of the organization should be motivating and guide to a common goal (Cruz, 2005).

The Strategy. An organization exists to satisfy costumers' needs and expectations, and always take into consideration the objectives and how to achieve them. The fulfilment of the vision and mission through the development of strategies to achieve the goals prior established underlies the organization onset (Cruz, 2005).

To define the way forward becomes imperative to conduct an internal review of the strengths, weaknesses, opportunities and threats to your activity.

To set the course is to define the strategy.

Thus, as Bruce Henderson wrote in article "The Origin of Strategy", strategy "is a deliberate search for a plan of action that will develop a business's competitive advantage and compound it." (Henderson, 1989).

Competitive advantage differentiates organizations, so it is important that an organization excels at differentiation to strategy formulation as Michael Porter in his article "What is Strategy" mentions, "competitive strategy is about being different. It means deliberately choosing a different set of activities to deliver a unique mix of value" (Porter, 1996).

The Michael Porter's Value Chain. The term 'Value Chain' was used by Michael Porter in his book "Competitive Advantage: Creating and Sustaining superior Performance" (Porter, 1985). A value chain is a set of activities that an organization performs in order to provide value for the customers and for the market, as profit for the company. The value chain analysis describes the activities the organization performs and links them to the organization competitive position (Dagmar, 2001). Therefore, it evaluates which value each particular activity adds to the organizations products or services (Dagmar, 2001). This idea was built upon the insight that an organization is more than a random compilation of machinery, equipment, people and money (Dagmar, 2001). Only if these things are arranged into systems and systematic activities it will become possible to produce something for which customers are willing to pay a price (Dagmar, 2001). Porter argues that the ability to perform particular activities and to manage the linkages between these activities is a source of competitive advantage (Dagmar, 2001).

The value activities are distinct blocks of competitive advantage. At each stage of the value chain there is an opportunity to contribute positively to the organization competitive strategy by performing some activity or process in a way that is better and/or different than the competitors offer, and so provide some uniqueness or advantage (Hollensen, 2007).

In competitive terms, value is the amount that buyers are willing to pay for what an organization provides them with (perceived value) (Hollensen, 2007).

The value chain displays total value and consists of value activities and margin. Value activities are the physically and technology distinct activities that an organization performs and are the building blocks by which an organization creates a product valuable to its buyers. Margin is the difference between total value (price) and the collective cost of performing the value activities (Hollensen, 2007).

The value chain activities are a key link between the fundamental company resources and the strategic position in the global market (Hollensen, 2007). Value activities can be divided into two broad types: primary activities and support activities.

The basic model of Porter's Value Chain is present in Figure 1 (Porter, 1985).

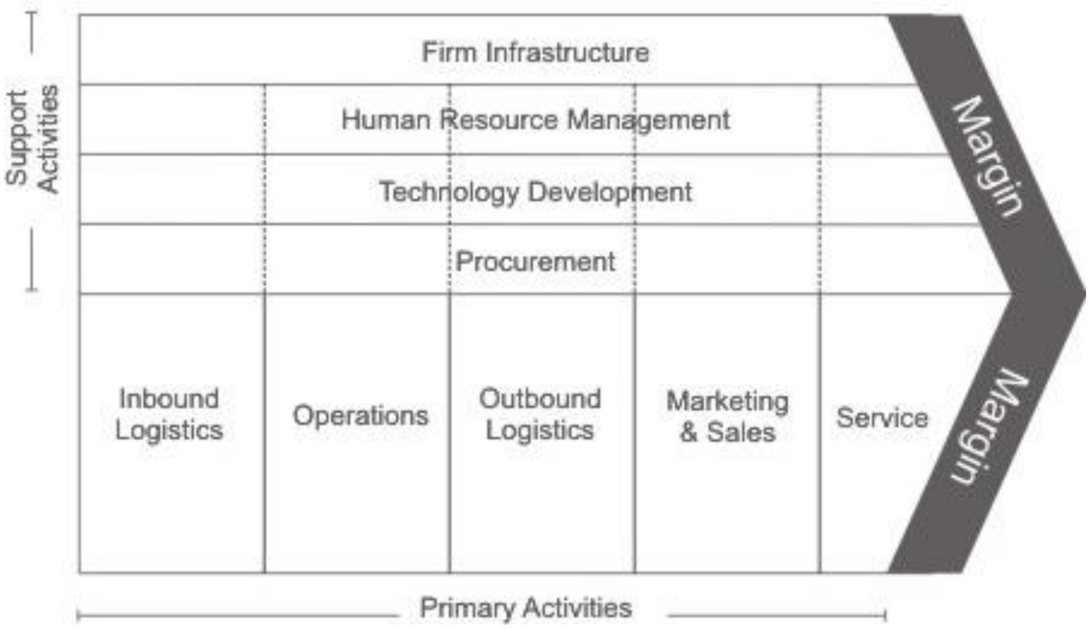

Figure 1 – Michael Porter's VALUE CHAIN (Porter, 1985)

Primary activities

Primary activities, listed along the bottom of Porter's value chain figure, are those involved in the physical creation of the product, its sale and transfer to the buyer, as well as after-sales assistance. In any organization, primary activities can be divided into five categories or main areas: inbound logistics, operations, outbound logistics, marketing and sales services:

- **Inbound logistics**: the activities concerned with receiving, storing and distributing the inputs to the product/service. These include materials, handling, stock control, transport, etc.
- **Operations**: the transformation of these various inputs into the final product or service, like machining, packaging, assembly, testing, etc.
- **Outbound logistics**: the collection, storage and distribution of the product to the customers. For tangible products this would involve warehousing, materials handling, transport etc. In the case of services it may be more concerned with bringing customers to the service if it is at a fixed location.
- **Marketing and Sales**: these provide the means whereby consumers/users are made aware of product/service and are able to purchase it. This would include sales administration, advertising, selling etc. In public services, communication networks that help users access a particular service are often important.
- **Service**: all those activities which enhance or maintain the value of a product/service, such as installation, repair, training, spares, etc.

In any company, all categories of primary activities will be, in some extent, present, and will play a role in the competitive vantage.

Support activities

Support activities can be divided into four areas:

- **Infrastructure**: The systems of planning, finance, quality control, etc. are crucially important to an organisation's strategic capabilities in all primary activities. Infrastructure also consists of the structures and routines of the organisation which sustain its culture.
- **Human Resource Management**: This is a particularly important area which transcends all primary activities. It is concerned with those activities involved in recruiting, training, developing, and rewarding people within the organisation.
- **Technology Development**: All value activities have a technology, even if it is simply "know-how". The key technologies may be concerned directly with the product, a process, or with a particular resource.
- **Procurement**: This refers to the process for acquiring the various resource inputs to the primary activities.

ORGANIZATIONAL FRAMEWORK

LIPOR – Intermunicipal Waste Management of Greater Porto is responsible for the management, recovery and treatment of the Municipal Waste produced in the eight associated municipalities: Espinho, Gondomar, Maia, Matosinhos, Porto, Póvoa de Varzim, Valongo and Vila do Conde.

The strategy of LIPOR towards Sustainability has a very strong inherent message that demonstrates the base and inseparable concept of integrated management, whose main objective is to maintain financial stability, protect natural resources and the environment, not forgetting its responsibility to the community and its employees. In a perspective of continuous improvement and proximity with their stakeholders, LIPOR, as an active agent and engine of change, believes in its role and defends the principles of sustainable development, applying them in the daily management.

Always at the forefront, LIPOR prioritizes the analysis of the results in time, identifying new opportunities, the incorporation of "defined" strategy in the "emergent" strategy and it is assumed as a versatile organization, receptive to change and continuous improvement, with the goal of establishing win-win relationships partnerships. In other words, the decisive factor for the daily success of LIPOR is to maintain its performance in the areas of sustainability, thus achieving excellence.

Consolidate the positive differentiation of LIPOR regarding Quality Management was a strategic objective in 2013.

The extension project of the quality standards to all activities in LIPOR was not a project of a given technical area but rather a global project, with adaptations and the intervention of the entire hierarchical structure of the organization. In teamwork, streamlined by the Quality Group, all employees had and will have a key role in maximizing the effectiveness and efficiency of processes through the potentiation of the continuous improvement.

APPROACH AND METHODOLOGY

The Quality Management Standard promotes the process approach to managing an organization. The clause 0.2 of ISO 9001:2008 supports the adoption of a process approach when developing, implementing and improving the effectiveness of a quality management system, to enhance customer satisfaction by meeting customer requirements.

The LIPOR's value chain review emerged following the ISO 9001:2008 standard project extensions throughout the organization. For this, it was used a management project tool coupled with the quality standard implementation/revision model.

There were used strategies to achieve the planned phases that involved all areas of LIPOR; in particular, an internal multidisciplinary working group was created, constituted of an employee of each organizational unit acting as a link with the quality area.

Project Management Tool. Project management is the application of knowledge, skills, tools, and techniques to project activities to get the project requirements (PMBOK Guide, 2008). The project management processes comprise five process groups: Initiating; Planning; Executing; Monitoring and Controlling; Closing.

The project management plan is the process of documenting the actions necessary to define, prepare, integrate, and coordinate all subsidiary plans. The project management plan becomes the primary source of information for how the project will be planned, executed, monitored and controlled, and closed (PMBOK Guide, 2008).

The project management plan was defined and the following points were identified: the scope and goal; the project team; the requirements; the communication plan; the work breakdown structure; the deliverables and milestones; the risk management plan; the costs and budget; the procurement plan; the quality, environmental, security and safe plan.

The work breakdown structure (WBS) was interactive and went through progressive elaboration throughout the project's life cycle. However, the WBS creation was the process of subdividing project deliverables and project work into smaller activities. The sequence of activities and the duration of each one was set (PMBOK Guide, 2008).

Quality Standard Implementation/Revision Model (AEP, 2006). Before starting the implementation/review process of the quality management standard (ISO 9001:2008) the reading and analysis of the following standards was performed:

- NP EN ISO 9000:2005 - Quality Management Systems. Fundamentals and Vocabulary.
- NP EN ISO 9001:2008 - Quality Management Systems. Requirements.
- NP EN ISO 9004:2011 – Managing for the Sustained Success of an Organization. A Quality Management Approach.

The planning of the project was carried out according to the project management methodology, aiming to temporarily set the phases of the project and identify necessary resources and key people.

The definition and implementation of a quality management system cannot be the responsibility alone of the quality manager. Thus, a working group was created - the Quality Group - which represented the various areas of LIPOR so that all units were an active part in the definition, implementation and extension of the system.

The training of the Quality Group of the quality standard, ISO 9001:2008, was essential for the initiation of the process. Thus, an external entity, at LIPOR's units, conveyed the basic concepts and requirements of quality management.

ISO 9001 standard promotes the adoption of the process approach. Under this approach, the key point in the quality management system, the processes of the organization, as well as their interactions were identified. Process management is also a factor to consider in order to ensure continuous improvement.

At this stage, the process approach has been extended to the not certified areas to assure that the entire organization processes were aligned and structured by the same methodology.

The working group began by developing the structure of the value chain, identifying the organization's processes, the closest possible to the LIPOR's reality.

In order to validate the outline of the value chain, a diagnosis on the processes into LIPOR was made. Thus, it was confirmed which processes/activities were not documented, the importance for the LIPOR's core business and to the ISO 9001:2008 standard requirements.

The context in which the system was already implemented was analysed and the description of processes and the associated documentation checked.

Thus, based on the structure of the processes, they have been described as well as their interaction.

FINDINGS

The ability of an organization to understand its own capabilities and the needs of the customers is crucial for a competitive strategy to be successful. Thus, the value chain definition is an important tool for the competitive advantage analysis and must be used as a simple checklist to analyse each activity in the business with some depth (Pearson, 1999).

Due to the positioning of LIPOR with its stakeholders, the value chain has been revised. Unlike the Porter's general chain composed of sets of primary activities (macro processes) and support activities (support processes) performed by an organization, by a margin of added value in each of the activities and the relations established between themselves, the new LIPOR's value chain (Figure 2) unfolds macro processes in management processes and business processes:

- **Management Processes**: are necessary but not sufficient for the implementation of the strategy, to the extent that they complement business processes.

- **Business Processes**: are indispensable for implementing the strategy, since they directly affect the organization's performance in critical success events.
- **Support Processes**: are required for the operation of the organization, whatever its strategy, but have a very low impact on competitive performance.

In this model, a margin of value added for each process was not considered, and the procedural connections were represented in the network of LIPOR's processes. The margin was not taken into account in the model of the value chain, since LIPOR as an association of municipalities (public company) is a non-profit organization.

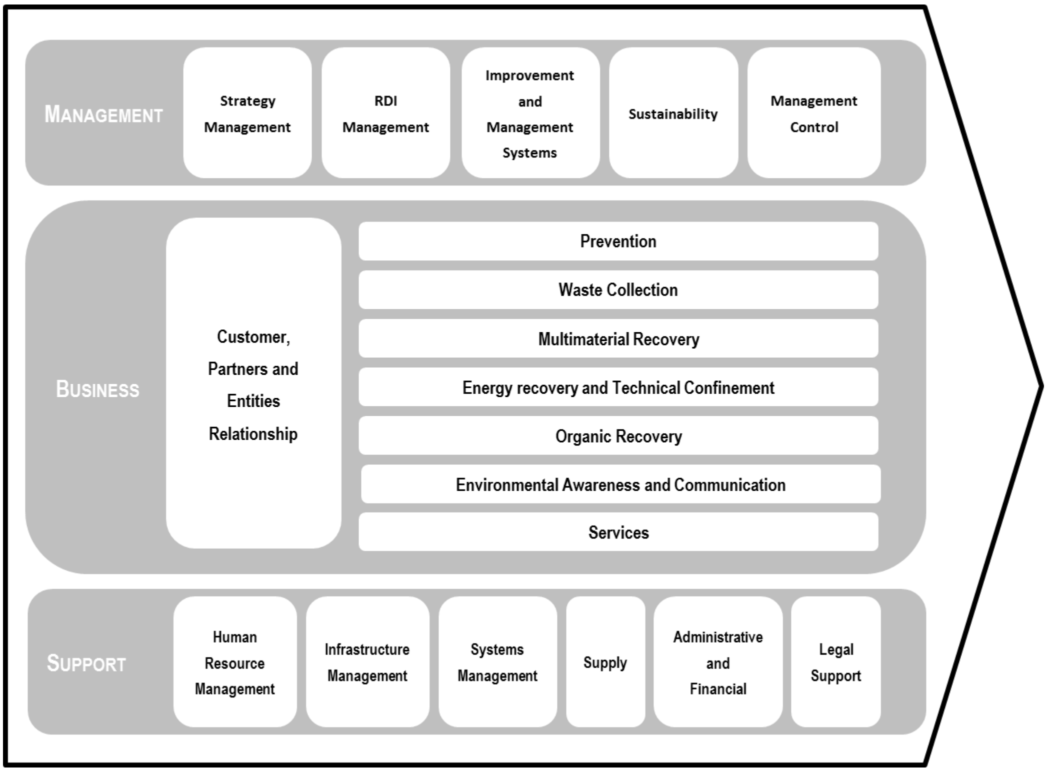

Figure 2 – LIPOR's VALUE CHAIN

Management Processes

- Strategy Management: Strategic Management Process.
- Research, Development and Innovation (RDI) Management: Interfaces and Knowledge Management Process; Project Portfolio Management Process; Project Development Process; Ideas, Challenges and Contests Management Process.
- Improvement and Management Systems: Audit Process; Management Systems Process.
- Sustainability: Support and Sponsorship Process; Bottle Caps Operation Process; Agenda 21 Process; Development of the Sustainability Report Process, Stakeholder Involvement Process (AA1000 APS).
- Management Control: Report Process.

Business Processes

- Customer, Partners and Entities Relationship: Call Service Process; Customer Management Process; Customer Technical Support Process.

- Prevention: Organic Waste Prevention Process.
- Waste Collection: Waste Collection Process.
- Multimaterial Recovery: Recycling and Multimaterial Recovery Process.
- Energy Recovery and Technical Confinement: Energy Recovery and Technical Confinement Process.
- Organic Recovery: Organic Recovery Process; Product Marketing Process; Graveyard Green Waste Recovery Process.
- Environmental Awareness and Communication: Communication Plan and Environmental Awareness Process; External and Internal Communications Process; LIPOR's Educa Process.
- Services: Visits Process; Adventure Park Streamlining Process; Camps Promotion Process; Auditorium Management Process.

Support Processes

- Human Resource Management: Training Process; Occupational Health Process; Pay Roll Process.
- Infrastructure Management: Machines and Equipment, Buildings and Infrastructure Maintenance Management Process; Green Spaces Management Process; Contract for Public Works Management Process; Fleet Management Process.
- Management Systems: Technical Support Process; Software Development Process; Computer Consulting Process.
- Supply: Warehouse and Tooling Management Process; Purchase and Acquisition Process.
- Administrative and Financial: Month Closing Process; Suppliers Payment Process; Document Management Process.
- Legal Support: Legal and Administrative Support Process.

This strategy resulted in the enhancement of quality in LIPOR's organizational culture, in the promotion of quality management practices and improvement, through the involvement of this team work, of redefining the value chain and process documentation.

CONCLUSION

The value chain framework has been used as a powerful analysis tool for organizational strategic planning for nearly two decades now. The value chain framework shows that the value chain of an organization could be useful in identifying and understanding crucial aspects to achieve competitive strengths and core competencies in the marketplace. The model also reveals how the value chain activities are tied together to ultimately create value for the consumer (Karki, 2008).

The nature of value chain activities differs greatly in accordance with the types of organizations and industries.

Thus, with the resetting of the value chain as a basic tool of management by processes, it was possible to carry out a systematic analysis of all the activities of LIPOR, which will allow in the future to:

- understand the source of competitive advantage of the organization;
- review the business practices in order to anticipate market trends;

- disclose of the operating model of the organization;
- provide a complete view of the relationships between processes;
- monitor the Strategic Performance Indicators, as well the Departmental and Quality Management Systems Indicators and others that the organization has integrated with the performance of value chain processes;
- promote the evolution of the performance of the processes in the organization.

Therefore, an organization that adopts a value chain approach generates confidence in the ability of their process and in the quality of their products and provides the basis for continuous improvement. This can lead to increased customer satisfaction and other stakeholders, and also to the success of the organization.

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Developing an integrated management system in a waste treatment facility

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ABSTRACT

Integrated management systems have been implemented in several industrial sectors aiming to fulfil, simultaneously, several stakeholders' requirements. The most common management subsystems combined into an integrated system are the quality management subsystem, the environmental management subsystem and the occupational health and safety management subsystem. It is intended in this paper to report an *in situ* implementation of an integrated management system based on the quality and environmental management subsystems in a waste treatment facility. The main features concerning the current implementation phase will be presented as well the strategies adopted to assure a full integrated and functional system. Some specific issues concerning the industrial sector (waste treatment) will be discussed and some critical successful pre-requirements (namely those related to information flow within the organization) will be reported. Finally, this paper will address also some information collected from the bibliography available on this topic as well the integrated management systems dissemination throughout Portugal.

Keywords: integrated management system, implementation, waste treatment

INTRODUCTION

Current issues concerning management systems. The development of an integrated management system (IMS) has been focused as a research topic by several authors. Amid the studied features, the main motivations (Simon *et al.*, 2012; Domingues *et al.*, 2014), drawbacks (Domingues *et al.*, 2012, 2014) and expected benefits (Zeng *et al.*, 2011; Domingues *et al.*, 2014) as well the critical success factors (Sampaio *et al.*, 2012) and the integration strategies (Almeida *et al.*, 2014; Bernardo *et al.*, 2011; Domingues *et al.*, 2014) were widely reported. The available bibliographic resources may be useful when implementing an IMS *in situ* since previous experiences may preclude some implementation errors and mistakes. Additionally, some redundancies could be prevented leading to a more efficient and manageable organizational system.

In our days, organizational efficiency relates hugely with the information flow within a company, namely, how it is designed, implemented and adopted. A great deal of information technologies (ITs) based systems, such as databases, are available in the market providing companies with a tool to successfully manage the data. This data is used to populate the indicators and so, to forecast some challenges, to identify business opportunities and threats, to benchmark some features from the competition and, ultimately, to manage the company.

Some software data management development considers two different teams: one with a software training background and other with a quality management training background. Moreover, a great deal of the software adopted is either a generic pre-existing pack or developed by an external team. Some shortcomings and drawbacks arisen from this traditional approach, namely, those faced when new processes or existing processes demand new tools to assess the inputs and outputs. In addition, an integration strategy step-by-step over an all-in strategy introduces indicators not previously consider at the time of the software development. This fact imputes and encompasses new costs by purchasing new software or by adapting a pre-existing one.

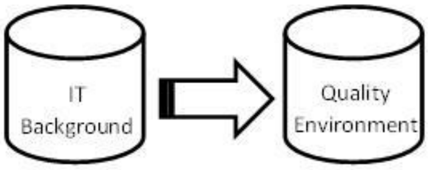

Figure 1: An approach concerning data management.

The available software in our days adopts a friendlier environment to quality managers that do not have a background in information technologies (ITs). A previous check of the amount of variables to monitor and a forecast of the number of records to be developed by time frame allows one to select suitable friendlier developer software that may be managed by quality background responsible. Hence, it is possible to adopt the approach suggested by Figure 2, that is, quality managers developing a suitable and tailored software environment to manage all the appropriate data.

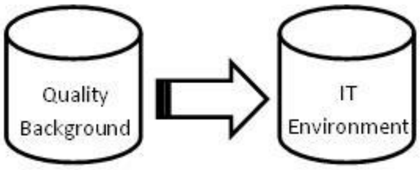

Figure 2: Alternative approach concerning data management.

The Portuguese context concerning Integrated Management Systems. By 2013, there were 1038 Portuguese companies ruled by an IMS considering their certification according the ISO 9001, ISO 14001 and OHSAS 18001 standards. The most common IMS typology considers the quality management system (certified according ISO 9001 standard), the environmental management system (certified according ISO 14001 standard) and the occupational health and safety management system (certified according OHSAS 18001 standard). The typology considering solely the environmental management subsystem and the occupational health and safety management subsystem coexisting together in the same organization was the least represented (Figure 3).

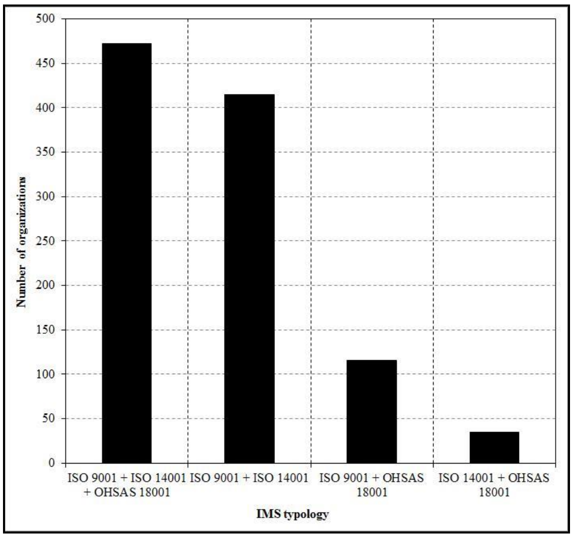

Figure 3: Number of Portuguese companies by IMS typology (adapted from GEC, 2013)

Figure 4 presents the dissemination throughout the different regions of the country. This dissemination matches the industrial density of Portugal, being the regions of Lisbon, North and Centre those in which a high amount of organizations ruled by an IMS may be found.

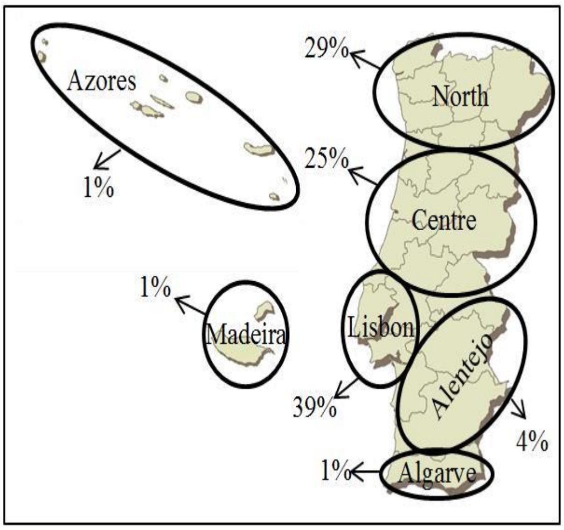

Figure 4: IMSs distribution throughout Portugal (adapted from adapted from Saraiva and Sampaio, 2012)

Figure 5 displays the chronological evolution (2007-2011) of the number of integrated management systems (IMSs) (all typologies) certified according the standards ISO 9001, ISO 14001 and OHSAS 18001. Considering Figure 5, one may conclude that IMSs of the Portuguese companies have increased in number by approximately 22% between 2007 and 2011.

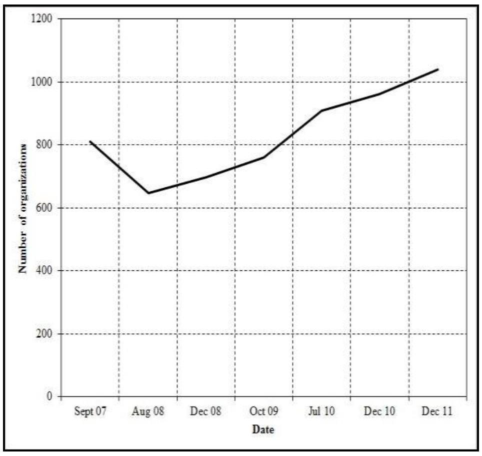

Figure 5: IMSs chronological evolution (2007-2011) (adapted from Saraiva and Sampaio, 2012)

MATERIALS AND METHODS

The issues and relevant features concerning an ongoing implementation of an IMS will be discussed. The company focused on this study, Semural WE, develops environmental activities related to waste treatment being located at the North of Portugal. Its main customers are public and private organizations and its specialty field of action relates with industrial waste, demolition and construction waste and waste from water treatment facilities. Concerning the integration strategy, the company achieved earlier ISO 9001 certification and currently is in the process of developing an IMS supported in the quality (ISO 9001 standard) and environmental management subsystems (ISO 14001 standard).

RESULTS AND DISCUSSION

The company focused in this study found to be an asset the implementation of an environmental management system due to several reasons. The main reason concerns with the activity sector where the company develops its activities (waste treatment) and with the policy and vision adopted by the top management. Top management vision was that the company should be a referential concerning environmental management and the prior development of a quality management system provided a positive feedback on standardised management systems. Other reasons and potential benefits are listed in Table 1.

Table 1: Reasons and potential benefits to implement an IMS combining an environmental and a quality management subsystems.

Reason/Benefit	
To eliminate redundancies.	To optimize costs.
To decrease on the number of audits.	To decrease on the paperwork.
To improve the corporate image.	To improve internal communication.
To improve system manageability.	

Considering Table 1 one may conclude that the reasons stated are in accordance with the main reasons described in the bibliography covering this topic.

Some features have been taken into account previously to the implementation of the IMS. Table 2 presents those features and the actions developed to encompass it within the already implemented quality management system.

Table 2: Features and actions concerning the IMS.

Feature	Action
New designation of the quality management system.	All references to the “quality management system” should be avoided and substituted by the “management system”. In the event of mandatorily mention the quality or environmental systems these should me mentioned as “quality management subsystem” and “environmental management subsystem”.
Documental integration.	The following procedures should be integrated: Audits; Non-conformities and corrective actions; Top-management review;
Information flow throughout the organization.	Development of a software relational database.
Organogram.	Transversal activity of the quality management subsystem.
Processes managers.	Scheduled of meetings with the processes managers.
Management system manual.	Policy and vision revision concerning the new stakeholder.
Functions and responsibilities manual.	Integration of functions, activities and responsibilities regarding the environmental management subsystem.
Processes description.	Environmental aspects evaluation. Legal requirements. Integrated indicators, goals and objectives (open issue).

Concerning the software development aiming at the management of the data outputted by the different processes of the IMS the novel approach (Figure 2) was adopted and, after a review regarding the records and processes involved, the Microsoft Office Access 2010 (MOA2010) was chosen as a suitable development environment. MOA2010 enables one to develop several objects in order to achieve a friendly user environment that may be used by unexperienced employees. The object “Table” is the cornerstone of the software development and the ability to edit relationships between several “Table” objects outperforms the traditional spreadsheets. Figure 6 presents the main MOA2010 objects displaying the “Table” objects as a central feature.

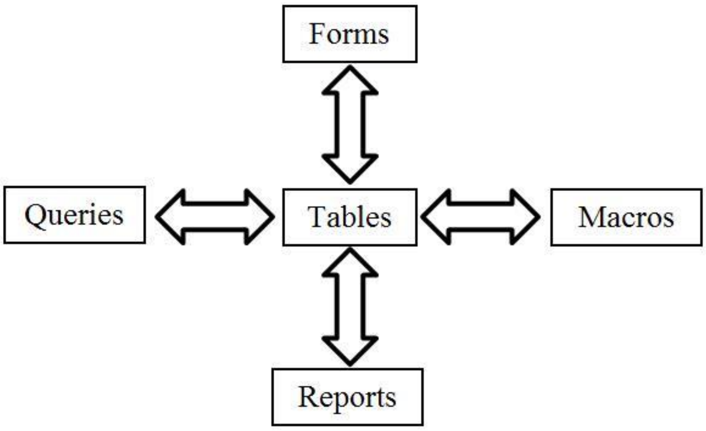

Figure 6: Microsoft Access 2010 objects.

A critical issue when developing databases is the identification and characterization of the relationships between the tables so they mimic the “real world” relationships. Considering this fact, it is advisable to thoroughly study the processes and the way the information flow within and between them. In addition, it is intended that several objects shared with the sites where the information is available so the inputs be available to the manager as soon as possible.

With this database, Semural WE, have an easy access to the key information to manage the IMS, and the deviations to the goals can be quickly analysed and corrective actions taken. At the same time, all organization has the same information of the management systems and can be early involved in the important decisions to improve the company performance.

Although the IMS is not already completed, Semural We, have now biggest knowhow of the necessities of their stakeholders and a quickly answered to their necessities, because they can better manage their resources.

CONCLUSIONS

This paper reported that IMSs are increasingly been adopted by Portuguese organizations. Although data concerning other countries had not been presented in this paper evidences suggest the same trend. The *in situ* ongoing implementation of an IMS supported on the quality and environmental management subsystems and the features derived from that have been reported, as well, a novel approach to assure a proper information flow within and throughout the organization. This novel approach is enabled by the increasingly friendly software development environments available in the market and that may be a useful solution namely for micro enterprises and SMEs.

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A study of critical success factors in applying Thailand Quality Award framework in an electronic manufacturing company: A case study

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ABSTRACT

Purpose. The purpose of this research is to identify key Opportunities for Improvement (OFIs) and the organization's Critical Success Factors (CSFs) in their journey to excellence using Thailand Quality Award (TQA) framework. This framework was translated from Total Quality Management (TQM) concept which is a well-known integrated management philosophy aimed at improving the performance of every aspect of products, processes and management of an organization. Although the award was launched since 2001, there had been limited numbers of successful implementation especially to the level of TQA Award.

Design/methodology/approach. Two sets of questionnaire, the simplified and the overall requirements, were developed using TQA framework to interview 3 levels of respondents in an electronic manufacturing company. The result from the questionnaires will be used to identify the key OFIs and validated the CSFs.

Findings. Both sets of questionnaire can filter the key issues for improvement. The factors derived from the simplified questions are mainly related to general process gaps while the factors from the overall questions are more focus on improving the organization towards industrial leadership.

Originality/value. The result from this study reveals that although the framework proofed to be quite robust in identifying key opportunities for improvement, but deep understanding on the TQA/TQM concept is required to validate the response. In addition, translation of these findings into roadmap for successful implementation to the company was recommended.

Keywords: Thailand Quality Award **(**TQA) framework, Total Quality Management (TQM), Organizational Assessment, Critical Success Factor (CSF)

Article Classification: Research Paper

INTRODUCTION

Quality becomes an important factor in today business to make sure products and services meet customers' requirements. It creates consistency through the whole organization, competitive advantage, reduces waste, ensures customer satisfaction as well as increases revenue which is the major goal for every company. Quality improvement concept was developed after World War II (Evans, 2011) by W. Edwards Deming and Joseph M. Juran who firstly introduced statistical quality control system in Japanese company to strive over the business crisis. This concept was accepted and received good responses from many companies in opening new market with high benefit and made Japan become a role model of quality. In 1980, U.S. started introducing similar concept in automobile industry and could make a high profit ever. The Malcolm Baldridge National Quality Award (MBNQA) was established in 1987 (Wisner and Eakins, 1994) by United States Congress to recognize U.S. organizations in the business, health care, education, and non-profit sectors for performance excellence. Many countries then established their own quality awards afterwards but framework is still in the extent of Total Quality Management (TQM). TQM concept is a well-known integrated management philosophy and widely used in the world aimed at improving every aspect of products, processes and management of an organization with all workforce engagement. It is translated to quality award in several countries, including Thailand Quality Award (TQA) framework which consists of seven categories; Leadership; Strategic planning; Customer focus; Measurement, Analysis and Knowledge management; Workforce focus; Operational focus and Business result. Most of the frameworks begin with Leadership dimension and summarize all the outcomes in Business Result rated the highest score while Deming award of Japan focuses on 3 major dimensions; basic category, unique activities and role of top management. It was found that dimension in most quality awards can be classified into three categories; i.e. core criteria, internal environment criteria and goodwill criteria which represents organization's sustainability (Talwar, 2011). There was a study investigated the organizations which received quality award (Chung et al., 2008) and result revealed that their financial capability demonstrates 1.5 times better than industry standard value. The reasons most companies adopting TQM concept or quality award (Iñaki et al., 2006), such as EFQM, are to focus the internal factors in the organization related to internal improvement, management and establishing strategic framework which can link to the external factors; e.g. customers' requirements and build organization's image. This study corresponded to another study (Saizarbitoria, 2006) that quality award can improve company capability both internal and external factors such as motivation and satisfaction of workforces, reducing waste, improve product quality, increasing share market and profit as well as creating customer satisfaction.

Critical Success Factors (CSFs) are the internal and the external factors which impact to the success and failure of the organization (Jha and Kumar, 2010). They are essential and have to be executed with full engagement of all workforces to achieve company's goal and strategy. The success factor can be classified into four categories (Grienitz and Schmidt, 2011), strategic success factors, critical success factors, balanced success factors and overrated success factors. The strategic success factors are important to competitive advantages and company's long-term success. It was also found that there are two levels of success factors classified in general (Caralli et al., 2004), i.e. higher CSF or enterprise level and lower CSF or operational level. Both levels support the success of each other, the higher CSFs cannot be achieved if the lower CSFs are not achieved or do not support the strategy. There are four major factors Management should focus as CSFs of implementing TQM in an organization, i.e. commitment from senior management, strategic planning, training and process management (Jamali et al., 2010). The findings also confirmed that commitment from senior management is one of important items for company's success (Talib et al., 2011).

A case study organization is an electronic company which adopting TQM concept to improve company as a whole towards quality award and operational excellence. TQA framework which is considered robust and has maturity level of score was selected to be a tool to assess and identify key Opportunities for Improvement (OFIs) and the organization's Critical Success Factors (CSFs) in their journey to excellence using such framework.

OBJECTIVES

The objective of this research is to use Thailand Quality Award (TQA) framework for organizational assessment to identify the key Opportunities for Improvement (OFIs) and the organization's Critical Success Factors (CSFs) in their journey to excellence.

TOOLS AND METHOD

Thailand Quality Award (TQA) framework consists of seven categories; Leadership; Strategic Planning; Customer Focus; Measurement, Analysis and Knowledge Management; Workforce Focus; Operational Focus; and Business result. The framework comprises of a structural set of questions which are useful for organization's journey to excellence by doing a self-analysis. The criteria requirements in each category are expressed as questions in three levels namely; basic, overall and multiple. As the organization goes through each level of the criteria requirements, the breadth and depth of their process deployment expand to cover organization-wide business excellence.

Using the framework as an assessment tool, two sets of questionnaire, the simplified (QI) and the overall questions (QII), were developed. The intention is to test both sets for organizational assessment and to identify key improvements especially in the areas leading to performance excellence. The simplified questions (QI) are easy to understand and have the detailed content so the understanding in TQA/TQM concept of respondents is not required. The developed questions with reference to TQA framework were used to interview the selected respondents of an electronic manufacturing company separated into three levels, top management, line management and key workforce. Each question requires respondent to rate the score from 0 (no approach) to 5 (having systematic and effective approach). The derived factors from these questions, however, are only at the beginning stage aimed to identify and close the process gaps.

The overall questions (QII), the second set of questionnaire, were then developed with the hypothesis of identifying key improvement area to validate "At which level of employee able to identify the key improvement and are valid". All respondents were interviewed through the developed questions which consist of two main parts. The first part is the questions related to the background information of respondents inquired about years of experience in the company, understanding level of TQA/TQM concept of respondents and understanding level in the organization's goals and strategy. The second part consists of seven categories of questions asking respondents to rate the score from 0 (no approach) to 5 (having systematic and effective approach) and identify the most significant area required improvement. The questions in QII questionnaire are the core concept of TQA framework so the factors derived are the key improvement factors for the organization that can lift up the score toward the TQA level or at the score of 650. Therefore, these questions require respondents who have good understanding in TQA/TQM concept to validate the result.

The result derived from both QI and QII questionnaires was validated and used to develop the third set of questionnaire (QIII) to identify Critical Success Factors (CSFs) for organization. The questionnaire contains 30 factors filtered from the key improvement area and was used to interview respondents asking to identify the importance level rated from 1 (not important) to 5 (the most important). All of the identified OFIs and CSFs are then summarized and provided recommendation.

RESULT AND ANALYSIS

The result and analysis of the result can be categorized into two topics based on the defined objectives, identifying the key Opportunities for Improvement (OFIs) and identifying the Critical Success Factors (CSFs).

Identifying the key Opportunities for Improvement (OFIs). There are 18 respondents from key workforce and line management participated in the interview to identify the key OFIs using the simplified questionnaire (QI) which has 10 questions in each category. Each respondent was asked to rate the score in each question from zero (0) to five (5) whether the item has no approach or has systematic and effective approach with fully response to organizational needs. Result indicates line management gave a little higher score than key workforce level in most items but no outstanding score in any specific item can be seen. The average score is in the range of 3.5 of 5 point scale, as shown in table 1.

The result, however, is still unclear to identify the key improvement areas and confirm the validity using the simplified questions (QI). The overall requirement questionnaire (QII), which has 5-6 questions in each category, was then used to ask respondents to confirm with the result analysed earlier. The result reveals that, in most questions, there is not much difference in the evaluating score between groups of respondent. The average score is in the range of 3.65 of 5 point scale, as shown in table 2.

Table 1 – Assessment score from the simplified questionnaire (QI)

Question	Category 1	Category 2	Category 3	Category 4	Category 5	Category 6	Category 7
1	3.500	3.111	4.056	3.333	3.278	3.278	4.000
2	3.556	3.778	3.889	3.556	2.944	3.500	3.944
3	3.500	3.444	3.556	3.611	3.056	3.333	3.667
4	4.167	2.889	3.667	3.500	3.611	3.389	3.556
5	3.778	3.333	3.333	3.667	3.778	3.500	3.667
6	3.667	3.278	3.500	3.889	3.222	4.000	3.278
7	3.056	3.000	3.833	3.667	3.389	3.667	3.278
8	3.444	3.667	3.944	3.556	2.889	3.778	3.444
9	3.333	3.611	3.444	3.222	3.500	3.833	3.500
10	2.944	4.056	3.667	3.833	3.444	4.056	3.333
Average	**3.494**	**3.417**	**3.689**	**3.583**	**3.311**	**3.633**	**3.567**
Total Average	**3.528**						

The score from respondents was also examined by 3 sub-hypotheses below using statistical method.

(1) Years of experience in the company create perception in the evaluation score and help identify OFI

(2) Understanding level of TQM/TQA concept significantly impacts responses & identify OFIs

(3) Perception and understanding level of organization's goals and strategy have bias towards evaluation score

Table 2 – Assessment score from the overall questionnaire (QII)

Question	**Category 1**	**Category 2**	**Category 3**	**Category 4**	**Category 5**	**Category 6**	**Category 7**
1	3.778	3.333	3.944	3.563	3.471	3.500	3.667
2	3.667	3.611	3.944	3.778	3.667	3.500	3.882
3	3.444	3.471	3.944	3.556	3.824	3.389	3.722
4	3.500	3.412	3.833	3.667	3.667	3.833	3.722
5	3.500	3.500	NA	3.778	3.353	3.389	3.722
6	3.556	NA	NA	NA	NA	NA	4.222
Average	**3.574**	**3.465**	**3.917**	**3.668**	**3.596**	**3.522**	**3.823**
Total Average	**3.652**						

From statistical method using non-parametric test with 90% confidence level, probability value (P-value) is more than significance level of 0.10 in most of the questions for all 3 sub-hypotheses. This indicates all three factors; years of experience in the company, understanding level of TQM/TQA concept and understanding level of organization's goals and strategy, do not create different perception in the evaluating score which can help identify the key OFIs.

In addition, the comparison result derived between the simplified (QI) and the overall (QII) questionnaire shows no difference in the evaluating score, as shown in figure 1. Therefore, it can be concluded that both sets of questionnaire can yield the same level of scoring band regardless of the background of the respondents. It is also recommended that the questions should be developed in a simple way but with detailed content to provide better understanding to respondents so the valid feedback can be received. The key OFIs are identified based on 3 criteria.

(1) The factors which have the lowest score from both sets of questionnaire

(2) The factors which shown significant difference from hypothesis test

(3) The factors identified by respondents' opinion

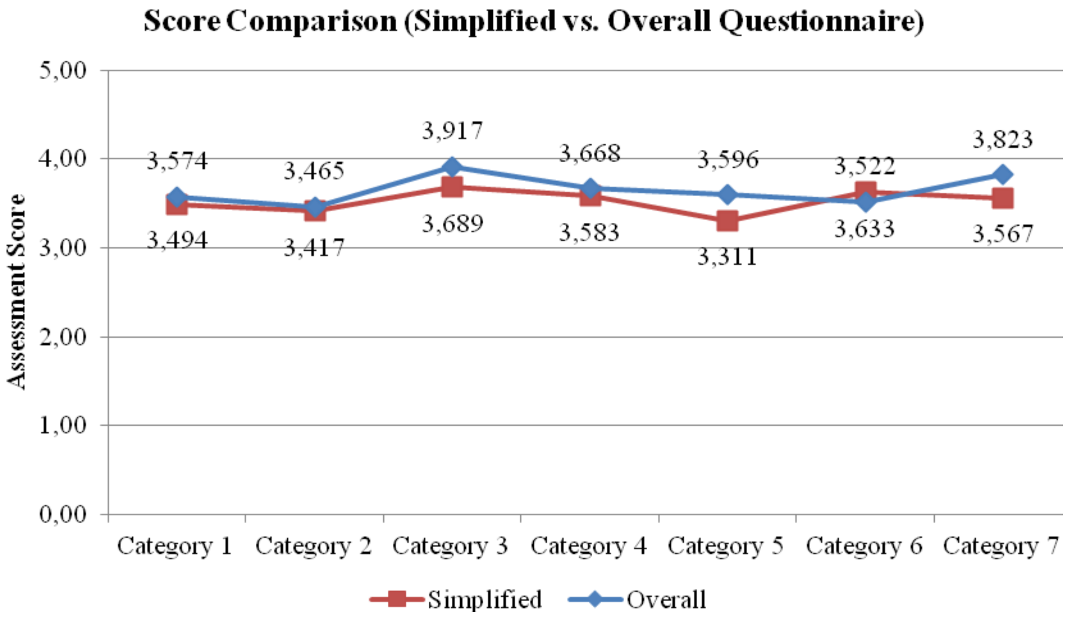

Figure 1 – Assessment score comparison between simplified vs. overall questions

Result of the identified factors corresponds with the hypothesis initially developed that the factors derived from the overall questionnaire (QII) are the key improvement of the organization towards TQA level while the factors derived from the simplified questions (QI) are the basic factors at the beginning stage used to identify and close the process gaps. There are 23 key OFIs can be identified and most of them are in Leadership and Business result area. All factors can be classified based on TQA framework as follows (table 3):

Table 3 – Factors derived from the simplified (QI) and overall (QII) questionnaire

TQA Main Category	OFIs derived from QI	OFIs derived from QII
1. Leadership	1. Stakeholder involvement 2. Support and strengthen communities	1. Create environment to ensure legal and ethical behaviour 2. Innovation environment 3. Effective communication
2. Strategic planning	Strategic objectives balance employees' needs and identify HR plan	1. Consider strategic challenges 2. Clearly define strategic objectives and action plans
3. Customer focus	Effective complaints and response mechanism (CRM)	1. Build relationship and communicate with customers 2. Communication of customer result
4. Measurement, analysis and knowledge management	Tracking daily operations and use information to improve organizational performance	Improve on organization's Knowledge management and clearly identify knowledge assets

5. Workforce focus	1. Recruiting, hiring and retaining employee 2. Fairness and equity	Improve on workforce capability, capacity and engagement
6. Operational focus	Working system for corporate's achievement and customers' needs	1. Organization's overall cost control and supply chain management 2. Innovation for future
7. Business result	HR satisfaction and process improvement	1. Report of product performance 2. Report of workforce-focused result 3. Customer satisfaction and engagement

All identified key OFIs are validated by interviewing 19 respondents from Top and Line management using three questions; whether or not those factors are valid, worth doing and difficult to pursue. Most of the respondents inferred that all key OFIs are valid and worth doing but not so difficult to pursue, except Stakeholder involvement, Fairness and equity and Workforce capability, capacity and engagement which were scored high by Top management. Although the respondents' inferred that most factors are no difficult to pursue, these are just simple presumptions. The implementation process has not begun and critical success factors have not taken into consideration.

Identifying the Critical Success Factors (CSFs). The third set of questionnaire (QIII) was used to identify CSFs. It consists of 30 factors filtered from the key OFI. All 35 respondents from Top and Line management were asked to identify the importance level of each factor scored from 1 (not important) to 5 (most important). The total average score of importance is 4.2 and there are 20 factors identified as important and most important (score ≥4), as shown in figure 2.

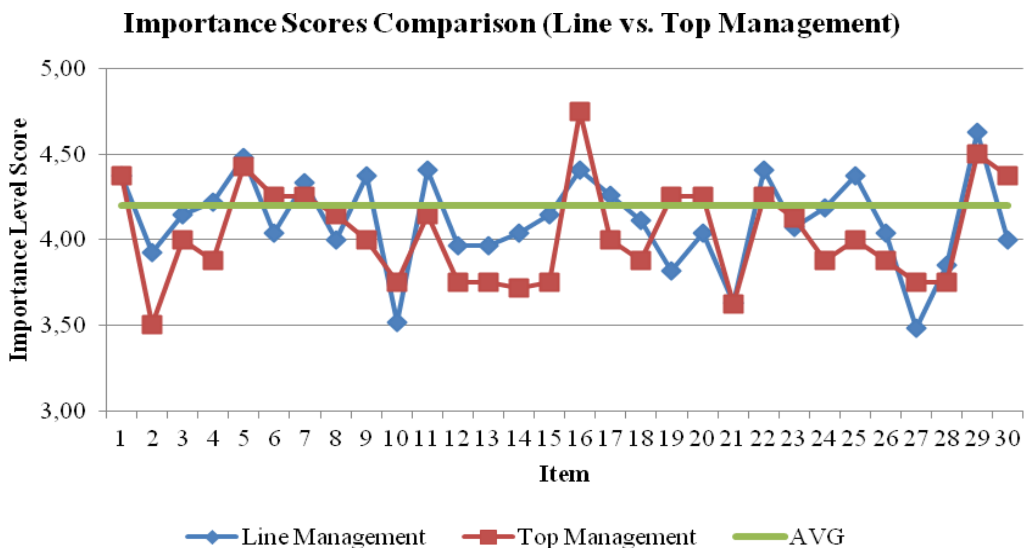

Figure 2 – Importance level score comparison between Line and Top management

The Critical Success Factors (CSFs) were identified based on importance level of score as follows:

- The factors both Top and Line management inferred important or critical are HR capability and engagement, Product performance and quality, Customer satisfaction and engagement and Defining clear goals and strategy.
- The factors Top management alone defined critical are Process capability, Be a role model of success, Company culture and Goals clearly link to excellence. These are main factors required senior management clearly cascaded to lower level in most companies.
- The factors Line management alone defined critical are Problem detection and solution capability, Clear direction from management, Goals clearly link to bottom line result and Commitment from senior management. These factors are essential for operational point of view.

CONCLUSIONS

From the study of identifying key improvement or OFIs and CSFs of an organization using sets of questions with reference to TQA framework, it can be concluded as follows:

- The TQA framework, which is considered robust and has high maturity, used to develop questionnaires are able to identify key OFI with valid information.
- Both sets of questionnaire, either the simplified or overall versions, can filter the key OFIs. The factors derived from the simplified questions are mainly to close general process gaps while the factors from the overall questions are to improve the organization towards industrial leadership.
- Although the TQA framework proofed to be quite robust in identifying key OFIs, but deep understanding on the TQA concept is needed to validate the response.
- The key OFIs rated as “not difficult to pursue” is because respondents are not aware of the difficulty in the journey or do not understand the process of successful implementation.
- The CSFs were identified based on perception and level of respondents. Top management focused on the whole picture of organization while Line management focused on operational capability.
- Leading company towards the excellence is not only identifying key OFIs and CSFs. The implementation plan and clear roadmap with commitment from senior management and workforce engagement are much more important for journey to excellence.

RECOMMENDATIONS

Recommendations for other researchers interested in identifying the key OFIs and CSFs are as follows:

- Questionnaire should be developed in a simple way but with detailed content for respondents to have better understanding and provide valid responses.
- The identified key OFIs and CSFs are based on group of respondents and time of interviewing. Performing similar study with different group of people and time of study may result in different outcomes. Researcher should properly define framework and group of respondent for a valid result.

- Though the topic of "Training and understanding of TQA/TQM concept" was not considered as CSFs, this factor is an important foundation and essential for every organization to improve capability towards the excellence.

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Using a Six Sigma Project to Improve Canteen Quality and Management

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ABSTRACT

The purpose of this work was to improve the quality of meals and service in the canteens of the polytechnic Institute of Viana do Castelo (IPVC), with a simultaneous reorganization of internal processes trying to achieve sustainability.

A team of quality experts, managers and food engineers was set up and used a few quality tools and models, including a Balanced Scorecard and a SWOT analysis, which led to the definition of a six sigma (6σ) project aiming at analyzing possible ways of improving meal quality and implementing preservation processes for precooked meals, thus enhancing the reorganization of canteen operations.

Several preservation processes for precooked meals were compared, namely freezing, refrigeration with vacuum and refrigeration with several modified atmospheres. Initial parts of the project were carried out at the laboratory level, which were followed by a scale up process where some problems related to equipment handling and lack of specific workers' training had to be dealt with. A FMEA was very helpful to overcome these problems.

The project dealt with a few important questions and demonstrated the applicability and success of quality models and tools, in the sense that it applied new methods to solve problems in a public institution, where many resistances are usually met whenever one is facing the implementation of new procedures.

At this stage of the project it was possible to introduce profound changes in spaces, meal production and preservation, keeping or even increasing clients satisfaction, while obtaining substantial financial outcomes as demonstrated by the chosen key process indicators.

Keywords: Six Sigma, DMAIC, Quality Management, Canteen Management

Article Classification: Case study

INTRODUCTION

The Polytechnic Institute of Viana do Castelo (IPVC) comprises six schools and one academic centre, spreading over the region Alto-Minho, a 2210 km^2 area in North-western Portugal. In addition to dispersion throughout the region, schools vary in number of students and in the existence of regular, late-afternoon and evening courses that causes several management problems.

The Social Services of IPVC are responsible for a series of activities supporting students' needs, among which providing meals is one of the major concerns. There are great problems in what concerns canteens' management: the seven canteens show a great asymmetry in number of meals according to season, among different canteens and between lunch and evening meals. Factors like the great dispersion throughout the region, coupled with a very conventional service and legal difficulties in personnel management, do not allow an easy rationalization in order to reduce costs with a simultaneous increase in service quality.

Therefore, in 2010 a team of managers, food engineers and quality experts was set up aiming at examining ways of improving canteen management, namely increasing flexibility and reducing canteens' operational costs. The team decided to look for quality models and/or tools that could provide guidance and maximize the efforts to be developed along the project.

IMPORTANCE OF QUALITY MODELS AND TOOLS

Quality tools are well defined ways to solve specific problems (Beckford, 2000; Juran and Godfrey, 2000; Westcott, 2009). Examples of quality tools are: (i) the RACI matrix (Haughey, 2010) used to assign responsibilities to team members; (ii) the Gantt diagram (Chauvel, 2009) used to help planning actions along a project lifetime; (iii) the Ishikawa diagram (Stamatis, 1996), also known as the fishbone or cause-effect diagram, aiming to help putting forward all possible causes for a given problem; (iv) the 6M, usually coupled to the cause-effect diagram, which helps to discover potential causes by following an *a priori* classification; (v) the SWOT analysis which helps to compare strengths, weaknesses, threats and opportunities, and therefore how competitive a given organization or business can be; (vi) FMEA, which stands for failure modes and effects analysis was designed to help evaluating risks at all stages of a given process (Stamatis, 1996); (vii) The balanced scorecard, or BSC (Kaplan and Norton, 1992 and 1996) which defines the main organizations perspectives to assure sustainability. Quality models may be defined as integrated methodologies coupled to quality tools, aiming at helping organizations implementing good practices (Upton, 1996). Examples of quality models are ISO 9001, TQM and EFQM (Beckford, 2002). Six sigma (6σ), as presented by the ASQ 6σ Body of Knowledge (ASQ, 2013), is a quality model, rather than a quality tool, since it incorporates a series of other tools, quality charts, sampling plans and other statistical methods, as well as the DMAIC methodology (Antony, 2006; Antony et al., 2007; Chakrabarty and Tan, 2007; Pyzdek, 2003).

Now-a-days, there is a wide number of tools designed to solve specific problems, a huge number of reference books explaining how to apply these tools and software with forms that can be downloaded for immediate use. Therefore, it is important to gather a general knowledge on tools and models, in order to find out which are the most useful for a given problem.

METHODOLOGY

Following the recommendations of the ASQ 6σ Body of Knowledge (ASQ, 2013), the team used several quality models/tools of which the following deserve a special mention: BSC and SWOT analysis as the initial steps of the work. The 6σ was followed, adhering to the DMAIC methodology (Pyzdek, 2003). Project forms, RACI matrices, the SIPOC (suppliers, input, process, output, costumer) way of developing fluxograms, Gantt diagrams and FMEA. Modified atmosphere packaging (MAP) was implemented according to conventional methodologies (e.g., Church, 1994; Hintlian and Hotchkiss, 1986). Sensory analysis and consumer studies followed Stone and Sidel (2004) and Meillgaard et al. (2006) recommendations. All microbiological analysis were carried out according to Portuguese norms (NP 3277:1987, 3788:1990, 4062:1990, 4400-2:2002, 4396:2002, 4405:2002) and European norms (EN ISO 6679:2002, 11290-1:1996 and 15213:2003).

RESULTS PREVIOUS TO THE 6σ PROJECT

As explained before, in 2010 a team of managers, food engineers and quality experts was set up aiming at examining ways of improving canteen management, namely increasing flexibility and reducing canteens' operational costs. The team selected compromised itself with a handful of quality tools and models with potential to be helpful for the completion of several project tasks.

The work was initiated by the definition of the Social Services' vision, followed by the formulation of strategic objectives, factors critical to success, indicators and action plans for each of the perspectives postulated by Kaplan and Norton (1992, 1996) in the Balanced Scorecard. Table 1 shows an extract of the Social Services' BSC, depicting objectives and indicators in what concerns canteen management. This work enabled a first, consistent approach to the analysis of the aspects that must be taken into consideration if canteen sustainability is to be achieved. It also enabled a first approach to the definition of important indicators, also known as KPI (key performance indicators) to measure the impact of the project activities. Because the BSC forced the team to think about four well defined perspectives, the KPI will measure how sustainable the organization is at the starting reference point and will be at the work's completion, thus enabling quick comparisons and determination of achievements.

Although a BSC indicates some directions that can be followed, it was important to carry out a SWOT analysis in order to highlight problems and pitfalls so that work definitions could take into consideration the IPVC strengths and weaknesses, as well as yhe surrounding threats and opportunities. The SWOT analysis highlighted the positive aspects of the co-operation between the IPVC Social Services and the Food Engineering Group, as well as the less favourable points faced by the IPVC canteens. The summary of this analysis is shown in Table 2.

Table 1: Extract of the balanced scorecard in what concerns canteens

Vision	We want to be known by the quality of our products and services, assuring na attractive ratio price/quality.			
perspectives	financial	client	Internal processes	Learning and development
objectives	To reduce operational costs and the cost of raw materials, while keeping labour costs constant	To be the main meal provider to students and staff; To increase food/service perceived quality	To reduce production costs; To increase process efficiency; To assure food safety	To take full profit of available scientific and technological capacity; To develop new solutions

Indicators	Operational results per worker; Total cost of meal; Cost of raw materials and average cost of staff per meal.	Number of meals served; Client's satisfaction in terms of food and service Time available for service.	Productivity per equipment; N. of meals per worker; Percentage of non-conformities.	N. of projects developed; N. of training sessions for canteen staff N. of new products launched per year

Table 2: SWOT analysis to canteens managed by the IPVC Social Services

Strengths	**Weaknesses**
Knowledge in the fields of hospitality and catering, on the processes of freezing, modified atmosphere packaging (MAP) and sous-vide cooking/preservation, and on analytical methodologies such as chemical, physical and sensory analysis, as well as consumer studies; Skills in the area of quality management; Leaders of IPVC Social Services and Food Engineering Group motivated for applied investigation and innovation; Clients are indoors.	Low attractiveness of canteen spaces, which are uncomfortable, seldom small and lacking flexibility; Low mobility of canteen workers, who show a great resistance to change and some fear of innovations; Geographical distribution of canteens throughout the region does not facilitate change of experiences and mutual support; Geographical distribution does not allow The budget for improvements is low.
Threats	**Opportunities**
Great competition among the many restaurants in the neighbourhood, serving low-cost meals; People tend to react negatively to the idea of having meals in canteens, preferring restaurants or snack-bars.	Low mobility of students; Schools far from city/village centres; Students need more spaces to be in school; Better spaces and better meals at school will help managing time.

The SWOT analysis showed that the renovation of canteen spaces could make them more attractive and flexible. Also, improvements in meal quality as well as in preservation of pre-cooked meals could help reorganizing canteens' operations.

As a consequence, two lines of work were implemented: renovation of infrastructures and improvements in meal processing and preservation.

Following the BSC and the SWOT analysis, it became obvious that a 6σ project seemed to be a good methodology to follow, given its structured steps from project definition to findings and conclusions.

RESULTS OF THE 6σ PROJECT

The 6σ model uses a methodology known as DMAIC, which refers to five phases of a project development, namely the define, measure, analyse, improve and control phases. These phases were conceived in order to make sure that all steps of a project are taken care of, without missing any important points. This phases will be described shortly in the next sections, giving the improve and control phases a little more space in sections 5.4 and 5.5.

Define phase. The phase *Define* of a 6σ project comprehends, at least, the following steps: (i) problem statements; (ii) goal statements; (iii) project definition (iv) and definition of key process indicators (KPI).

The problem statements. These were referred in the introduction and can be summarized as follows: (i) asymmetry of canteens in terms of number of meals at lunch and dinner time, throughout the year, and among canteens, with some being very small and not sustainable; (ii) lack of mobility of workers; (iii) traditional cooking and serving systems which do not allow easy improvements in meal and service quality; (iv) difficulties in creating links between canteens, due to great geographical distances.

Goal statements. These were put forward in the BSC shown in Table 1, and can be summarized as: (i) rationalize the working hours, trying to avoid peaks of high work load with intermediate periods with no work to be done; (ii) increase the offer, i.e., the number of different meals available at any time; (iii) concentrate production in the central canteen at the E.S.T.G.; (iv) increase clients satisfaction; (v) to assure the quality and safety of meals; (vi) reduce the costs per meal; (vii) increase the number of meals served throughout the year.

Project definition. The team responsible for the 6σ project defined the implementation of a continuous production system at the central canteen, and subsequent preservation for at least one week. The preserved meals should be distributed to all other canteens. Possible preservation was to be assayed were freezing, vacuum packaging, and refrigeration coupled to the process known as MAP (modified atmosphere packaging).

Defectives. Any meal would be considered as defective if rejected by sensory experts (if classified with 1 to 3 on a 5 point scale in any of the following 5 parameters: aspect, texture, taste, odor and temperature), by consumers (if more than 10% of inquired people attributes less that 4 on a 9 point hedonic scale), by microbiological analysis (if any parameter exceeds recommended levels), by gas analysis (if gas inside packages approaches air composition).

Key process indicators. These were defined in the BSC (Table 1) for financial purposes, although at this define phase, they are merely indicative. The final financial KPI were: (1) total cost of personnel; (2) total cost of raw materials; (3) total number of meals; (4) cost of raw materials per meal; (5) average cost of personnel per meal; (6) and number of meals per student. KPI for meals and service were defined as: (i) the percentage of rejected meals (percentage of defectives); (ii) the global clients satisfaction, including friendliness, hygiene, quickness and perceived meal quality.

Although results are not shown, the team used the RACI matrix, the Gantt diagram and the SIPOC analysis as tools to help organizing the work to be carried out.

Measure phase. In phase *Measure*, data important for financial purposes was collected in relation to year 2009, and sensory experts and food technologists analyzed aspects of meals to determine the number of defectives. In this way a reference situation was built.

Analyse phase. In phase *Analyse* each canteen, as well as the overall situation, were typified in terms of operational costs, meal quality, global clients satisfaction, amount of wasted food and consumer acceptability. A general picture of the Social Services and all problems related to canteens was obtained, creating a good reference point. Data is not shown at this point, but will be incorporated in the following discussions and data tables related to phases improve and control.

Improve phase. Following the define phase, the improve phase was devoted to the analysis of several preservation systems for pre-cooked meals, aiming at rationalizing raw material utilization, processing operations and personnel needs, and to the scale up of the best solution, having as background the data obtained in the measure and analyze phases for comparison purposes.

Initial stages of development

Several meals were prepared by the canteen cooks. For each meal, the procedure was as follows: (i) small portions were put in small plastic containers and immediately refrigerated to 2°C; (ii) all portions were transported to the laboratory; (iii) some portions were frozen to a temperature lower than -18°C; (iv) some portions were packed under vacuum and kept at 2°C; (v) some were packed in three types of modified atmospheres, i.e., 40% CO_2 and 60% N_2, 50% CO_2 and 50% N_2, 60% CO_2 and 40% N_2, all of which were also kept at 2°C. All containers were closed with a plastic film with low permeability to CO_2.

Seven days later, all samples returned to the canteen kitchen where they were regenerated and tasted by a panel of 10 experienced sensory judges. Meals freshly cooked were also tasted, to serve as controls.

As shown in Figure 1, the attribute list used by sensory judges was adapted from the scoring method stipulated in the IDF Standard 99C (1997): it contained four attribute classes: aspect, aroma, texture, taste (when used for experts) and a fifth one, temperature, when used for canteen clients. For each attribute a scale with 5 categories was provided. Judges should rate a 4 or a 5 if no problem was detected. In case of any problem being detected, judges should rate the attribute with a 1, 2 or 3, and write down the problem detected. All samples were also analysed in simple microbiological and chemical terms (total microbiological counts at 30°C and acidity, respectively). The gas composition inside packages was also monitored.

The results obtained showed that meals with greasy sauces sometimes developed off-flavours when in MAP and could not withstand their typical texture upon freezing or under vacuum. Soft foods saw their texture dramatically altered by vacuum packaging. All other meals were found to be undistinguishable from freshly cooked ones, irrespective of the preservation method used. No differences were found in microbiological and chemical terms.

As a consequence, it was decided to avoid greasy sauces. Since no noticeable differences due to preservation techniques were identified, the cheapest one was chosen as the preservation technique. Freezing and regeneration of meals is expensive because energy consumption is very high and is also very time consuming. Among the modified atmospheres, the higher the CO_2 content, the more expensive the atmosphere is. Therefore, packaging in 40% CO2 and 60% N_2 coupled with storage at 2°C was the chosen as the preservation technique.

attribute	presence of a defect			no defect present		if a defect is present, identify the defect in this space
	extreme	big	small	good	excelent	
aspect	1	2	3	4	5	
aroma	1	2	3	4	5	
texture	1	2	3	4	5	
taste	1	2	3	4	5	
* temperature	1	2	3	4	5	

Figure 1: List of attributes used for sensory judges and consumers

Scale up

The canteen kitchen was equipped with a new vacuum packaging machine, two gas cylinders filled with the mixture 40% CO_2 and 60% N_2, and a new blast chiller with capacity for ten GN1/1 gastronomic trays. With this equipment it was possible to refrigerate and pack with the desired atmosphere between

150 and 200 individual portions in about 1.5 hours. Therefore, the capacity to produce preserved meals was set to around 1000 individual portions in just 8 hours working.

Several meals were produced and preserved in this way and transported to several of the IPVC canteens, where they were kept refrigerated at 2°C for seven days, after which they were tasted and analysed.

A set of analyses were used to monitor the whole process: atmospheres inside packages were analysed with a portable gas analyser purchased for this purpose; comprehensive microbiological analyses were carried out; sensory judges evaluated meals following the same method as described for the initial studies; consumers also analysed meals according to the same parameters as the ones used by sensory judges, and also evaluated serving/eating temperature as explained before (Figure 1).

The results showed that the preservation technique was very good, producing meals that could not be distinguished from freshly cooked meals. However, some problems were found that needed attention: (i) gas analysis demonstrated that some packages had an atmosphere close to air, losing the CO_2 protective effect, meaning that the plastic films had lost their integrity; (ii) in all such packages microbiological results showed that meals were not fit for consumption; (iii) some packages were in proper condition, but microbiological analysis demonstrated that some contamination was taking place, and this was accompanied by an increase in the CO_2 percentage inside packages; (iv) students complained about the meal temperature, which was quite often found to be extremely cold.

Final adjustments

Many of the problems just referred were the result of the scale up. The beginning of the work, including all the preservation steps, was carried out and controlled in the food laboratories. In the scale up phase, all operations were carried out at the canteen facilities with different equipments, workers, containers, etc., and the fluxogram was also adapted to this new situation. These alterations justify the problems encountered.

In order to solve these problems, the food engineering team decided that a comprehensive analysis of the process was necessary and a FMEA (failure mode and effects analysis) was carried out.

The FMEA (results not presented) showed the existence of possible problems related to packaging. Mainly, it showed that some containers (gastronomic trays) had small cutting edges ripping the plastic films during handling, therefore being responsible for the loss of package integrity. These containers where put aside, a stronger plastic film was used, and workers were instructed to handle packages with care in order to avoid problems during normal handling and transportation.

FMEA also enabled to observed that there were too many opportunities for problems depending on the way operations were conducted. Sometimes, meals that were not consumed during lunch or dinner time, were used for preservation, a fact that cannot be allowed, since for preservation it is crucial to cook meals with high temperatures, and chill them quickly afterwards, in order to reduce the chance for microbial growth. These meals systematically showed an increase in CO_2 percentage. A training program was set up in order to guarantee that canteen workers understood the need to take special care when cooking is being carried out for preservation purposes.

An important practical conclusion derived from the FMEA analysis was that whenever there was a problem related to package integrity or to bad cooking/preservation practices, the CO_2 level inside the package decreased or increased, respectively. This fact showed that gas analysis inside packages was a good indicator of the preservation conditions, and could be used to quickly assess if a preserved meal is in proper conditions to be consumed or not.

To try to solve the low temperature of meals, the water bath temperature was identified as the only variable that could be controlled, and was increased to around 85°C.

Control phase. After the introduction of all changes implemented in the last part of the improve phase, the canteen started producing meals for preservation purposes on a regular basis. Meals were produced in the central canteen (located at E.S.T.G.), and transported to all other canteens where they were stored at 2°C until consumption. The maximum time allowed between production and consumption was seven days.

Initially, several meals were produced and controlled by sensory analysis, consumer analysis, detailed microbiological analysis, and analysis of gas composition inside packages. Meals subjected to all these analysis were: roasted chicken with potato and rice, roasted redfish with potato, meat in laurel spit with potato and rice, roasted pork with rice, and stewed veal with rice. All meal components were analyzed separately for microbiological hazards at 7 and 15 days after production.

The consumer results are shown in Figure 2. More than 100 answers were obtained, showing that consumers classified aspect, aroma, taste and texture with a 4 (the mode of the distributions of answers), i.e., as good with no defects detected, exception made for temperature (indicated as "temp" in figure 2), where more than fifty percent of the consumers considered the meal temperature as not good. Some negative marks given by a few consumers for texture and taste reflect a problem with potatoes, an opinion that was in agreement with the sensory judges opinions using the same attribute list.

The analysis of gases prior to opening the packages, as shown in Table 3, demonstrated that all gases exist in the expected percentages, with the exception of two packages with potatoes, which showed a low CO_2 and high O_2 percentages, demonstrating that possibly the initial atmosphere was not correctly administrated. This fact was attributed to a sporadic problem with the initial vacuum before administration of the CO_2/N_2 gas mixture.

The comprehensive microbiological analysis (Table 4), evaluating individual meal components at 7 and 15 days after production, showed that all meals were stable, with all values bellow the recommended limits. It is evident that the preservation process is quite effective, assuring microbiological quality.

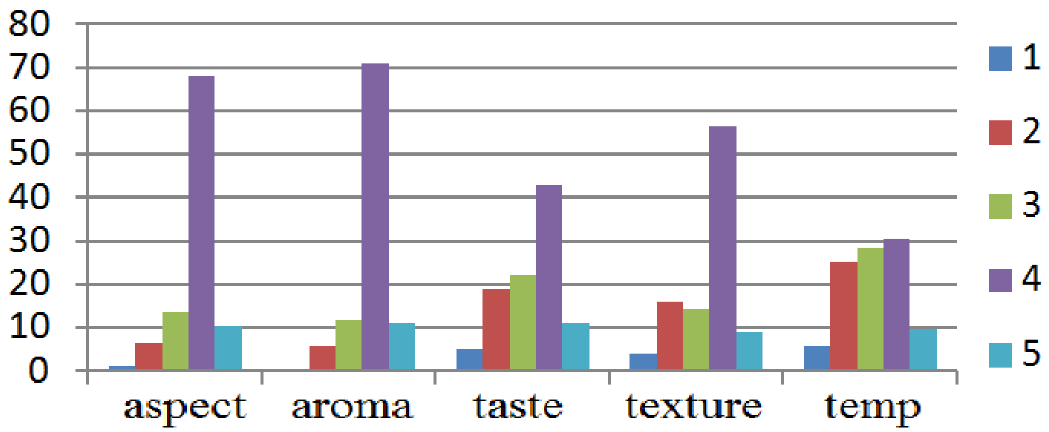

Figure 2: Evaluation of meals by consumers

Using the proposed indicators just referred for the perceived quality of meals, about 60% of the meals would be rejected by consumers due to meal temperature problems, showing that there is an opportunity to keep on working in order to improve this important point.

Sensory judges rejected two out of sixteen products (due to problems with potatoes), representing a 16.6% rejection level. The same level of rejections would be due to gas analysis due to the deficient atmosphere in potato packages.

No rejections would be made on the basis of microbiological control. This means that rejections were made on the basis of perceived quality (by consumers and sensory judges) and on the basis of gas analysis, but not on the basis of microbiological grounds,. Therefore hygiene and safety were assured.

Table 3 : Results for control of gases inside packages

Meal	ingredient	N_2	O_2	CO_2
Roasted chicken, potato and rice	potato	77,41	0,2	22,4
	rice	74,34	0,31	25,35
	chicken	76,55	0,2	23,25
Roasted redfish with potato	fish	78,64	0,29	21,07
	potato	78,13	12,7	9,17
Meat spit, potato and rice	spit (meat)	73,68	0,08	26,23
	rice	75,92	0,35	23,73
	potato	78,13	12,7	9,17
Roasted pork with rice	pork	78,64	0,29	21,07
	rice	75,92	0,35	23,73
Stewed veal with rice	veal	76,37	0,23	23,4
	rice	75,83	0,24	23,93

Table 4 : Results for detailed microbiological control

meal	time	1	2	3	4	5	6	7	8	9
		cfu/g	cfu/g	cfu/g		cfu/g	cfu/g	cfu/g	cfu/g	cfu/g
Roasted chicken, potato and rice	T0	$1{,}1x10^2$	<10	<10	ND	<10	<10	<10	<10	<10
	T1	$8{,}9x10^2$	<10	<10	ND	<10	<10	<10	<10	<10
Roasted redfish with potato	T0	$4{,}2x10^4$	<10	<10	ND	<10	<10	<10	<10	<10
	T1	$1{,}2x10^3$	$1{,}0x10^2$	<10	ND	<10	<10	<10	<10	<10
Meat spit, potato and rice	T0	$1{,}2x10^3$	<10	<10	ND	<10	<10	<10	<10	<10
	T1	$2{,}6x10^2$	$1{,}6x10^2$	<10	ND	<10	<10	<10	<10	<10
Roasted pork with rice	T0	$1{,}8x10^4$	<10	<10	ND	<10	<10	<10	<10	<10
	T1	$9{,}0x10^4$	<10	<10	ND	<10	<10	<10	<10	<10
Stewed veal with rice	T0	$2{,}8x10^4$	<10	<10	ND	<10	<10	<10	<10	<10
	T1	$2{,}9x10^4$	$1{,}0x10^2$	<10	ND	<10	<10	$1{,}4x10^2$	<10	<10

Legend:
1 mesophiles at 30°C
2 coliforms
3 *Escherichia coli* β-glucuronidase+
ND = not detected
4 *Salmonella*
5 Stafilococos coagulase +
6 Sulphite-reducing *Clostridium* spores
T0 = 7 days in storage
7 moulds and yeasts
8 *Bacillus cereus*
9 *Listeria monocytogenes*
T1 = 15 days in storage

One of the main purposes of this work was to increase the satisfaction of the IPVC canteens' clients, in terms of food quality and service quality. The project started in 2009 and data available for the period 2009 – 2013, in what concerns global satisfaction, is shown in Table 5. This table shows the results of the client's opinions in relation to service and meal quality, per school and per year. It can be seen that in almost all criteria there is a steady state or an increase in satisfaction. Taking into consideration that profound changes were operated, the global result were considered as very good.

Another important goal was to improve meal and service quality but, simultaneously, improve the financial canteen aspects in order to approach sustainability. The major indicators are shown in Table 6, comparing data before the project start (2009 was the reference year) and data from 2013 (the last available data). It is evident that all changes introduced in service and meals were accompanied by a considerable improvement in financial indicators. Mainly, the total costs of personnel had a small reduction while the costs of raw materials increased around 9%. However, there was over 25% increase in the number of meals served. Consequently, there was a global reduction of the average unitary cost of meals equal to around 50 cents per individual portion, which corresponds to a global reduction equal to roughly 42.500€ just in year 2013.

Table 5: perceived quality of food and service

Sites	Items under evaluation	2013		Evaluation 2012	Evaluation 2011	Evaluation 2010	Evaluation 2009
		N answers	Evaluation				
A.C. (Academic Centre)	1, Service:	-	-	-	-	-	-
	1.1. Friendliness	52	3,75	3,62	3,60	3,35	
	1.2. Hygiene	52	3,50	3,24	3,50	3,09	
	1.3. Quickness	52	3,33	3,17	2,33	2,85	
	2, Meal:	-	-	-	-	-	-
	2.1. Quality	52	2,85	3,10	3,20	3,02	
	Total	**-**	**3,36**	**3,28**	**3,16**	**3,08**	
E.S.E (Superior Schoo lof Education)	1, Service:	-	-	-	-	-	-
	1.1. Friendliness	126	3,44	2,76	2,98	2,87	3,41
	1.2. Hygiene	126	3,26	3,13	3,12	2,79	3,23
	1.3. Quickness	126	2,77	2,22	2,70	2,13	2,67
	2, Meal:	-	-	-	-	-	-
	2.1. Quality	126	2,64	2,43	2,80	2,13	2,90
	Total	**-**	**3,03**	**2,64**	**2,90**	**2,48**	**3,05**
E.S.A. (School of Agriculture)	1, Service:	-	-	-	-	-	-
	1.1. Friendliness	54	2,83	2,83	3,46	3,34	3,24
	1.2. Hygiene	55	2,73	2,72	3,35	3,12	3,13
	1.3. Quickness	54	2,67	2,67	3,19	2,82	2,68
	2, Meal:	-	-	-	-	-	-
	2.1. Quality	55	2,73	2,72	3,19	3,20	2,89
	Total	**-**	**2,74**	**2,74**	**3,30**	**3,12**	**2,99**
E.S.T.G. (School of Technology & Management)	1, Service:	-	-	-	-	-	-
	1.1. Friendliness	96	3,26	3,26	3,15	2,78	3,16
	1.2. Hygiene	96	3,10	3,10	3,11	2,58	2,53
	1.3. Quickness	95	2,62	2,62	2,76	2,47	2,18
	2, Meal:	-	-	-	-	-	-
	2.1. Quality	95	2,85	2,85	2,86	2,68	2,54
	Total	-	2,96	**2,96**	**2,97**	**2,63**	**2,60**
E.S.S.	1, Service:	-	-	-	-	-	-
	1.1. Friendliness	22	3,86	3,86	3,53	3,74	2,93
	1.2. Hygiene	22	3,68	3,68	3,11	3,76	3,14
	1.3. Quickness	21	3,29	3,29	2,70	3,24	2,55
	2, Meal:	-	-	-	-	-	-
	2.1. Quality	22	3,05	3,29	2,52	3,21	2,20
	Total	-	3,47	**3,47**	**2,95**	**3,48**	**2,71**
E.S.C.E. (School of Economical Sciences)	1, Service:	-	-	-	-	-	-
	1.1. Friendliness	19	4,00	4,00	3,77	3,72	3,61
	1.2. Hygiene	20	3,70	3,70	3,65	3,50	3,26
	1.3. Quickness	20	3,50	3,50	3,32	3,17	2,74
	2, Meal:	-	-	-	-	-	-
	2.1. Quality	20	3,30	3,30	3,15	3,00	3,08
	Total	-	3,62	**3,62**	**3,48**	**3,35**	**3,17**
Canteen Totals	1, Service:	**-**	**-**	**-**	**-**	**-**	**-**
	1.1. Friendliness	**369**	**3,40**	**3,23**	**3,26**	**3,33**	**3,24**
	1.2. Hygiene	**371**	**3,22**	**3,14**	**3,20**	**3,20**	**2,97**
	1.3. Quickness	**368**	**2,86**	**2,74**	**2,77**	**2,84**	**2,50**
	2, Meal:	**-**	**-**	**-**	**-**	**-**	**-**
	2.1. Quality	**370**	**2,80**	**2,83**	**2,88**	**2,97**	**2,68**
	a.s. index:	**-**	**3,07**	**2,98**	**3,03**	**3,08**	**2,85**

Legend: all values reflect the averages of answers given by canteens' clients, using a 5 point scale with 1 = poor, 2 = average, 3 = good, 4 =very good and 5 = excellent.

Table 6: Main financial key process indicators (KPI)

Management data	2009	2013
total cost of personnel	94.297,21 €	94.034,00 €
total cost of raw materials	105.643,23 €	114.699,00 €
total number of meals	67.368	84.961
cost of raw materials per meal	1,57 €	1,35 €
average cost of personnel per meal	1,40 €	1,11 €
number of meals per student	23,23	26,55

CONCLUSIONS

Although the work herein reported was carried out in a public institution, it is shown that it is difficult, but possible, to improve the way the work is carried out, providing all important intervenients are available and compromised in special projects.

It is shown that it is very important to adhere to quality models and tools, in order to achieve the best results with a minimum effort. Specially, these models and tools help focusing in the main issues, turning the work and the projects more effective and efficient.

In this work a 6σ project was defined and taken forward. However, as it was observed in the improve phase, several changes had to be made, and problems in the scale up phase were met. As a consequence, the project took around four years, while a 6σ project typically should last no longer than 6 months. This happens whenever a 6σ project is started without previous works solving common problems. In other words, this 6σ project had two parts: a first part where evident, common problems were found and solved, and a second part, corresponding to a real 6σ methodology, where solutions to specific problems were found and implemented.

The KPI enabled to identify and measure the improvements of the project. Although these KPI are usually characterized in the define phase of the DMAIC method, using an initial Balanced Scorecard was helpful to guarantee that the main canteen perspectives were taken into consideration.

The 25% increase in the number of meals served compares favourably with all other similar institutions in the country where a decrease is being observed during the last years. This increase, being achieved simultaneously with a change in the processes which always carries out some disturbances, and in a time of crisis, is a very promising outcome of the project. Financial data shows that canteen operations can be sustainable in the near future. A follow up is now being carried out with encouraging results.

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Manufacture Optimization with the creation of the Method Quality Execution Systems: Fusion of the systems SCADA, E.R.P AND M.E.S and use of basic quality tools

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ABSTRACT

Most manufacturing companies have systems that are able to assist in the decision taking in the whole strategic scale. The system operation is valid when there's direct action on the problem resolution. Efficient systems that reproduce a manufacturing operation structure productive indicators or integrate different areas of the productive sector that can develop process improvement when analyzed in a whole, all together. Quality tools can assist decision taking from the resources generated through this information integration. This paper carries a proposal of creating a new methodology that absorbs the integration information of SCADA, MES and E.R.P systems, transforming the strategic decisions in production optimization through some basic quality tools.

Keywords: Quality tools, M.E.S., SCADA, E.R.P., Optimisation

Article Classification: Case study

INTRODUCTION

In the current market competitiveness, it is highly important that managers, supporters and operation make correct decisions. Often, these decisions have a great impact in a company's result, raising the level of importance in the composition of the data provided for these decisions. Kletti, Jurgen (2007) affirms that classic factories, where products are mainly valued for it components, have given way to modern service centres that face a new challenge of production: continually adapt to market demands. In manufacturing companies, whether discrete or continuous, the information about products in process, produced, or even issued to its costumers are required to obtain a variety of data and indicators. Productivity, rework of products, product variable costs, inventories (measured by the accuracy), compliance to the master production plan, loss in the process and product are some indicators that could be measured from the factory operation to the top managers, which will enable more assertiveness on the findings and definitions of strategies for continues improvement of the process, enhancing its production. The ERP (Enterprise Resource Planning), the M.E.S. (Manufacturing Execution Systems) and the SCADA system (Supervisory Control and Data Acquisition), when used together, will give to the company the perspective of what really happens in the operations and will allow greater alignment between strategic, tactical and operational levels, besides being able to expand these benefits to the entire supply chain (MARDEGAN, AZEVEDO and OLIVEIRA, 2002). However, despite a company have access to plenty of information in a short time due to the application of the lean manufacturing principles, the use of this content becomes irrelevant and unproductive if methods of solving problems are not addressed. Information will be generated for the improvement of processes and important decision-makings, however, without an effective driver for the continuous improvement of production. Basic Quality Tools can solve the equation, which used to be described for the information systems. It holds the role for stratify, identify the chronic anomaly, study it and propose actions to eliminate the main cause of the problems. Any deviation from normal operating conditions is considered as an anomaly and requires a corrective action (FALCONI, 2011). This article proposes a development for a method of decision-making, based on the fusion of three unidirectional systems (SCADA, MES and ERP) and the Quality Tools, drivers to the continuous improvement of productive systems and foment the efficiency of problems solving.

JUSTIFICATION

The available information are frequently constituted by data from diverse precision ratings: some are known for sure, other are estimated carefully and, finally, there are data which the accuracy is not good enough (MOREIRA, 1993). Even if there are loads of accurate and available data, with no guideline or direction of how to treat them, the amount of information would worth only as a database. These databases can be accessed in industries, service companies and consultancies inside programs or systems. Many areas need these data to develop its routines and apply improvements in its processes constantly. Whether it is MCP (Manufacturing Controlling and Planning) sector, by developing production master plan based on the database from the year before, aiming the material, machinery, workforce and supply management (RIBAS, BRAMBILLA, FERNANDES JR., 2010); the Quality sector, by verifying the historical series of a machine in order to proceed a PEC (Processes Statistic Control), with the three main ingredients: statistics techniques, problem solving techniques, leaderships/attitudes for improvement of productivity and quality, quality and systematic methods management (HRADESKY, 1989); the Maintenance sector, with its measures of reliability, that direct the best machine and the machine with the highest number of failures (FLOGLLIATO and RIBEIRO, 2009). Many are the areas that manage these information in order to improve the decision making. And, according to Moreira's (1993) description, despite the fact that each decision problem has its own specificity character, it is possible to gather common elements to all decision problems. In other words, there are operational management systems, process control and area integration, such as SCADA, M.E.S and ERP, respectively, that work as information integrator to get to know the problems and make people able to treat them.

The majority of the companies do only gather information and do not utilise the focused on the problems resolution. There is this deficiency in many enterprises, that limit the reasons analysis only with the PDCA cycles, generating actions that usually are premature and fundament less. The fabrication process can be visualised as a group of variation causes. These causes lead the changes in the various characteristics of product quality, what may give rise to defective products (WERKEMA, 1995). The start-up of analysis begin in the operations (Gemba for Kaizen) and need to achieve a dimension of continuous improvement. Elaborating this new method will bring a wider vision of what to treat and how to do it, and, leaving from the 5W2H sphere, of how to improve the process and/or product from accurate and given in real time data.

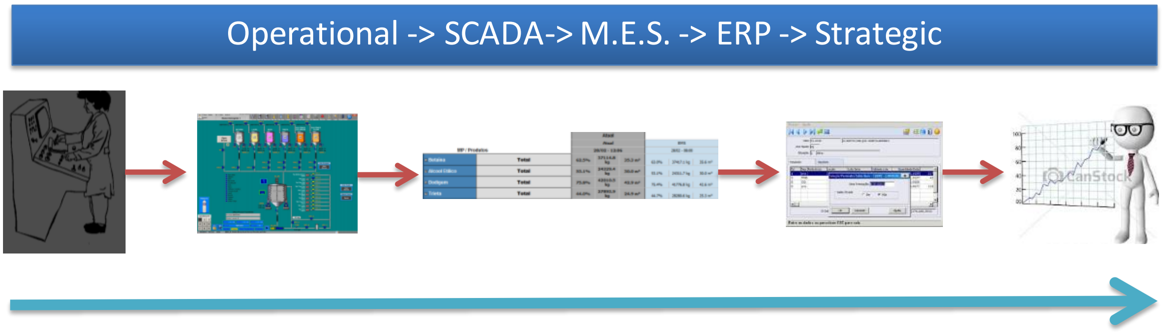
THE QUALITY TOOLS

The quality of a product could be defined through variables, attributes, or a combination of both (MOREIRA, 1993). From this theory, it comes the requirement that a product or process fits in the requirements determined by the company. To reach these standards, the Quality Tools are used different moments. According to Carpinetti (2010), the Quality Tools are Stratification, Sheet Verification, Pareto Chart, Cause and Effect Diagram, Histogram, Diagram of Dispersion and Control Chart. The Quality Tools are used to collect, synthesize and analyse data (quantitative and qualitative), on the other hand, the basic techniques such as brainstorming, 5 Whys, affinity diagrams, 5S, 3Mu, 5W1H and 6M are used to help the members of the Circle of Quality of Control to think creatively (TOYOTA, 2008). There are many others Quality Tools used in different companies, such as the PDCA Cycle. According to Falconi (2011), this tool is considered as a model of management for problem solving.

Quality tools should work as activities where the improvement follows the resolution of problems of products and processes. Also, it should not have only corrective actions from the analysis carried out by working groups, Kaisen, DFMEA (Design Failure Modes and Effects Analysis) or TPM (Total Productive Maintenance). It is hoped that the problems identified with this methodologies do not occur with the preventive actions that will be addressed and implemented. This reality becomes increasingly incipient, due to the inaccurate information, misleading analysis or even operational inefficiency. Without real information, the tools will not follow an objective way for the resolutions of problems and anomalies.

UNIDIRECTIONAL COLLECTION AND DISTRIBUTION OF DATA

The flow of information has a unique way, in which its distribution depends on the focus that the manufacture exerts on its products. The operations electronic data collection, that happens in the operations sector of a company, can be done through the utilisation of sensors (digital and analogic), which are monitored by software SCADA, and the data transferring is done by a Fieldbus network type by matching the sensors that can be linked to various machines in the operations or to the data collectors (MELLO, CREADO JR., OLIVEIRA, BREMER, 2010). These information are collected to the M.E.S System, that identifies all the data and transform them into management computerization, applicable to a Analyst, for example. From these data, ERA performs a control and an integration between what was generated by M.E.S and what the other manufacture associated areas can directly interfere in its processes and vice versa. This brings to the manufacture manager, for example, a wider view above the processes of each production line, of each sector, of each product. The “whole” is seen to important decision-makings. If this integration is not correctly performed (even with accurate data), the largest objective of a company might suffer retractions: expediting products with high costs, higher lead times and weak process management. It is needed a clear understanding of the tools in order to correct where there are gaps and implement the strategies to improve associated to Quality.

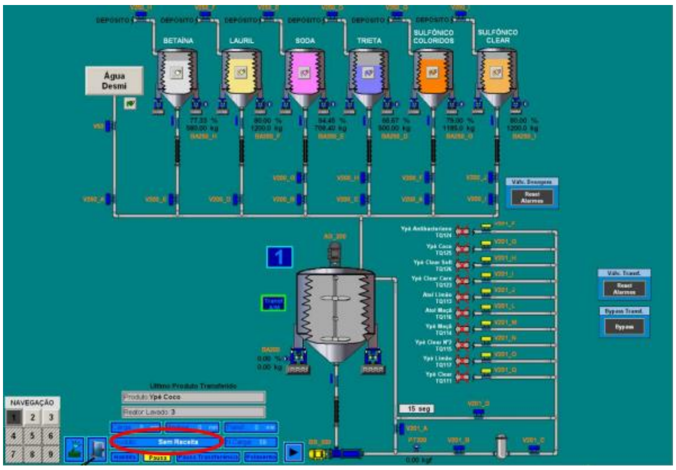


Picture 1: Scheme of the unidirectional data flow generated in the manufacture

Source: authors, 2014

Starting from this flow, the operational can be better understood and how the information reach the company strategically.

SCADA System. Silva and Salvador (2005) bring an actual concept of the SCADA System, in which the supervisory systems allow productive process or physical installation information to be monitored and tracked. Such information are collected through data acquiring equipment and, on the following, manipulated, analysed, stored and later, presented to the user.

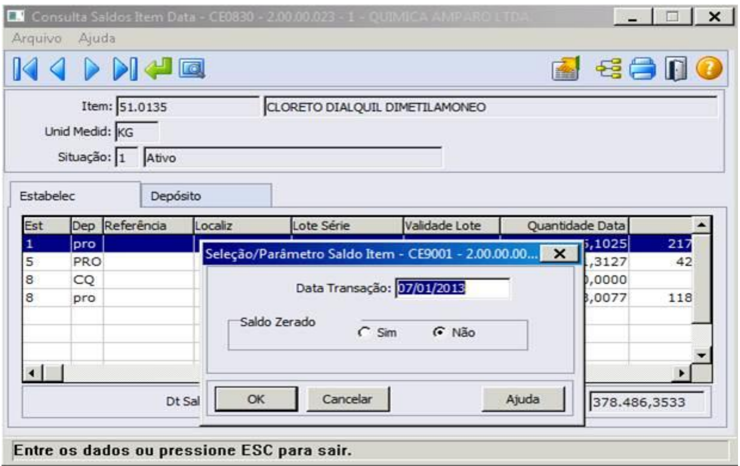


Picture 2: SCADA System supervisory system representation

Source: authors (adapted, 2014)

The information originating from various sensors and collectors that aim a higher precision in the capitation of data and insertions of these in the system. SCADA transforms these data in visual information, to instantaneous consults of what is happening in the operations. The collected data can be stored in a database, keeping available to other systems such as M.E.S and ERP (MARDEGAN, MARTINS, OLIVEIRA, 2003). Starting from these concepts, the manufacture has its information start up in SCADA, which characterizes the process in times, operation, quantities, batches number, etc. Such information are critical to the optimisation and customisation of products to be manufactured.

ERP. According to Cunha (1998), the ERP solution (Enterprise Resource Planning), represents an evolution of the MRP TI (Manufacturing Resource Planning) functionalities, incorporating important requirements of quality, maintenance, logistics, marketing, services and supplies. The MRP TI, on the other hand, means an evolution of MRP (Material Requirements Planning).

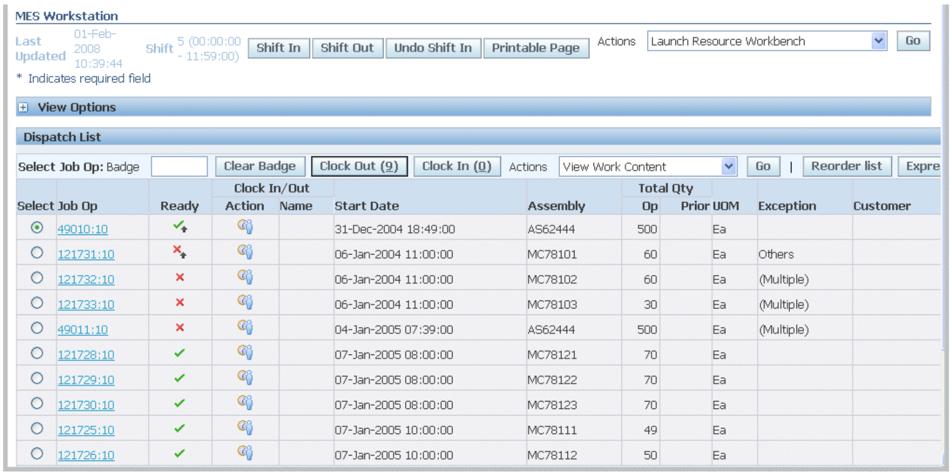


Picture 3: Data generated by the ERP system research representation

Source: authors (adapted E-MS, 2014)

Even if there is an integration between the areas (main purpose of ERP), the diffusion of these data becomes essential in the manufacture and later decision makings by managers. Freitas (2001) describes that, although ERP systems are excellent instruments in companies' operational activities support, these systems are weakened when its users need to take consolidated or strategic information of. Due to it, the difficult in directing the data and transforming them into decisions or improvements. The integration between the systems could be the first step to this strategic direction and better manufacture performance.

The M.E.S And Its Aplicability. According to Corrêa (1997), a M.E.S (Manufacturing Execution Systems) system collects and accumulates information of what was realised in the operations sector and feeds them back for the planning system. It has a direct interface with the SCADA system and may, as operational demands arise, possess the interface with the majority of the ERP systems available in the market. Its platform and layout describe the best visualisation of data when compared to the other two systems (SCADA and ERP), not taking off, however, the importance of these in decision making.

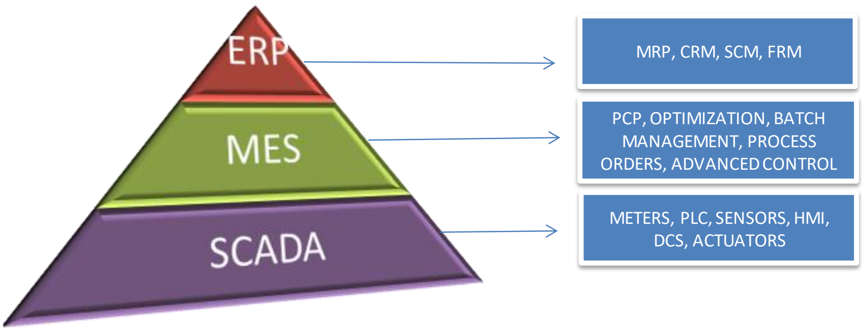


Picture 4: Discrete and continuous processes M.E.S general view.

The historical basis that M.E.S. provides through series graphs, real time mass balances, inputs and outputs of raw material, makes the system enriching in the processor-assisted manufacturing. For that, the sensors and data collectors precision should be in its correct set point, therefore wrong collections generate skewed and undesirable results.

APLICATION OF THE DEVELOPTED METHOD *QUALITY MANUFACTURING SYSTEMS* IN A MANUFACTURING INDUSTRY

The traditional model of Systems integration. The current scheme of the fusion of these systems, and its integrations in the current literature, exists in pyramid shape, in which's base concentrates the SCADA system, with its collectors and process viewers. Followed by the M.E.S. System with its process control information and then by the ERP system, for the visualisation of bulk cargo balance, accounting, manufactures, stocks, etc., as it is shown below:



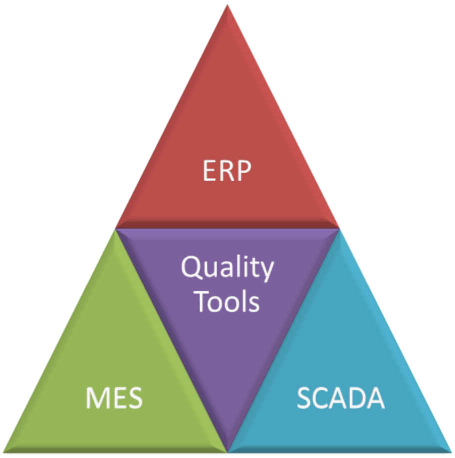
Picture 5: Current integration of tools in order of process

Source: the authors (2014)

This model reflects considerable advances, because there is uniformity and direction to where the information generates value. It also proposes which sector should have an information, which data must be integrated on the three systems and what are the main processes in which the top managers and the coordination level should be aware, to control and ensure that its process occur according to the Guidelines Management of the company. However, the provision of data is not enough for an effective decision-making. The manufacturing analysis should not be realized in parallel with the provision of data from the ERP, M.E.S and SCADA systems, but integrated to them, as to generate real data for the decision-making.

The proposed model: Quality Execution Systems. The efficiency of this process will be given by the application of basic management models Quality Tools, generating then the Quality Execution System method. For being a new decision making data management model, it should be pointed out and described its performance, mapping, layout and main results that can be acquired in applications in manufacture and in other service sectors such as banks.

The model should have the format conforming to the pyramid shown down:



Picture 6: Proposal of new model: Quality Execution Systems (Q.E.S.)

Source: the authors (2014)

The main tools to be utilised in this new method will be described by Tague (2004), who describes the seven basic tools: Cause and effect diagram, Verification Sheet, Control Graphs, Histogram, Pareto Chat, Dispersion and Stratification Diagram.

Case Study: Increase of productivity of discrete manufacturing

Current situation: Productivity of 53%. Company's target: 85%

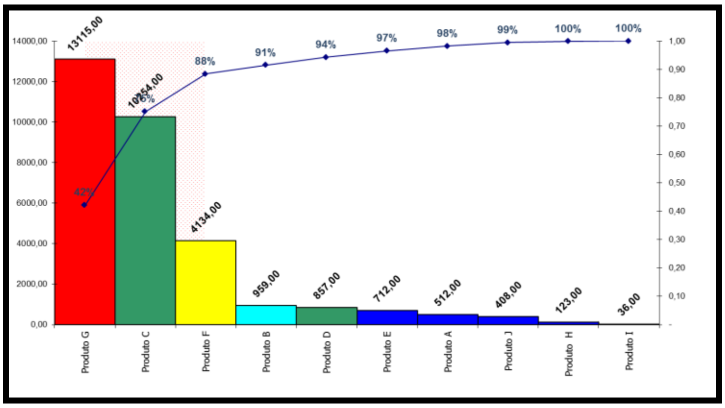
1st Step: Data collection – Done primarily by the SCADA system and directed to the M.E.S. Collected data of inventory and processes levels.

2nd Step: Reading of the data collected through M.E.S – Only bring some of the possible problems of not achieving the target of productivity. Also, combines the inventory management accomplished by the PCP, as a way of not missing row material and finished products.

3rd Step: Descriptions generated by the ERP system – Involves what M.E.S generated in the system and its integration with the others sectors, such as Quality, Logistics, Maintenance. This reading become essential due to the occurrences in Quality breaks corrected by the Maintenance and production driven by the Logistics.

4th Step: The use of Quality Tools in obtaining the main causes for not reaching the required productivity. – Following the order of some tools, it is described the ones considered as the most important for this analysis:

- Through the M.E.S, time series were removed, and placed in control charts to verify which days, hours and operators executed the production with detours of raw material, lead time out of the pattern and occurrences in Quality (defective raw material and finished product out of the specification). It was also covered the operational tokens to track possible occurrences that can influence in the productivity indicator.
- After mapping, the Pareto Diagram was used (80/20) to deploy the possible causes in 80% of the occurrences and 20% of effort, that will not be studied.



Picture 6: Pareto chart as exemplifying the methodology

Source: the authors (2014)

- The occurrences described in the 80% were analysed more succinctly with the cause and effect diagram, histogram, and dispersion and stratification diagram. These analysis shows that the real problems that this productive sector suffered and will be critical information for operational decision making, analytical, coordination and managements.

The productivity results were increasing in the first months, but did not reach the target immediately. The continuing uses of tools, allied to the data generated by the integration of the three systems were the main factors for the solid achievement of this indicator. With the control of the main known causes, the foundation of the numbers did not came in e do not go down.

CONCLUSION

The elaboration of a new method is a consequence of not only the innovation needed and demanded by the market, but to the companies' real needs promoted by its employees, methods that bring results both satisfactory and consolidated. There is no ideal method, or a perfect one, however there are methods that adapt to different types of production, manufacture, processes, etc. A same method could fit for two different companies, but could not fit for third company. The perspective of how to utilise is a sensible analysis and essential in obtaining improvements.

The Quality Execution Systems for big processes in manufacture becomes an adequate process and equivalent in maintaining the results of these processes. Productivity growth, stocks and machinery maintainability are a few possible measurements to be treated by this new method. There is a big study to be realised with more details, to indeed proceed with great projects, which would make viable best results. The process and product customisation and optimisation would be achieved with more earnings and the enlargement of the company's competitiveness in the market.

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Analysis of experiences on Quality Management Systems in Spain: Background and statistical trends

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ABSTRACT

Purpose. This paper seeks to explore the background and the general knowledge of Quality Management System (QMS) in Spain in addition to present the trend and the existing programs for the establishment of QMS across Spanish industries.

Design/Methodology/Approach. The data collection process related to the background of QMS in Spain was done through an exhaustive search of the databases of the past and existing certification bodies as well as the national government database and the EU existing programs for the establishment of QMS. The data collection related to the ISO 9001, 14001, 18001, 27001 etc. yearly number of certification was drawn from the ISO database.

Findings. The QMS in Spain started in 1945 and had its root with the Instituto de Racionalización y Normalización (IRANOR). However, the first certification was granted four decades after that. Ever since, the number of certified companies has grown in an exponential way. This study also observed that, some employees are already knowledge before getting the job. Mainly because, there are some official Master Degrees and Doctorate programs that offer taught courses on QMS. Furthermore, numerous organizations are also offering training programs to their employees in addition to accreditation bodies. This study also observed there are various programs in Spain related to the establishment of QMS in different industries set by the government and the EU.

Originality/value. This paper is the first in field QMS to analyze the existing programs for the establishment of QMS across Spanish industries.

Key words: Quality Management System, ISO 9001, ISO 14001, ISO 18001, ISO 27001

Article classification: General review

BACKGROUND OF QMS IN SPAIN

The history of Spanish standardization work started in 1945 by a public entity called the Instituto de Racionalización y Normalización (IRANOR) under the supervision of Centro Superior de Investigaciones Científicas. Because of the highly competitive foreign companies and the limited capacity of IRANOR, the government and some economic sectors agreed on the need to have a similar organization to those already existing in other European countries. Thus, it was decided to move the standardization activities and certification to a private entity which must be an independent establishment, private and non-profitable organization. The main aim of the private entity was to spread the culture of quality among the Spanish production sector in order to improve their competitiveness. To transfer the technical activities of IRANOR, 24 technical standardization committees were created in that first year. The starting point was based on the regulatory body standards (7.810 normas) which was also inherited from IRANOR. A year later, the Asociación Española de Normalización (AENOR) assumed the representation of Spain to the European (CEN, CENELEC and ETSI) and international bodies (ISO and IEC).

In 1986, the basic infrastructure to develop the certification activity was created. However, it was exclusively circumscribed to the product certification. The first technical certification committees were only related to plastics and household appliances. Gradually the committees were created to reach around 70 today. Product certification at that time, concerned building materials and electrical. In the late 90's there was a slow start of certification in new fields such as food, crafts or services.

Management Systems certification based on UNE-EN ISO 9001 began in 1989. Since then, it has been an unstoppable project with over 59418 certificates in 2012. In the 90s this certification was essentially indicated for purely industrial organizations. However, since 2000 the year of the release of the new version of ISO 9001, the range of certification has opened to service organizations and SME. Moreover, during the celebration of the Earth Summit in Rio de Janeiro 1992, there was a beginning for environmental policies. That same year, Spanish certification body (AENOR) started its activity in this field and proposed a standard related to environmental management systems in 1994.

Nowadays, with the increasingly more concentrating and demanding market, the certification procedure in which a third party gives written assurance that a product/service of an organization complies with specified requirements has become a tool of great economic and social utility. Certification, from its origin has a dual purpose: (i) those in needs are destined to select the management system standards on the basis of the organization objective and facilitate their purchase choices. (ii) MSS help certified organizations to add value to their overall activities by using, shared and integrated reference standards in order to rationalize and simplify their activities. Observably, the strategic importance of certification lies in the fact that it maximizes the commitment of an organization and protects it from unqualified competition. Actually, there are numerous national and international MSS certification bodies operating in Spain including: AENOR International; Applus+; BSI; Moody International; AJA Registrars; Nippon Kaiji Kyokai; ISACert Global; QSCert; BMC Certification; GIC; Bureau Veritas; EQA certification; LRQA; ProCert; DEKRA; QMI - SAI Global; BM TRADA; NSF – Cmi; Polish Register of Shipping; KEMA; APCER; FM Global; CCIC – China; Cotecna; GLI; Peterson Control Union; UL Verification Services; RINA; DNV (Det Norske Veritas); SGS; Global Group; ABS Group Services.

Even though there exist numerous certification bodies operating in Spain, the National Accreditation Body (Entidad Nacional de Acreditación) under the Royal Decree 1715/2010 has been granted the sole permission to operate the certification bodies and collaborate with public authority to grant accreditation in accordance with the provisions of the Regulation (EC) No. 765/2008 of the European Parliament and Council of the9 July 2008.

Since the mid 80´s, Spain has always adapted most of the ISO 9000 family, without modification. Nevertheless, Spain like many other countries in the world has denominated the ISO norm according to their own interests. Therefore, a relationship between ISO series and their adaptations is well established in Spain under the acronym UNE-EN-ISO[1] follows by the series. Then again, the concept of an environmental management system had evolved in the early nineties and in consideration of environmental issues; many countries began to develop and implement their own environmental standards. For example, in 1992, BSI Group in the UK published the world's first environmental management systems standard named BS 7750. Based on the BS 7750, the International Organization for Standardization developed the ISO 14000 series in 1996. The ISO 14000 series from its origin aims at creating an environmental management system with its principles and general guidelines, as well as its applications with focus on the development of specific considerations for small and medium organization. In Spain, the first specific standard for environmental management was UNE 77801 which was published in 1994. In 1996, the international standard ISO 14001 was recognized and adopted by AENOR and it is now known as UNE-EN-ISO 14001:1996.

Moreover, as by the end of the seventies, even though most developed countries possessed their own internal standardization bodies (at least for specific sectorial applications), the need of giving a unique and coherent international configuration to the quality assurance standardization structure and to the related activities (certification, accreditation, laboratories, etc.) began to be even more compelling. In areas like quality and the environment, companies have the models in the shape of international standards: the well-known ISO 9000 and ISO 14000 series respectively have allowed good quality management. Yet, the situation in occupational health and safety is apparently different.

So far, the absence of a globally adopted international standard on occupational risk prevention has to date favored the development of models, guides, or standards in different countries. For example, the UNE 81900 for prevention of occupational risks with general rules for implementation of an occupational safety and health management system (AENOR, Spain). The NPR 5001 which is the Dutch Technical Report that guide to an occupational health and safety management system (Nederlands Normalisatie-Instituut). In addition, there is a Norwegian proposal of the Management principles for enhancing quality of products and services, occupational health & safety and the environment (Norges Standardisengsforbung) under 96/402803 etc. Among European countries, Spain constitutes a special case due to some differentiating factors including: (i) its legislation that establishes organizational requirements of safety and health management planning for companies only based in its territory. (ii) Contrary to other proposed standards, it is specified that their occupational health and safety management systems must be audited (Abad et al., 2002). Nevertheless, the last few years have witnessed the emergence of some new proposals for global management models, such as the OHSAS 18001 standard proposed by the British Standards Institution.

GENERAL QMS KNOWLEDGE IN INDUSTRY

In general, Management System Standards (MSS) which are models for achieving better business and organizational practice are based on fixed specifications or benchmarks, which are established by independent bodies such as the International Organization for Standardization. It is generally accepted

[1] ISO standards in Spain are created by los comités técnicos de normalización (CTN) and are labelled as norma UNE (Una Norma Española) or UNE EN (UNE Estándard Europeo).

that appropriately implementing the right MSS will enable to apply best practice across the organization and to efficiently work toward meeting the organization objective. Successful businesses are generally believed to be those that attract, develop, motivate and retain the best people. Nonetheless, skills and knowledge acquired by the employees inside/outside the organization will ensure their ability to follow the quality standards and procedures implemented by the organization appropriately.

In general, the knowledge related to all aspects of the QMS in Spain is very high. For example, most managers have sharp knowledge and skills related to the preparation, planning, conducting, and reporting of audits and evaluating the compliance of the QMS. According to Arenas et al., (2006), 70 % of Spanish hospital they surveyed had a QMS, with a higher implementation in the area of Hemodialysis. Among them, more than 90% had a high medical protocol and nursing plans. Thus, the authors concluded that there is a clear trend that exists towards the use QMS. They further argued that this tendency suggests that in the near future, there will be a progressive implementation and routine use of QMS in the whole Nephrology Community in Spain. Furthermore, despite the fact that the implementation of ISO 9000 standards in Spain is voluntary, it is in fact obligatory in certain industry sectors (Karapetrovic et al., 2006). Studies analyzing the motivation of companies to become registered have therefore highlighted the perspective role played by large construction, automotive, energy and certain telecommunications companies, who saw in these standards a way of ensuring a certain level of quality in their suppliers, in the sense of systematization and formalization of key company processes, without increasing costs (Inaki et al., 2006).

In addition, some employees in Spain are already knowledgeable in terms of QMS even before starting to work in the field. Given that there are about 27 taught Official Masters and 6 official Doctorates Degrees offering programs related to QMS. Those officially awarded Degrees includes: Master in Quality Management; Integrated Master in Business Administration: Corporate Social Responsibility, Quality and Environment; Master in Food Quality and Safety; Master in Management of Occupational Risk Prevention, Quality and Environment etc. They also included awarded Doctoral Degree in Quality Management and Traceability in food of plant origin; Doctoral Degree in Quality Management in Health Services and Doctoral Degree in Quality and Food Safety etc. Likewise, numerous accreditation bodies are now offering training to individuals with no work experience or previous knowledge in QMS, to professionals as well as to the whole organization programs that goes from the general knowledge on QMS up to individual skills and competencies. In addition, they provide extensive knowledge on how to design, implement and monitor management system standards. Above all, they also provide programs and trainings on how to integrate the various MSS such as how to integrate for example the requirements for quality management systems, environmental management system and occupational health and safety.

Also, Spanish organizations are now providing resources and activities specially designed to develop their employees' skills as well as providing formative assessments to monitor their progress. For example most of the employers offer to their employee training regarding the recognition of the importance of documenting processes and environmental quality management as well as ensure that they understand their usefulness as elements of the organization management. Furthermore, professionals or employees generally gained knowledge or experience based on some practical training offered by the organization. For example quality control in the receipt and dispatch of chemical products required some special training at work relate to quality control systems used in the process control of raw materials and finished products that conform to the quality management of the chemical process. Moreover, it is also necessary for employees to be able to perform physical and chemical measures variables related to quality and raw materials product control in addition to provide adequate associated logistic documentation. Besides, many Spanish companies are also investing to develop seminars, training courses or workshops related to quality. Moreover, in order to refresh or update their employees' knowledge and skills, most of the organizations also sponsored some staffs to participate in national and international conferences and seminars.

STATISTICAL DATA OF QMS IN SPAIN

Following the obvious success of ISO 9000 additional management systems standards have been developed for a variety of applications including: Quality Management Assurance (ISO 9001) and Environmental Management Systems (ISO 14001), Food Safety Management Systems, as defined by ISO 22000:2005 contains MS principles associated with assuring safety food. Occupational Health and Safety Management Systems, as defined by OHSAS 1800:2007, contain MS principles associated with the reduction of Human Health and Safety Risks. Energy management systems, as defined in ISO 50001:201, Energy Management Systems, is an important new MS related to the management of energy use. In addition, ISO 26000:2010 provides guidance on how businesses and organizations can operate in a Socially Responsible way. Information Security Management in ISO 27001:2013 helps organizations to keep information assets secure. Moreover, ISO 28000:2007 for Specification for Security Management Systems for the supply chain etc.

Although there are many classifications of standards, this report only focused on the International Standardization Organization (ISO) standards, which lay down specific management systems that can be implemented in an organization. In general, the success achieved by management system standards in recent years has been nothing short of amazing. For example, in 2012 there were over 1.101 million worldwide certificates to ISO 9001 (which lays down the requirements for quality management systems) across 184 countries (ISO, 2012). This figure shows an increased uptake by 2% compared to 2011 and the number of businesses choosing to adopt ISO 9001 is likely to continue to grow. Among them, Spain with 59418 certifications was ranked second in Europe after Italy and third worldwide after China and Italy (see Table 2 for the trend since 1994). Spain was also the top three for growth in the number of certificates in 2012 follows by China and Romania. Compared with the top five EU countries with the highest number of ISO 9001 certifications, Spain was ranked fifth up to the year 2000 (see Figure 1).

Thereafter, Spain has experienced a period of rapid growth followed by a very deep crisis. During the period from 2000-2007, the Spanish economy was booming. The Spanish economy grew very fast and it was admired for its liberalization processes. Spain became more open to international markets with new emerging sector such as automobile, chemistry and agro-industry, transport and the highly dynamic housing market. Unemployment in 2007 was at the lowest because of the surge of companies. Consequently, it was not a surprise that the number of organizations that was ISO 9001 certified increased about 4 times more than in 2000. This figure ranked Spain second EU after Italy then Germany was third followed by the UK and France. In 2008, Spanish economy was hardly hit the world financial crisis. The Spanish economic miracle was gone. Now it was a country with the highest number of companies that went bankrupt and the higher number of unemployment rate in the EU amongst many other very serious troubles. Before then, very few organizations if any have decided to withdraw from ISO 9001 certification (see Figure 2 and Table 2). Since then, among the top five EU countries, Spain has remained the country with the highest number of ISO 9001 certification withdrawn. In 2009, there was a record 13504 decertification in Spain. The top five industries with the highest number of ISO 9001 certificates in decreasing order includes: Construction; Wholesale and retail trade, repairs of motor vehicles; Other Services; Basic metal & fabricated metal products and finally Transport, storage and communication.

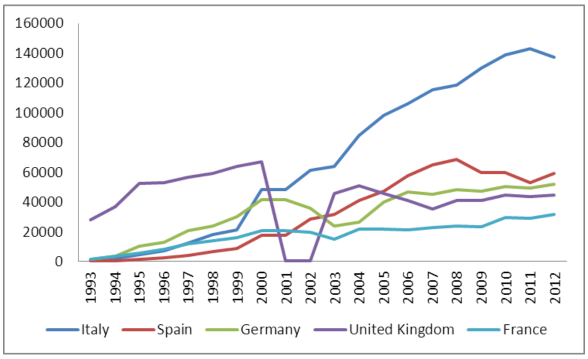

Figure 1: Trend of top five ISO 9001 certification in EU

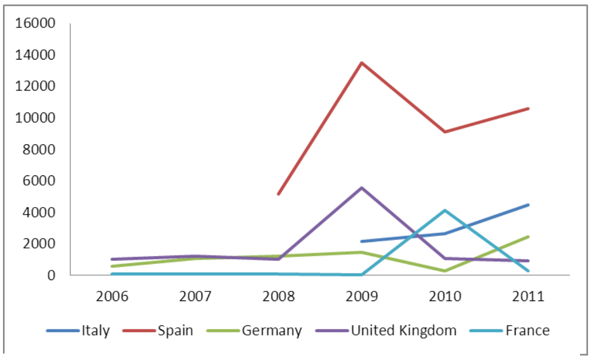

Figure 2: ISO 9001 decertification

In addition, ISO 14001 which gives the requirements for environmental management systems retains its global relevance for organizations wishing to operate in an environmentally sustainable manner. Up to the end of December 2012, Spain was ranked the fourth world country after China, Japan and Italy and second in the EU after Italy with 19470 certificates issued. Spain was also classified second after China for growth in the number of certificates in 2012. Even though there was 3076 decertification in 2009, Spain was remained the leading EU country with the highest number of ISO 14001between the year 2004-2010 (see Figure 3 and 4 and Table 2 and 3). The top five industries with the highest number of ISO 14001 certificates in decreasing order includes: Construction; Other Services; Engineering services; Food products, beverage and tobacco; Chemicals, chemical products & fibers.

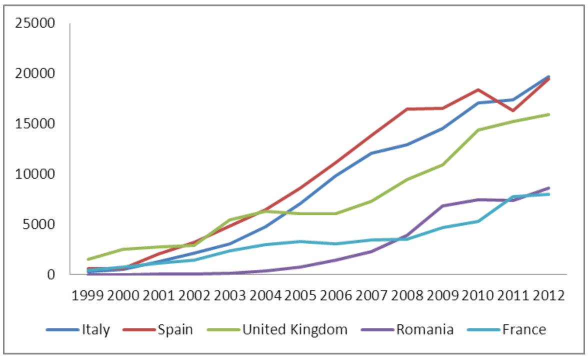

Figure 3: Trend of top five ISO 14001 certification in EU

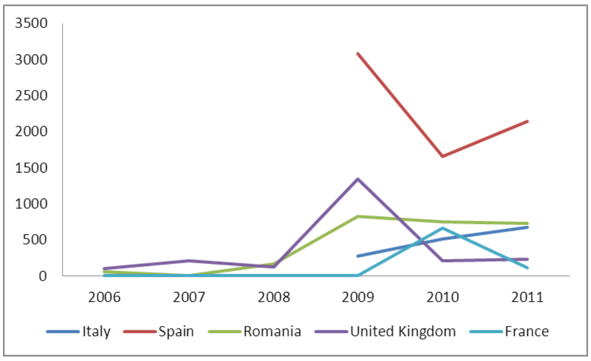

Figure 4: ISO 14001 decertification

Furthermore, at the end of December 2012, at least 19 577 ISO/IEC 27001 which gives the requirements for information security management systems had been issued in 103 countries and economies. Spain with 805 certificates issued was classified sixth country worldwide after Japan, UK, India, China, Romania, and Taipei Chinese. Spain was also ranked sixth worldwide in term of the number of certificates issued growth. Among the EU countries, Spain was classified third after UK and Romania. In Spain except between the period 2010 and 2011, the number of certificates issued have always increased throughout the years (see Figure 5and 6). Besides, 2011 was the year with highest number of (74) decertification.

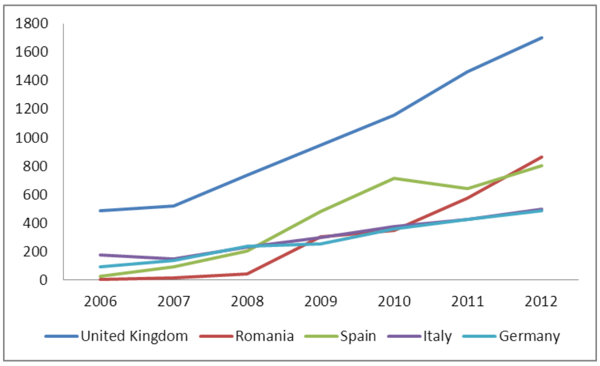

Figure 5: Trend of top 5 ISO 27001 certification in EU

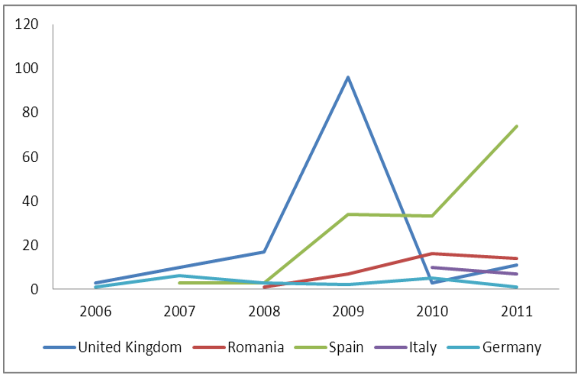

Figure 6: ISO 27001 decertification

Moreover, ISO 22000 which gives the requirements for food safety management systems indicated that up to the end of December 2012, at least 23 231 ISO 22000 certificates, had been issued in 142 countries and economies. The top three countries for the total number of certificates issued were China, India and Greece. Spain was raked number tenth worldwide with 468 certificates issued. Spain also took the tenth place in term of the number of certificates issued growth. Besides, Spain was classified as the sixth EU country after Greece, Romania, Italy, Poland and France. Since 2007, the number of certificates issued in Spain has always increasingly growth throughout the year (see Figure 7 and Table 2 and 3). Nonetheless, during that period there was also some certification withdrawn with the highest number (57) in 2009 (see Figure 8).

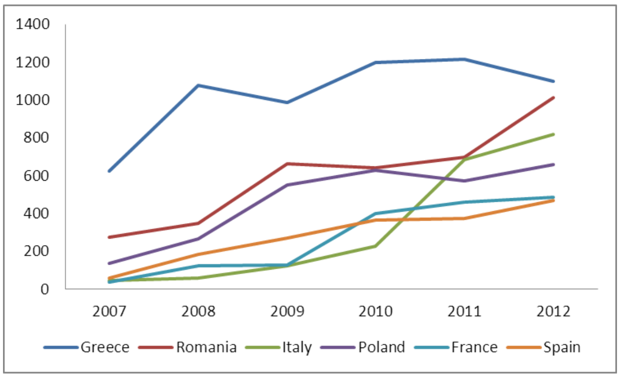

Figure 7: Trend of top 5 ISO 22000 certification

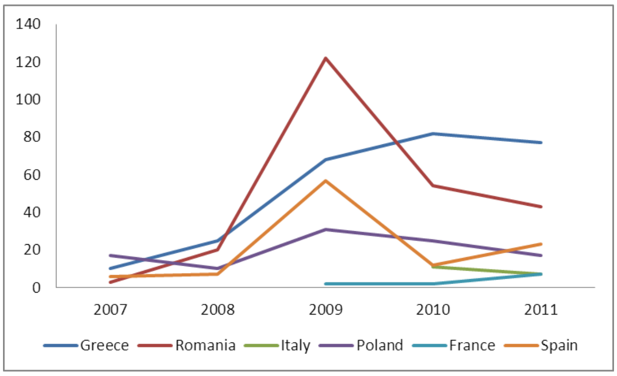

Figure 8: ISO 22000 decertification in EU

Moreover, ISO/TS 16949 which gives the requirements for the application of ISO 9001 by suppliers in the automotive sector showed 50 071 certificates had been issued in 83 countries and economies worldwide. Among them, there has been a continuous growth since 2004 in the number of certificates issued in Spain. In 2012, there were about 900 certificates issued representing nearly the double of certificates issued in 2004 (see Table 2).

Furthermore, ISO 13485 which gives quality management requirements for the medical devices sector for regulatory purposes indicated that up to the end of December 2012, at least 22 237 certificates had been issued in 97 countries and economies. In Spain, only 260 organizations had been issued the ISO 13485 certification. This figure represents about 259% growth compare to the year 2004. Although Spain was not classified among the top ten world countries, it was ranked in the fifth place worldwide in term of ISO 13485 certifications issued in 2012 and only 5 certificates were withdrawn in 2012 (see Table 2).

Finally, the new energy policy of the German government (the German Energy Transition which was implemented in 2011) is now the driving force behind the unprecedented growth in certifications to ISO 50001. Obviously, ISO 50001 gives the requirements for energy management systems. The standard was first published in mid-June 2011 and by the end of December 2012, at least 1 981 ISO 50001certificates, had been issued in 60 countries and economies. Germany with 1115 certificates issue was far ahead of other countries worldwide, follows by Spain with 120 certificates issued. Nevertheless, Spain was ranked number nineth in term of world growth. This trend is expected to rise over the next few years as the short-term benefits of energy efficiency become noticeable (see Table 2).

PROGRAMS OF THE ESTABLISHMENT OF QMS IN THE SPANISH INDUSTRY (NATIONAL GOVERNMENT AND EU PROGRAMS)

Products and installations. In the context of globalization of markets, the relevance of the principles of protection of consumer rights, free enterprise competition, and the need for environmental protection are two concepts inescapable part of reality: quality and safety. In Spain, a large number of services testing, inspection and certification provide accredited trust administrations for businesses and consumers based on the safety and quality of both products and the own production of goods and services. Some of the certification bodies back by the Spanish government and EU have now put in place number of training programs for the establishment of QMS including: Inspection of elevators, electrical, parks and sports facilities, gas stations, tanning devices. Moreover, trainings related to the inspection and certification required for marking of different fireworks products and devices, gas appliances, personal protective equipment, construction products, pressure equipment covered by the European Directives. Trainings are also offered for vehicle inspection, fire protection facilities and Metrologic control of equipment or systems such as scales and other weighing instruments for fuel pumps and water meters.

Food and agriculture. The food and agriculture are seen as strategic issues. Accredited services have emerged as a useful tool to address the challenges facing the industry from various fields such as food safety, quality differentiation as a source of competitive advantage, export or maintaining natural resources and territorial balance of rural areas. Spain is now offering certification in accordance with the various private schemes such as the International Schemes established by the distribution itself as an added way to control the products you. These schemes include: Global GAP, BRC, IFS or FACE which is a brand products for people with celiac disease).

On top of ISO/IEC 22000 (Management Systems for Food Security), some organizations are also taking advantage of any specific certifications developed in Spain such as certification of meat, ham, paddle and cane cured pork loin according to the standard of Productos Ibéricos e inspección de las explotaciones ganaderas de cerdos ibéricos. Numeral training programs are offered including: chemical and microbiological analyzes to determine the composition and characteristics of foods, control the presence of undesirable substances, residues of pesticides, PCBs, dioxins, micro toxins, heavy metals. Besides, trainings are given to identify the presence of microorganisms that can cause disorders, allergies, poisoning, toxic infections, or cause deterioration of food. Trainings are also given to the inspection of compliance with the principles of Good Laboratory Practice (GLP) test entities conducting studies to obtain data on the properties and hazards for humans, animals and environment protection products such as pesticides, insecticides, fungicides, etc.

Environment. The growing awareness of the impact of human activities on the environment and public health, has led to the development and use of different methods and technologies to reduce the effects of pollution. To do this, the Spanish government has adopted measures and political policy in order to minimize these impacts and ensure compliance with environmental measures. The participation of technically competent, accredited assessors brings to society in confident adequate pollution management and environmental protection. In general, Environmental Management Systems ISO 14001in Spain is implemented in the various fields of activity (food, energy, transport, communications, construction, chemical, automotive, retail, hospitality, public administration, education, health, etc.). Thus, programs for the establishment of QMS are broad and include: training related to groundwater, marine, underwater sediments, aquatic organisms. In addition, there are trainings related to Environmental Verification, according to European Management and Audit Scheme (EMAS). Besides, there are programs related to verification of emissions from different facilities and activities combustion plants, refineries, cement production, lime, glass, ceramics or pulp and paper, aviation subject to the Scheme for Trading Emissions Greenhouse Gases etc.

Health services. The quality and security are strategic elements in the transformation and improvement of modern health systems. The use of accredited institutions provides confidence in the various areas and stages of the provision of health services (hospitalization, blood transfusion, laboratory tests, medications, etc.). Spanish organizations can freely implement Quality Management Systems for medical devices based on UNE-EN ISO 1348. Nevertheless, some certification bodies are also offering certification of quality standards for the various health services (hospitals, primary care centers, hemodialysis units, pharmacies, etc.) that are established and recognized by some Autonomous Communities. Moreover, clinical laboratory is a fundamental part of health care. Therefore, most of Spanish patients are now taking the advantage of analytical services of different organizations, from national reference centers to routine hospital laboratories and emergency public and private that currently have accreditation.

Programs for the establishment of QMS include: trainings on microbiological, chemical and pharmaceutical characteristics necessary to ensure users´ quality requirements and safety of chemical drugs or biological origin derived from medicinal plants and their raw materials. Besides, training on forensic evidence, such as DNA, fingerprints or palm, voice identification, graphistics, documentoscopy, identifying accelerators combustion fire scenarios, gunshot residue, ballistics, etc. which play an important role in crime investigation, counter-terrorism, disaster victim identification in studies of parentage (paternity, illegal adoptions, pits, etc.).

Construction. On top of the various ISO management systems there are also some other accredited certifications such as certification of quality management systems and environmental or verification of greenhouse gas emission (Entidades Colaboradoras en la Gestión de Licencias Urbanísticas: ECLUS) which is offered by the Madrid City Council services. Furthermore, different programs are put in place for the testing and certification for different quality brands as well as programs related to assessment of products and precast concrete construction; structural steel, steel products for concrete, cement, sanitary fittings, sanitary wares. Moreover, there are training programs related to testing, inspection and certification required by EU regulation on safety requirements of the various products covered by the Directive of Construction Products (89/106/EEC) that includes masonry additives, precast concrete, bituminous mixtures. There are also programs related to the safety of equipment and facilities, elevators, electrical systems, fire protection systems, water supply facilities, gas appliances, hot water boilers, cranes etc.

Energy and Mines. The increasing energy demand coupled with the need to develop alternative energy with lower impact on the environment is some of the elements that have driven the development and evolution of this sector. The help of accredited service related to conformity assessment have complemented this development by pushing energy companies to respond to those needs. Currently, a large number of certification, inspection and auditing services are now providing accredited trust to administrations, businesses and consumers related to the safety and quality of the processes of generation, transmission, distribution and sale of both nonrenewable energy (coal, oil, gas and nuclear) and renewable (wind, solar, biofuels, etc). Since 2011, a large a number of accreditation services have started to offer ISO 50001 certifications. There are number of programs available including: certification, experiment, practice related to wind turbines and wind power. There are also programs related to characterization of wind turbine power curve, power quality, adequacy of response to voltage sags, evaluation of potential wind sites. In addition, there exist training and certification related to gas fitters and specialist commissioning, maintenance and repair of gas appliances. Moreover, there are trainings related to the inspection of the safety of facilities for production, processing, transport and distribution of electricity. In addition, there are also programs related to the testing and monitoring of photovoltaic modules and systems. Design qualification and type approval, electrical safety; power, thermal and visual inspection system response of photovoltaic conversion to voltage dips, calibration of solarimeters etc.

Safety and health at work. Safety and health at work is a right for all. Secure it now constitutes an obligation and an objective of public authorities and other actors involved in the prevention of occupational hazards. QMS contributes to accomplish these goals by helping to reduce the risks associated with health and safety in the work environment and by helping to integrate prevention of occupational risks in business. Large number of accreditation bodies offer Management Systems Certification for Health and Safety at Work (OHSAS18001).Obviously, OHSAS18001 is internationally recognized and was developed with the collaboration of the leading trade organizations, international standards organizations and certification and can be implemented in all types of organizations.

On top of the existing MSS certifications, Spanish companies can also get accreditation related to health and safety including certification on the determination of pollutants in industrial atmospheres, asbestos fibers, metals, organic vapors, ammonia, noise, calibration of equipment for measuring environmental conditions sound level meters , light meters, or certification on the detection equipment and fire protection. Spain offers a number of programs related to certification, inspection, auditing etc. The tests, inspection and certification for the EU market related to the machinery, presses, machine tools, machinery for underground work covered by the Directive 2006/42/EC which establishes the essential requirements necessary to ensure the proper degree of security, designing, installing, maintaining and using such devices. There are also programs related to certification, assessment, practice etc. related to the employee protection from risks that may threaten their health and safety and any other personnel in the company. There are also training programs related EPIs which is an equipment systems of protection and restraint against fall, respiratory, eye and face protection. Besides, there trainings related to footwear safety, impact protection elements including elements of collective protection (safety nets, edge protection systems).

Transport and Automotive. Transportation has ever since been a key element in our society. Transportation is one of the activities most directly related to the various economic sectors and the citizens themselves, in which issues such as safety of passengers and goods, the quality of services and facility transport and environmental impact are basic. Evidently, QMS help to improve the safety and the quality of the different modes of transportation such as road, rail, sea and air transport. Large number of accreditation bodies offer ISO/TS 16949 which is a MSS for the automotive sector. They also offer certification of the QMS to organizations in the aviation sector based on TEDAE scheme which is a certification referential of quality of services of the Spanish state ports. There are a number of programs related to the certification, inspection, training etc. related to vehicle safety and interoperability of components and rail systems based on EUROBALIZAS.

There are also programs associated with road safety including elements of active and passive safety of vehicles, road infrastructure and equipment or meteorological control radar as well as alcoholmeters certifications. Besides, there are programs related to the inspections of safety transport of dangerous and perishable goods, the recreational vessel as well as trainings on inspection and certification of Tachographs technical centers. Without forgetting the training on vehicle inspection called ITV in Spain and training on technical services reform of new or historical vehicles. In addition, there are programs related to the inspections and annual survey based on the EU Regulations Requirements in order to provide air navigation services in the framework of the Single European Sky initiative etc.

Tourism and Leisure. Products and services of leisure and tourism have become one of the major Spanish economic activities. They represent almost the main source of foreign exchange and the economic engine of many autonomous communities or regions. The certification brand for Spanish Tourist Quality is called MARCA Q. A Spanish organization can obtain MARCA Q accreditation for products and services associated with tourism and leisure related to hotels, apartments and rural accommodation; caterers, beaches, ski resorts and mountain resorts, golf courses, campsites; holiday resorts, tourist information offices, agencies, reservation centers etc.

Actually, there are many programs that help to ensure the quality and safety of products and services for leisure and tourism such as physical, mechanical, chemical, electrical and sanitary measures that verify the safety of toys and ensure the necessary conditions for evidential use. There are also programs related the inspection of equipment (swings, slides, seesaws, soils zip lines, etc.) Play areas and playgrounds as well as trainings in sporting goods (footwear, apparel, helmets). There are also programs related to bet and gaming machines these includes behavior management and credit check, book awards, price and gameplay, check the percentage of return of awards. It also includes meteorological control gaming machines counters. There are programs related to the characterization of sports flooring (buffer, deformation, vertical pot ball, rolling ball, dribbling angled, rotating traction resistance, slip resistance, among others) as well football fields (artificial or natural grass) to meet FIFA Recommendation.

Chemistry industry. The chemical industry represents a significant percentage of industrial GDP of any advanced country and supplies products to all sectors of the economy. The chemical industry includes sectors related to health, construction, agriculture, transport, an industry that covers plastics to pharmaceuticals, detergency paints, specialty chemicals and industrial and medicinal gases. On top of existing MSS, industry organizations also have other types of accreditation related to dangerous goods, welders and emissions trading of greenhouse gases. There is also certification of emissions and discharges, the regulation of fireworks certification activities required services by the directive and the regulation of fireworks and oil pumps and industrial pumps. There are programs that help to evaluate Good Laboratory Practice (Buenas Prácticas de Laboratorio: BPL), studies related to pesticides in both the laboratory and experimental activities (e.g. crop field, greenhouses, fishponds, etc.). There are also programs related to the storing of liquefied gas facilities, warehouses and distribution of liquefied gas containers, satellite liquefied natural gas, service stations for vehicle gas-storage of chemicals, and oil installations etc.

CONCLUSIONS

Indeed, the use of MSS is widespread, an accepted mechanism to promote a common understanding between individuals and businesses in both private and business activities in all aspects of life. Thus, most of businesses organizations are now characterized by a growing awareness of the importance of quality, safety and environmental management system standards. Therefore, many organizations have started to incorporate them as differentiating factors in their business strategy. Indeed, MSS is the ISO's most well-known standards. They provide a model to follow when setting up and operating a management system. Like all ISO standards, they are the result of international, expert consensus.

Therefore, by implementing a management system standard, organizations can benefit from global management experience and good practice.

According to Pember (2006), management system standards generally go unnoticed. They are mostly quiet, unseen forces, such as specifications, regulations and protocols that ensure that things work properly, interactively, and responsibly. They also depend upon the company's and the environment in which the activity is performed. Based on that, this report seeks to first explore the background of quality management system (QMS) in Spain. Thereafter, discusses the general QMS knowledge in the industry. Then, presents the statistical data on the adoption of QMS over time and concludes with the existing programs for the establishment of QMS for industry. The MSS had its root in Spain since 1945 with the Instituto de Racionalización y Normalización (IRANOR). However, the first certification was granted four decades after that.

Ever since, the number of certified companies has grown in an exponential. By the end of 2012, Spain was classified among the top three leading companies worldwide in term of ISO 9001 and ISO 14001.

This study also observed that, some employees are already knowledge before getting the job. Mainly because, there are some official Master Degrees and Doctorate programs that offer taught courses on MSS. Furthermore, numerous organizations are also offering training programs to their employees in addition to accreditation bodies who also offer training programs to professional and nonprofessional. This report also argued that in Spain there are various programs related to the establishment of QMSS in different industries set by the government and the EU. Overall, MSs are well established in Spain. Even though, the financial crisis had hardly hit Spanish companies, most of organizations have kept the spirit of getting MS certification and hopefully the number certified companies will continue to grow.

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Analysis of training programs in the field of Quality Management Systems in Spain

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ABSTRACT

Purpose. This paper aims at identifying, discusses and analyzes the existing training programs related to Quality Management System (QMS) in Spain.

Design/Methodology/Approach. exhaustive search of the education system database was used to map the multifaceted of Spanish education system and professional training in addition to their relationships with the labor market. Thereafter, a thorough scan of the existing training related to management system standards was used to classify them into different subgroups as well as identifying possible education and the professional trainings related to QMS.

Findings. The overall results showed that general education in Spain and in particular related to QMS can be classified into four different groups including: Official University, Unofficial University, Official Non University and Unofficial Non University. Moreover, this study observed that the general concern about the employment and earnings in Spain has led the national government and the governments of the autonomous communities to launch measures designed both to continue increasing the quality of the workforce and to ease the difficulties encountered when entering the labor market.

Originality/value. this study is the first to analyze and map the multifaceted of Spanish education system and professional training related to Quality Management System.

Keywords: Quality Management System, Education, Education system, Professional Training Programs, Spain

Article classification: General review

INTRODUCTION

The economic globalization and the ultimate financial crisis have drastically altered the world economic order. Organizations have now been pushed toward providing more quality and respond more effectively to consumers' needs and fulfilling customer requirements. To adapt to this new environment, businesses need ways to improve their operations in different frontages including: better gain, serve and retain customers while reducing costs and improving their profit margins. Sound, documented evidence from the academic studies now confirms that implementing Management Systems (MS) can help businesses to achieve success on all of these frontages. Given that the majority of extant literature point toward that there is a significant relationship between the implementation of MS and/or Management System Standard (MSS) and customers' satisfaction, loyalty and business performance.

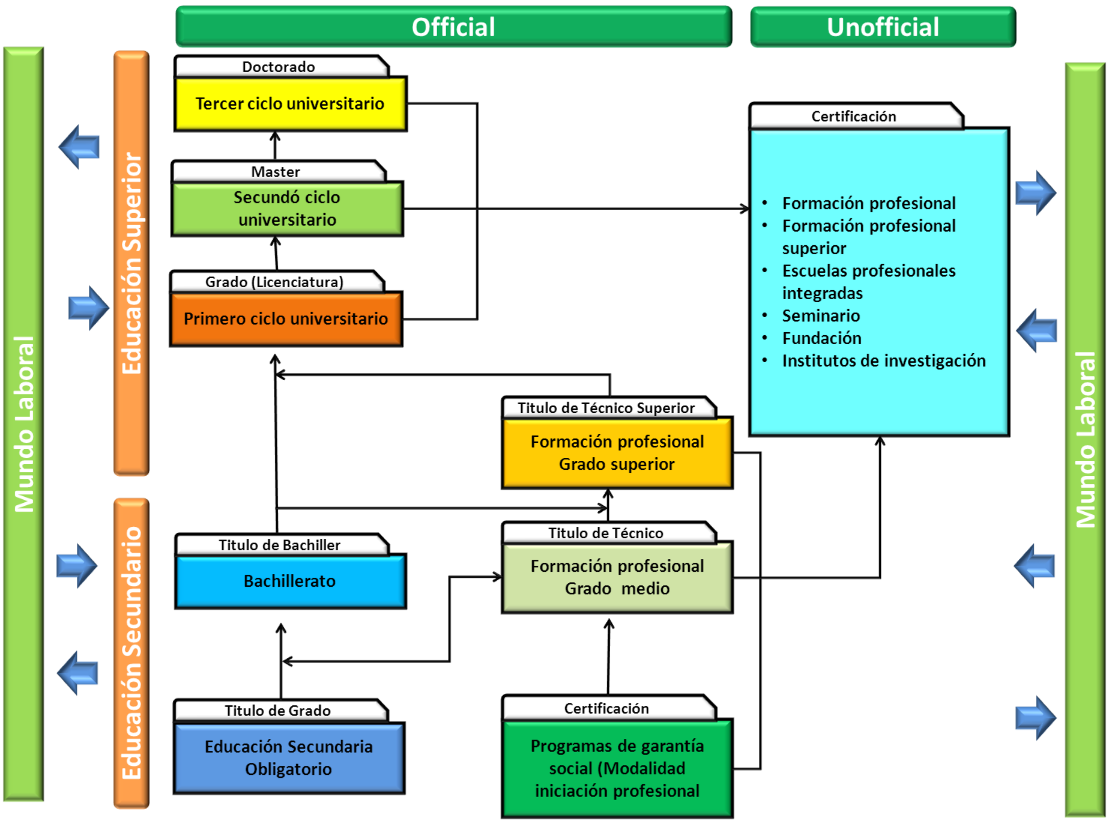
Furthermore, expectations about effective performance at work have changed radically over the past decade and will continue to do so. Since, it is now common for people to be recruited, selected and trained, besides being developed, reviewed and rewarded against the degree to which they add value to the organization (Pember, 2006). In addition, previously successful companies no longer exist, either at all or in their original form. Given that new types of enterprises continually emerge because of the new era of e-commerce, globalization and technological uncertainty that operate in different ways. Consequently, organizations nowadays demand high technical professionals with the cultural level, scientific and university education. They also require continuing education throughout life, not just in the macroeconomic and structural order but also as a means of personal fulfillment.

In general, education and training programs in Spain are closely linked to the labor market. They are also closely link to the composition of the work force as well as the nation´s economic structure. Moreover, founded on the belief that the consistent use of adequate and properly trained employees is an absolute imperative to ensure success on all the frontages previously mentioned, this paper aims at identifying, discusses and analyzes the existing training programs related to Quality Management System (QMS) in Spain. The findings of this study may be useful for organizations trying to evaluate their QMS efforts and engage their people's energies for facing competitive challenges that lie ahead. Given that it is thus beneficial to tap into the potential of entire workforce and make learning available to all employees (Pun and Chin, 1999).

GENERAL EDUCATION SYSTEM

Although, the teaching and/or the professional training language(s) depends on each autonomous community, the legislative structure of the education system in general is defined at national level by the Ministry of Education Social policy and Sport (Ministerio de Educación, Cultura y Deporte). Nevertheless, each autonomous community can develop their own complementary legislation and regulate the non-basic elements of the education system. In addition, they have executive and administrative powers which allow them to administer the education system within their own territory (Santiago et al., 2009). The current Spanish education system followed la Ley Orgánica de Educación (LOE) that corresponds to the Fundamental Law of Education in English as. As mentioned before, education and training programs in Spain are closely linked to the labor market. Figure 1 mapped and summarized the interrelationships between education, higher education as well as professional training and the world of work.

Figure 1 Spanish education system and the world of work



PRIMARY AND SECONDARY EDUCATION

Generally, education in Spain is compulsory, free from 6 to 16 years of age and supported by the Government in each Region. Obviously, obligatory education starts at the age of 6 (primary school). Besides, at the age of 12, children are compulsory enrolled to secondary school (Educación Secundaria Obligatoria: ESO). At this point children are provided with either the basis for further high school studies or professional training. At the end of this stage, Students are often awarded with a certificate called Graduado/o Educación Secundaria. With this title, students have three options: they can opt for start working, start vocational training or intermediate education and voluntary continue to secondary education. The ultimate option leads to the Bachelor level (Bachillerato).

The Bachillerato is the final stage of the secondary education and it is not mandatory. The entry requirement is the ESO or a vocational training title (Formación Profesional de grado medio). The lessons at the Bachillerato are tailor-made to students' interests in future education. One can choose Artistic path, Natural Science and Technology path or Humanities and Social Sciences. The Bachillerato is also essential to enter the market labour or to gain access to university or to undertake further vocational education. Moreover, the option of professional training can be done in two ways. The first way is the vocational training at the intermediate level (Formación Profesional de Grado medio) which can be a substitute for secondary school and it finishes with a technician diploma (Técnico). The second way is the vocational training at the superior level (Formación Profesional de Grado Superior). The Formación Profesional de Grado Superior is a post matriculation school and it gives the title of technician diploma called (Técnico Superior).

HIGHER EDUCATION AND TERTIARY EDUCATION

According to the Spanish Ministry of Education of the year 2014 data report, the Spanish higher education is composed of 82 universities spread over 236 campuses with physical presence and 112 with no physical presence. Out of the 82 universities, 50 were publicly owned and 32 private. In 2013, there were about 1.561 million University students in Spain. The figure represents about 1.75 universities per million inhabitants and the equivalent of 24.6 per million inhabitants of the theoretical university population aged from 18 to 24(Ministerio de Educación, Cultura y Deporte, 2014).

Under Graduate University Degree (Grado). Like most of EU member states, Spain has undergone radical restructuring of its higher education system by fully implementing the Bologna process. Bologna process is a system of easily readable and comparable degrees with the aim of promoting European citizens employability and the international competitiveness of the European higher education system (Keeling, 2006; Crosier et al., 2012). In addition, the Bologna Process has encouraged manifold developments in the area of quality assurance both within higher education institutions and externally (Voegtle et al., 2009). Within this framework, university education is to be structured around two main cycles: undergraduate and postgraduate.

According to the Ministerio de Educación Cultura y Deporte (2014), during the academic year 2012-2013, the whole Spanish University System has produced 2 464 verified and taught Degrees in which 1.046 million students were enrolled. Out of it about 48 public universities offered 1956 degrees to 912 thousand students registered and 508 taught Undergraduate Degrees in 29 private universities to134 016 students. Overall, 35% of those verified and taught Degrees were affiliated with Social Science and Jurisdiction, 27% to Engineering and Architecture, 16% to Humanity and Arts, 13% to the Health and only 9% to Science.

Masters and Doctorate Degrees. Access to the second cycle requires successful completion of first-cycle studies which is accomplished with a minimum of three years. The second cycle also covered two levels: the Masters and the Doctorate degree (Másteres y Doctorado). According to the Ministerio de Educación Cultura y Deporte (2014), in September 2013 there were 3 519 Master's Degrees registered, compared to 3 292 in the previous year. This figure includes 439 inter-universities Masters Degrees as well as 385 official Master's Degrees who are in the process of extinction but have led to a new verification. It should be noted that a part from the 71 Master Degrees from the Universitat Internacional de Andalucía (UNED) and 24 Master Degrees from Universidad Internacional Menéndez Pelayo (UIMP), each University must independently register their taught Master Degrees. This must be done with the endorsement of their Autonomous Community and in accordance with the guidelines and conditions set by the government. Although the number of verified Master Degrees continues to rise, they have not yet reached the system stability level which is the extent to which Undergraduate Degrees are produced and those Degrees give access to the same Master's Degree (Ministerio de Educación Cultura y Deporte, 2014). Furthermore, there was about 10 531 Doctorate thesis dissertations read in 2012. This figure represents 11.1% increase over the previous year. Besides, since 2008 the number of reading thesis has increased by 35%. Only 17.7% of the theses are read by students under 29, and 54.4% under 35 years. In Spain 28% of Doctorate thesis are read with more than 40 years. These data are significant in view of the employment of doctors in Spain.

MANAGEMENT SYSTEM STANDARDS

As we previously argued the increased use QMS is not surprising because of the exponential increase MS, MSS, Total Quality Management (TQM) etc. For example, in 2012, there were over 1.101 million certificates of International Standardization Organization (ISO)[2] 9001 issues across 184 countries. This figure represents a 2% increase since 2011 and the number of businesses choosing to adopt ISO9001 is likely to continue to grow. Following the obvious success of ISO 9001 and ISO 14001, additional management systems standards have been developed for a variety of applications. A quick look at these new standards shows that they contain many of the basics of ISO 9000 that was used as a catalyst of the existing tendencies. With the purpose to induce organizations towards a structural model based on the logic of strategic quality management that has evolved during the last 100 years or more.

Nevertheless, these new management systems standards all include practices associated with their specific purpose. In addition to Quality Management Assurance (ISO 9001) and Environmental Management Systems (ISO 14001), the following list offers a brief summary of other management systems standards that have been developed and deployed during the last 15 years: Food Safety Management Systems, as defined by ISO 22000:2005 contains MS principles associated with assuring safe food. Occupational Health and Safety Management Systems, as defined by OHSAS 1800:2007, contain MS principles associated with the reduction of Human Health and Safety Risks. Energy management systems, as defined in ISO 50001:201, Energy Management Systems, is an important new MS related to the management of energy use. In addition, ISO 26000:2010 provides guidance on how businesses and organizations can operate in a Socially Responsible way. Information Security Management in ISO 27001:2013 helps organizations to keep information assets secure. Moreover, ISO 28000:2007 for Specification for Security Management Systems for the supply chain etc.

Quality products and services can be delivered best externally and internally when QMS is efficiently focused on the same target (Pun and Chin, 1999). In general, MSS contain basic concepts that can be applied to achieve any desired goal. However, MSS alone will never fix a mismanaged organization. Evidently, successful implementation and operation of MSS requires good management and more importantly a crowd of properly trained workforce. Given the obvious truth that MSS can help prevents problems from occurring and possibly adds value to the organization. However, without the involvement of properly trained employees, it cannot itself do the procedures, the documentations or all the paperwork and records. Therefore, the following section discusses the existing training related to QM in Spain.

EDUCATION AND PROFESSIONAL TRAINING IN QUALITY

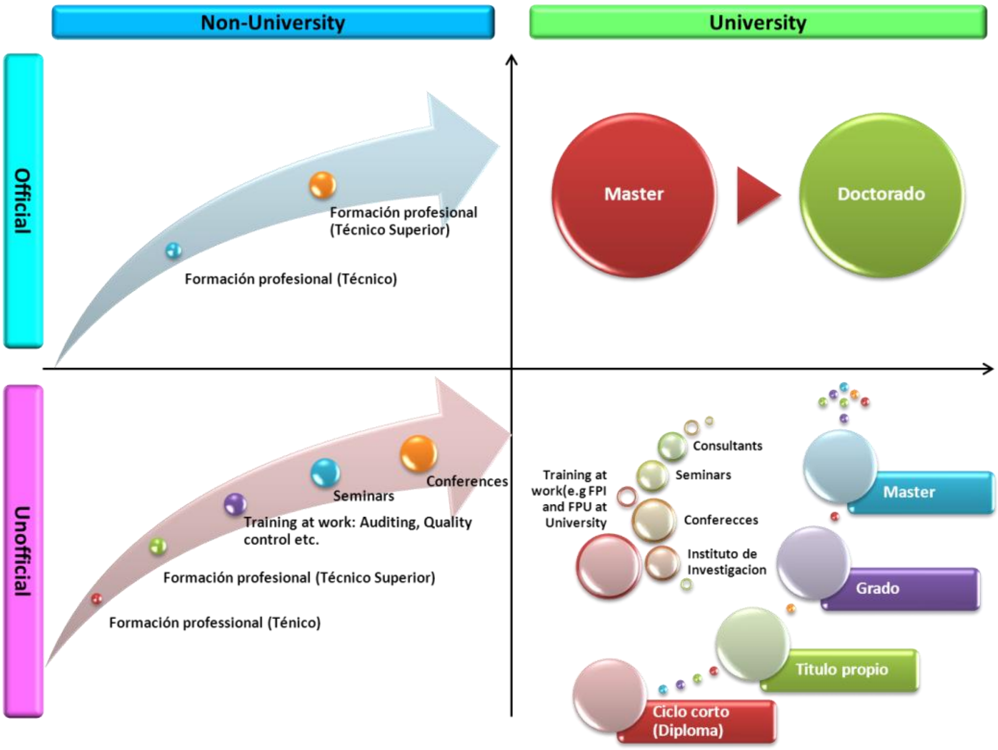
In general, quality can be defined in different ways. For example it can mean excellence, zero defects, satisfying customer needs or operational improvement. Moreover, Quality Assurance, Quality Management as well as Quality Management System and Quality Management Standard can all be defined in different ways. In this document, all these terminology will be used interchangeably because here they mean anything related to MSS

After a thorough understanding of the Spanish education as a whole, we scanned the existing training related to management system standards and classified them into 4 different groups as presented in Figure 2. The existing education and professional trainings were classified according to the University and No-university education, as well as to the Official and Unofficial qualification. Official qualification here referred to those education programs and existing professional trainings that were fully accredited by the Ministerio de Educación Cultura y Deporte. Any other education programs and existing

[2] ISO standards in Spain are created by los comités técnicos de normalización (CTN) and are labelled as norma UNE (Una Norma Española) or UNE EN (UNE Estándard Europeo).

professional trainings recognized by the government but not accredited and registered in the Boletín Oficial del Estado (BOE) or the Authorized Autonomous Community were classified as Unofficial.

Figure 2 Official and non-official QM training in Spain



University Official education and training programs. To obtain the existing official university program related to quality, we did an exhaustive search of the database (Registro de Universidades, Centros y Títulos: RUCT) maintained by the Spanish ministry of education. The searching keywords comprised "quality"; "business"; "business" administration"; "tourism" etc. The results of the search indicated that from the 2464 registered Undergraduate Degrees and 3292 Postgraduate degrees, there were only a tiny minority of 94 verified and taught university programs related to "quality". After carefully scanning of those existing programs, we observed that there were some official Degrees such as: Doctorate in Biomedicine, quality of life and health as well as the Official Doctoral Program in general Education, Society and Quality of Life; Master in Continental Water Quality, Master in Taxation and International Taxation etc. that were not related to quality management education programs. Consequently, they were not taken into account in this study. The overall results of the remaining official university programs presented indicated that there was no official Undergraduate Degree program related to Quality. On the other hand, there was about 27 Official Masters and 6 official Doctorate Degrees totally offering programs related to QMS. Those officially awarded degrees included: Master in Quality Management; Integrated Master in Business Administration: Corporate Social Responsibility, Quality and Environment; Master in Food Quality and Safety; Master in Management of Occupational Risk Prevention, Quality and Environment etc. They also included awarded Doctoral Degree in Quality Management and traceability in food of plant origin; Doctoral Degree in Quality Management in Health Services and Doctoral Degree in Quality and Food Safety etc.

The modules thought in those Degrees include: the general introduction to the fundamental concepts about quality and management system as well as quality procedures, planning, organization and control. Moreover, students are introduced with Standardization, Certification and Homologation as well as Systems of quality assurance in Europe and Spain, international regulations on quality and environmental management. The modules thought also include an introduction to service quality, management standard integration .They focus on processes, integrated policy and planning of the integrated management system. As well as, identifying and assessing environmental management aspects, besides hazard identification and risk assessment etc.

Unofficial university training

Ciclo corto (Diploma)

Although the degree structure described above is already applied in most of Spanish Universities, there are universities that are still under revision how to adjust their programs to the requirements of the Bologna Declaration. Accordingly, those universities continued to offer short cycle courses (Ciclo corto). Indeed, Ciclo corto may be done in two different ways. On one hand, there is a first cycle which is oriented towards professional skills, with duration of two to three years and leading to the Diploma degree. On the other hand, the second cycle course that leads to the Licienciatura. It generally lasts two years for students that have gained a first cycle qualification or completed the Grado. Obviously, universities can still offer courses that lead to official degrees valid throughout Spain as well as courses that might not lead to a title but may be, for example, part of a professional specialization. As already mentioned, valid official degrees nationwide are those that are part of the Registry of Universities Centres and Courses (RUCT). Nevertheless, we were able to trace some diploma and/or Licienciatura in Business Administration, Economics and Business Administration, Business Management tourism etc. with some quality management module included in their programs. There is also Diploma related to Integrated Management Systems of Quality, Safety and Environmental management standards.

Titulo propio

The continuous scientific and technological development, coupled with the evolution of the socioeconomic environment and increased competitiveness at the work level, is now forcing many professionals and students to continually recycle themselves and complete their education or training. Thus, many Spanish universities are now offering the opportunity for students and professionals to improve their career by taking Personal Training (Titulo Propio). Indeed, Titulo Propio can be a graduate and postgraduate program that is intended for the acquisition by the student specific training and multidisciplinary oriented academic or professional specialization. These programs are often designed by a university in collaboration with professionals and experts from different organizations. They are designed to respond swiftly and effectively to the needs posed by the society and the labor market. The access to the program related to quality depends on the number of credits and previous courses taken on the topic. For example for Masters and Specialist courses, students must be in possession of a Bachelor's degree or a Degree or Diploma.

Grado

As we previously discussed, Grado is the first university cycle training which is adapted to the European context academic studies so that the duration, the learning methods and evaluation of academic activities etc. are harmonized. The Grado degree aims to provide a general training directed to the preparation for the performance of professional activities. Our search indicated that there was no official Grdo related to quality management. However, we have identified in our some unofficial Grado that keep track of the quality and environmental management systems implanted in different areas including water purification, desalination, integral water cycle, restoration, social health as well as in the textiles industry, food and beverages, metals and metal manufactures etc. We also identified some modules that keep careers on the large area of risk prevention, environmental quality in the area of chemicals, shipbuilding and automobiles. In addition, we found throught modules based on quality management system in tourism, clay and refractory products, pharmaceuticals and medical equipment. Moreover, we also found thought modules related to technical, social, economic and legal aspects that influence environmental quality management issues and quality management and risk prevention.

Masters

Apart from the official Masters, there is also a wide range of masters that are not official and classified as postgraduate studies. To access to those unofficial Masters studies it is necessary to have previously completed (like in the official Masters) a bachelor's degree or equivalent. In the quality field, we have identified scores of online universities, private companies and agencies of management system standard accreditation offering Masters Courses. The aim of most of those Master degrees is to provide participants with the knowledge, skills and competencies. In addition, to provide knowledge on how to design, implement and monitor management system standards. As well as, provide knowledge on how to integrated management system for quality, environment and occupational health and safety. For example one of the leading agencies of MSS accreditation (AENOR) offer a Master Degree to people with no work experience and / or professionals with no previous knowledge of the UNE-EN ISO 9001:2008, EN ISO 14001:2004 and OHSAS 18001:2007 Standard. Who want to be trained on how to carry out an integration project of the three management systems or are to take responsibility for an integrated management system as well as anyone interested in acquiring an education that can develop your career in the future.

Training at work (University)

The Ley Orgánica de Universidades (LOU) recognized the quick rise of the knowledge globalization phenomenon. The LOU also acknowledged the process derived from scientific research and the technological developments are transforming the ways of learning, organizing, generating and above all the ways of transmitting knowledge. In that sense, Spanish universities as a whole are now intensifying their scientific research activities. In addition, they are also creating models that strengthen their research activities and knowledge diffusion as well as extending their national and international collaboration capability. To guarantee the quality of teaching and research, there is program for human resources training set by government. The program includes aid for training researcher staffs (la Formación del Personal Investigador: FPI) and university teachers (la Formación del profesorado universitario: FPU). According to the

Ministerio de Educación Cultura y Deporte, 1.018 FPI y 810 FPU representing an investment of 75.5 and 54.2 million respectively were awarded in 2012. Those figures include university teachers and researchers in the field of quality.

Instituto de investigacion (Institute of Advanced Research)

Instituto de investigacion is a tertiary education which refers to programs offered by institutions that extend beyond universities. Instituto de investigacion plays a role of overcoming the insufficiency of the departmental structure of Spanish universities, following the proposal of the LOU which foments the creation of university institutes as a focal point of research activity. Instituto de investigacion is often devoted to advanced study and original research. It is also intended to provide sufficient qualifications for gaining entry into advanced research programs and professions with high skills requirements. In addition, it is generally more practical, technical and occupationally specific. Besides, it aids networking in inter- universities cooperation to foster a work between researchers from different fields, on both national and international levels. Moreover, it promotes research from a multidisciplinary perspective including research related to quality management as a whole. It is noteworthy to mention that above the Instituto de Investigacion there is a Higher Council for Scientific Research (Consejo Superior de Investigaciones Científica: CSIC). CSIC main function includes the training of specialized personnel, the transfer of the research results to the business sector as well as supporting the creation of technologically-based companies.

Seminar and Conferences (university)

Most of Spanish universities encourage students and university teachers to participate in national international conferences and seminar. Since, it is generally accepted that conferences, seminars and trainings offer opportunities to learn the latest improvement ideas, connect with likeminded colleagues, and generate the impetus for change in the organization and research where necessary. In addition, most universities encourage students and teachers to develop and make extensive use of their competence in research and intensively contribute to the knowledge transfer via scientific publication, seminars and conferences. Furthermore, Spain organized every number of national and international conference related to quality. In addition, the number of Spanish scientific publications related to management system standards has increased considerably over the past years leading Spain to be among the top countries in the field.

Official Non-university training education related to quality

Most of accredited non-university educations are vocational training. Vocational training is typically provided in centres based in both public and private schools and also through distance education. As we explained earlier, vocation trainings are tailor-made as an alternative for students who do not want to attend university but seek a practical and higher education that qualify them to join the workforce. We have also searched through the database maintained by the Spanish National Institute of Qualifications (Instituto Nacional de las Cualificaciones and Educaweb) to identified existing vocational trainings related to quality management. The Spanish National Institute of Qualifications is responsible for defining and updating the National Catalogue of Professional Qualifications. The results of the search indicated that there are some official registered education and professional trainings in glass, textile and leather industry. There are also official training in transport, retails and restoration.

Some of the modules thought are related to characterization of testing and monitoring supplies, finished products and process manufacturing. There is also a thought module related to the products processing based on the environmental quality standard instructions that ensure the quality and safety of operations. We also identified some modules that assist in the organization and development of quality control of products in textile and leather. Some of those modules also sharpened students with the ability to monitor the implementation of such quality control and where appropriate may conduct technical tests to check the product/service technical specifications that ensuring compliance with management and environmental standard systems. Some discuss the certification and the regulation on registration whereas others tackle the issues related to the evaluation, authorization and restriction of chemicals especially when it concerns the protection of human and environmental health.

Moreover, there are modules discussing the basic strategies of customer satisfaction and quality service in retails and small own businesses. Moreover, some modules related to cost management training and quality of service of Road Transport as well as the characteristics and the implementation of quality systems and continuous improvement of trucking service and logistics. They are also thought module that define and plan restoration service processes according to the service standards and organizational procedures.

Unofficial Non-University education related to quality

Técnico and Técnico superior

According to the LOE, Spanish economic model can be achieved if the education system trains tomorrow's workforce adequately and efficiently. With the aim of moving the economy towards a sustained growth path and to improve linkages between education and business, Spanish government often promotes professional career development training program through the Centros Integrados de Formación Profesional. Those training programs are mainly professional training and intermediate vocational educations specially made for people who want to enhance or change their career. Our search related to quality indicated that there were some thought modules for example related to quality, safety and environmental protection in the restoration which trained professionals on how to analyze the process of design and implementation of management systems as a whole and in particular quality assurance and environmental management as well as how to adapt them in the organization. Some others modules are based on how to analyze data obtained during quality and environmental management processes and propose actions for continuous improvement of the company and / or entity.

Another module related to quality management in the food industry emphasized on how to analyze the quality and environmental management plan of the company based on the management system established. Moreover, some other modules lay emphasis on how to act responsibly in the workplace and on how to comply with environmental protection regulations. Furthermore, other modules also introduce students on how to analyze legal requirements and quality standards that a product must meet to ensure consumer safety. Besides, quality management and environmental control in textile industry offer to students the knowledge capability on how to analyze the samples of materials of textiles in progress and in finishing process as well as how to determine the suitable test procedures and quality control.

Training at work (organizations)

In Spain, a large proportion of human capital accumulation in the form of training takes place inside the organization. Therefore, it is not a surprise that most of the employers offer to their employee training regarding the recognition of the importance of documenting processes and environmental quality management as well as ensure that they understand their usefulness as elements of the organization management.

Furthermore, professionals or employees generally gained knowledge or experience based on some practical training offered by the organization. For example quality control in the receipt and dispatch of chemical products required some special training at work relate to quality control systems used in the process control of raw materials and finished products that conform to the quality management of the chemical process. Moreover, it is also necessary for employees to be able to perform physical and chemical measures variables related to quality and raw materials product control in addition to provide adequate associated logistic documentation.

Seminars and conferences (organizations)

A seminar in general is a form of academic teaching or professional training offered by a commercial or professional organization. It has the function of bringing together small groups for recurring meetings, focusing each time on some particular subject, in which everyone present is requested to actively participate. Organizations often see seminars as the perfect opportunity for employees to learn some skills and improve their know-how. Given that they create conditions for continuous learning and development of competence, innovation and dissemination of the results achieved at all levels of the organization. Consequently, it was not a surprise to see many Spanish companies that are now investing to develop seminars, training courses or workshops related to quality. Moreover, in order to refresh or update their employees' knowledge and skills, most of the organizations also sponsored a limited number of staffs to participate in national and international conferences and seminars.

Consultants

In general, many companies that opt to implement management system standards and achieve ISO registration often encounter numerous problems including but not limited to, the lack of formal structure related to work process, insufficient internal control procedures, uncomfortable level of the knowledge approach, as well as the limited number of employees and/or the employees natural resistance to change. In order to reduce these problems and increased effectiveness of the management standard, many Spanish companies often hire external consultants to help implement the management standard or to discuss the document of the various works in progress. Some other companies hire external consultants to train their employees and to provide advice on how to improve the process and maximize the productivity.

Additionally, not all consultants are external to the organization. We were able to trace internal consultants in bigger Spanish organizations. Those internal consultants also take on many of the same roles as their external counterparts.

CONCLUSIONS

Current social and economic conjuncture has caused changes in the labor market, in which most of the people opt for specialization training curriculum as a differentiating factor. In such context, one of the main challenges for the education and professional training is to meet the changing skills needs of individuals and the world of work in accordance with the principle of lifelong learning. While demand for new skilled workers is increasing, it is also necessary to attend to developing and upgrading the skills of the existing workforce and to promoting labor mobility.

In addition, most of businesses operating in the domestic and international markets are now characterized by a growing awareness of the importance of quality, safety and environmental management system standards. Therefore, many organizations have started to incorporate them as differentiating factors in their business strategy as well as training their employees or seeking new professionals in the domain. Furthermore, many people have also started to incorporate such demanded professional training to consolidate and improve their employment and career or to improve their positioning in the competing job application search that increasingly demands education and training specialization.

Moreover, the existing literatures also acknowledge that the best-trained and better-educated workforce has had effects on the business performance and the individual employment opportunities. Consequently, this document was intended to identify the existing education and professional trainings in Spain related to management system standards. In pursuit of this objective, this document first attempted to understand and describe the multifaceted of Spanish education and professional as a whole and their relationships with the labor market. Thereafter, this study thoroughly searched the existing education and the professional trainings related to quality and management system standard. The overall output results were classified into for different groups including: Official University, Unofficial University, Official Non University and Unofficial Non university.

In short, the concern about the employment and earnings in Spain has led the national government and the governments of the autonomous communities to launch measures designed both to continue increasing the quality of the workforce and to ease the difficulties encountered when entering the labor market. One of such measures is the education and professional training related to quality management. Obviously, education or training related management system standards provide to students and professionals the knowledge tools and experience that will ensure that their organization competitiveness goes beyond the limits imposed by the current management model. In addition, it helps to drive the organization development towards excellence.

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CRM in the libraries context: proposal of implementation in CEFET/RJ Central Library

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ABSTRACT

This paper presents a proposal for implementing Customer Relationship Management (CRM) in the CEFET/RJ Central Library using the DDI Model and CRM Four Pillars Model. Therefore, it addresses the management of customer relationships within a strategic management perspective of academic libraries. The research method adopted was the case study, with application of a specific instrument to measure the degree of relationship of the library with its customers, combined with an extensive literature research. After collecting and analysing the data, the aspects that can be improved in the library in question have been identified, and included in the proposal. This research is limited due to the method used in the sense of just addressing the point of view of a specific library and depending on scarce local research literature on the matter. The results showed that the studied library is able to adopt the focus on the user, through CRM, and that many of the elements of it are already covered by the collections management system already adopted. It was found that, with the adoption of CRM, libraries can achieve higher user satisfaction and operational excellence. Thus, this study mainly contributes to the strengthening of the theoretical studies of Librarianship focused on the strategic management of libraries and user studies and serve as a support tool for libraries that want to deploy CRM.

Keywords: Relationship marketing, CRM, Strategic libraries management, Academic libraries.

Article Classification: case study

INTRODUCTION

The libraries in the information society, need to reinvent themselves and make use of new and modern forms of management, since today face competition from the Internet, which offers a huge amount of information and, for reasons of ease and convenience, people tend to seek the information they need on the network, instead of searching libraries that hitherto exercised sovereignty of the function of providing access to information.

In this context, the implementation of Customer Relationship Management (CRM) is an alternative for libraries to able to successfully achieve their goals, knowing the exact needs of their users, in order to serve them properly, offering information services with quality. It is noteworthy that Information Technology (IT) is an ally in this process, seeking to facilitate the operational aspects of the strategies and CRM processes.

Given the mentioned above, the present article, in translating the concepts of CRM business environment for the library context, focusing in a more practical nature, aims at presenting a proposal for implementing CRM in the Central Library of the Federal Center for Technological Education Celso Suckow da Fonseca (CEFET/RJ), from the DDI Model and of the CRM Four Pillars Model. Therefore this research is an applied one, performed through a case study.

It is believed that working the concepts of libraries, whether academic, university, or specialized, based on the needs and relationships with customers can greatly contribute to the development of organizations to which they are linked, as pointed out by Finger, Castro and Costa (2007).

LITERATURE REVIEW

The improvement in internal processes of libraries, with regard to agility and efficiency, and services offered to customers / users is a real challenge. In fact, turns out to be a real challenge for libraries, even today, worry too much about the technical issues inherent in organizing collections over issues of access by the user of the materials, according to the real needs of each, exactly as Silva (2003, pp. 63) said:

> Normally, when holding the technicalities and the "esoteric" classification systems, the librarian can not see even the most urgent needs of the community it serves. Worried about giving the ten or twelve digits that make up the notation for the classification of work in technical preparation, the librarian does not realize that she is eagerly awaited by countless readers. But only when properly terminated the technical processing is that the book will be available to users. There may already be too late ...

However, in order to meet the pressures in order to progress and development in their management approach, both processes such as structure and services, various University Libraries (BUs) have sought new forms and models that enable them to reach (Finger & Castro, 2004). Therefore, currently the manager librarian tries to follow new trends and administrative paradigms, trying to adapt them to the reality of the library (Neves; Souza & Lucas, 2006).

The marketing is presented as a solution for this case, however, the relationship marketing itself as a better solution compared to traditional marketing, which is in the decline phase. For the libraries, as mentioned above, often seem to disregard your customer/user and their actual needs, the adoption of relationship marketing would provide better performance and results, as it seeks to create a good relationship between the company with customers, identifying their real needs and meeting them satisfactorily.

Peppers and Rogers (1997, pp. 85) state that:

> Relationship marketing was the way to do business before the Industrial Revolution, before the product of mass and before the mainstream media. The owners of a store, bank, barber shop or stable thought in your business primarily in terms of "customer participation". The shopkeeper was prior to the twentieth century, a marketing executive relationship that took care of the customers as individuals. He carried the database on the head.

In relationship marketing the company interacts with customers in order to target them and differentiate them by offering products according to the needs and desires of each client type. Thus, the company seeks a long-term relationship based on trust and loyalty with your consumers. The technology presents itself as the mediator of the company's relationship with the client, since it would not be a large company, for example, relate to all its customers, which can reach millions without using technology. According to Kotler (2006) companies to use e-mail, web, call centers, databases, software and websites in order to nurture such a relationship between company and client. Thus, states that the best relationship marketing is driven by technology. Gordon (2001) refers to the technology as a major component of relationship marketing, as seen above. If used properly, "technology can help the company learn from each intent with the client and deepen the relationship" (Gordon, 2001, pp. 98).

The technology is then girlfriend relationship marketing as Madruga (2010) states, since, after all, the same as the market grew, computer technology had significant improvements in cost and storage capacity (Vavra, 1993). At the time, the author dared to assert that, when facing the maintenance of the database of customers, current and future developments of the computer would be as important for marketing as the steam engine was to produce. Thus, the union of relationship marketing with Information Technology (IT) can help the company achieve competitive advantage, enabling it to increase the satisfaction and loyalty of your customer. Greenberg (2010), says that IT provides grants to operationalize the strategies and CRM processes, and fundamental to the organization to interact with their customers, creating various contact channels, information processing and transforming them into knowledge importance.

Relationship marketing has three key components identified by Vavra (1993). They are: quality, customer service and post-marketing. It is an approach to strategic management. It is used as an option for organizations that have the objective of profit, which is not the case for libraries. However, Oliveira (1998, pp. 174), to do a review of the international literature, emphasizes that "while some may question the applicability of management principles to the management of libraries, one issue is clear: nonprofits are actively adopting practices administrative ". Thus, Oliveira and Pereira (2003, pp. 27). Claim that for the units of information "a way of trying to 'survive' is articulate in terms of their products/services marketing, through relationship marketing".

Authors who approach the CRM define in various ways. Some define it as a philosophy, others as a business strategy, still others as a technological tool. There are even authors who have other definitions, however, it was considered in this study only the three mentioned initials settings. CRM as a management philosophy, is created from the identification of the need for customer centricity by companies for this reason, many companies have begun to turn to improving your relationship with your customers.

Valls, Souza and Beretta (2011) introduced the CRM as a management strategy, stating the following definition:

> The Relationship Management (CRM) is a business strategy that puts the customer as the central element of the business processes, understanding and anticipating their needs in order to serve them in the best way. The implementation of CRM though it is linked to the use of technological solutions, is much broader than that, because it involves the whole philosophy and practice management products and services, customer-driven processes and well-defined objective and measurable standards. (Valls, Souza & Beretta, 2011, pp. 14).

The definition given by the Gartner Group is as follows:

> CRM is a business strategy focused on understanding and anticipating the needs of current and potential customers and your company. From a technological standpoint, CRM involves capturing customer data throughout the enterprise, consolidate all internal and external data captured in a central database, analyze the consolidated data, distribute the results of this analysis to the various points of customer contact through any point of contact with the company. (Peppers & Rogers, 2004, pp. 48).

According to the definitions of CRM presented, one can define the user studies as the first attempt in the field of Librarianship to undertake the management of the customer relationship, since, according to the definitions presented by Figueiredo (1994), constitute a necessary action to identify exactly what the library needs and desires of their customers and turn them into demand for information products and services, with a view to supporting the development of collections.

According to the authors Newell (2000), Valls, Souza and Beretta (2011), CRM promotes customer loyalty by improving the quality of services offered by the organization, as well as their relation to those as mentioned Finger and Castro (2004). Peppers and Rogers (2004) propose four basic steps to the process of implementing a CRM program: identify, differentiate, interact and personalize.

Identify: is the identification of the organization customers, collecting the greatest possible number of data. It is essential to identify the customers so that we can establish a good relationship with them, otherwise the relationship is compromised. Thus, it is necessary to know the clients individually, in great detail. Once that is done proper identification, it is possible that recognition of them at every point of contact.

Differentiate: after identifying the customers, it is possible to differentiate them so that the company can prioritize their efforts. This differentiation can be made in two ways: the level of value to your business and the needs that have products and services of your company. Since the differences are established, the company can target and prioritize their efforts to take advantage of high-value customers, as well as customize their behavior based on the individual needs of services by customers.

Interact: consists of interaction between the company and its customers. The company should establish a good interaction with them, seeking, from the same, improving the quality of their services/products. That means establishing the optimal ways of interaction and communication with customers, due to cost and preference as well as analyze what the most useful ways in terms of return information about the customer and their behavior. An effective interaction helps to strengthen relationships with customers.

Personalize: to meet clients individually at the stage of identification, you can customize the products/ services of the company for each of them in order to better serve them. Customizing is one way that the company is to adapt to individual needs expressed by the client.

Madruga (2010, pp. 97) developed a methodology, called DDI, to implement the vision of CRM within organizations which, he said, is the step that must be antecedent to CRM investments. The model comprises three stages, which are outlined below:

1. **Discuss**:

- Strategic planning to be customer-oriented;
- The organizational structure of the areas of customer contact;
- The strategies, processes and business procedures to be aligned with the new vision;
- The focus of the organization and the relationship with customers and suppliers.

2. **Discard**:

- Rooted beliefs that puts the customer as the "necessary evil";
- Management attitudes that lead the child dependency and lack of autonomy;
- The idea that good advertising solves all the problems of relationship and customer satisfaction;
- The belief that marketing is synonymous only enemy of creativity and internal and external controls that benefit customers.

3. **Include**:

- The vision of legacy systems with new systems;
- All processes and interface that any impact on customers;
- The points of contact with the client, in whatever media or region is;
- Train people with new vision and the new changing environment to react favorably.

Thus, given the definitions presented for CRM, it is concluded that it can provide better customer service/user and hence a change in the actual management of libraries, with better reach your goals. After all, the librarian needs to understand that to survive he has to leave the comfortable position of receiver and executor and assume the role of protagonist in this story.

In this context, given that libraries can benefit from the use of new and modern ways of management and organizations with which they are linked, CRM is constituted as a strategic tool of relationship marketing, whose focus is on management the relationships between organizations and their customers and prospects. Thus, the implementation of CRM in libraries collaborate to achieve their goals of meeting the information needs of its customers, improving the quality of services offered and the relationship between libraries and users.

MATERIALS AND METHODS

For this study was adopted two methods of research: literature review and case study. For the literature review was conducted bibliographic sources that could support the discussion through bibliographic analysis of the materials found in searches. Searches were made in library catalogs and Internet search engines such as Google and Google Scholar; in databases of theses and dissertations of specific institutions and the Brazilian Digital Library of Theses and Dissertations; based on Scopus, the Journal Portal of the Coordination of Improvement of Higher Education Personnel (CAPES) and the Scientific Electronic Library Online (SciELO). Thus, the types of publications involved in the formulation of the theoretical basis of this study were the following: books, articles and scientific papers presented at events in the area of Librarianship and Documentation.

In conducting the case study of the instrument called Customer Relationship Scale (CRS), established and validated by Rozzett and Demo (2010) to measure the degree of relationship between companies and their customers has been applied. The universe worked corresponded to the total number of users of the Central Library of CEFET/RJ who owned asset register up to date 1/31/2014, totalizing 2,006 users to date of 9/10/2013, the start date of the interview. There was no sample selected for the questionnaire and therefore the questionnaire was sent to all users mentioned, comprising students from middle/technical education, students of post-secondary education, graduate students, students of technologist, students postgraduate studies, technical administrators and teachers servers. Sending the questionnaire was done by email and the return rate was approximately 23.7% (476 respondents). The application period is from 9/10/2013 to 11/04/2013.

THE CEFET/RJ CENTRAL LIBRARY AND YOUR RELATIONSHIP WITH USERS: CHARACTERIZATION AND CASE STUDY

The Central Library was founded on October 7, 1942, when the official opening of today Federal Center for Technological Education Celso Suckow da Fonseca (CEFET/RJ) Technical National School and support the development of teaching, research and extension institutions. The CEFET/RJ Central Library is considered in this study as an academic library type to cater for students in secondary/technical education, post-secondary, undergraduate, technologist, post-graduation and strictly. Moreover, it also serves faculty, technical and administrative staff and external community servers and is linked to a public educational institution. Has a collection of 9,088 titles and 19,575 copies, distributed among different areas. However the largest concentration of works in the collection are in the area of Engineering and Technology (3442 titles / 8649 copies). Adds that the collection is formed by the following bibliographic materials: books, reference works, academic papers and standards of the Brazilian Association of Technical Standards (ABNT). The services offered are: local consultation, joint loan, special loan, among the libraries of Education Decentralized Units, interlibrary loan (with other institutions libraries), renewal, reservation and preparation of catalog card work end of the courses the institution: final project, thesis and dissertation.

From the responses to the questionnaire, it was found that the most satisfactory review by the users was related to the honesty and correctness with which the library is the same, identified as a strong point. In contrast, the least satisfactory review was regarding the importance given by library users, identified as weakness, therefore, is an opportunity for improvement. When considering library consisting of seven dimensions (Treatment; Collection; Infrastructure and Environment; Signage; Services, Policies, Standards and Procedures; and Communication), it was found that the Treatment dimension received the most compliments and the Collection dimension received the most criticism. However, the most of the suggestions was focused on infrastructure and the library environment.

PROPOSAL OF CRM IMPLEMENTATION

The proposal to be presented was based on the DDI Model, Madruga (2010), and on the CRM Four Pillars Model, Peppers and Rogers (2004), in order to better serve its users the Central Library CEFET/RJ, investing in the quality of its products and services and to build a closer relationship of users, optimizing their satisfaction. It is noted that the data collected through the questionnaire applied to library users have contributed considerably to the development of the proposal, since it was possible to identify the strengths and weaknesses and opportunities for improvements in terms of managing the customer relationship in Examples of the library in question.

DDI Model

Discuss: strategic planning of the library to be user-oriented; the organizational structure of the areas of contact with the user, redesigning care processes; strategies, processes and procedures in the industry to be aligned with the new vision; the focus of the library and the relationship with users and suppliers; the technical processing to be speeded up the process of inclusion of works and that preference is given to inclusion in the system to the books that are most popular; formation of a multidisciplinary group formed by librarians, for a systems analyst and programmer, according to Lucas and Souza (2007); and a new form of reward to encourage employees to develop relationships with users.

Discard: rooted beliefs that put the user as the "necessary evil"; managerial attitudes that lead the child dependency and lack of autonomy; the idea that a good advertisement solve all relationship problems and satisfaction of customers/users; the belief that marketing is synonymous only enemy of creativity and internal and external controls that benefit customers; the idea that librarians must assume what the user wants, without even consulting them; the idea that every user has full knowledge about the use of the library; the idea that the library, because it is necessary for students not need to take marketing actions.

Integrate: all of the processes that influence and interface users in any way; the points of contact with the client, in whatever media or region is: phone, email, Web Terminal, among others; train people with new vision and the new changing environment to react favorably; the registration system used by the library with other systems of the institution, allowing a wider look on the users.

Four Pillars Model. The four steps presented by Peppers and Rogers (2004) are sequential steps. However, according to the figure shown at the time of interaction may result in information involving the identification of the user, returning to the first step (identifying) and redoing, if necessary, policies and established parameters (differentiate) to then customize the service or product. In Figure 1, the arrows with padding in black indicate the direction of information flow for each step. Have the arrows with gray shading indicate the sequence of steps involved in the implementation of CRM.

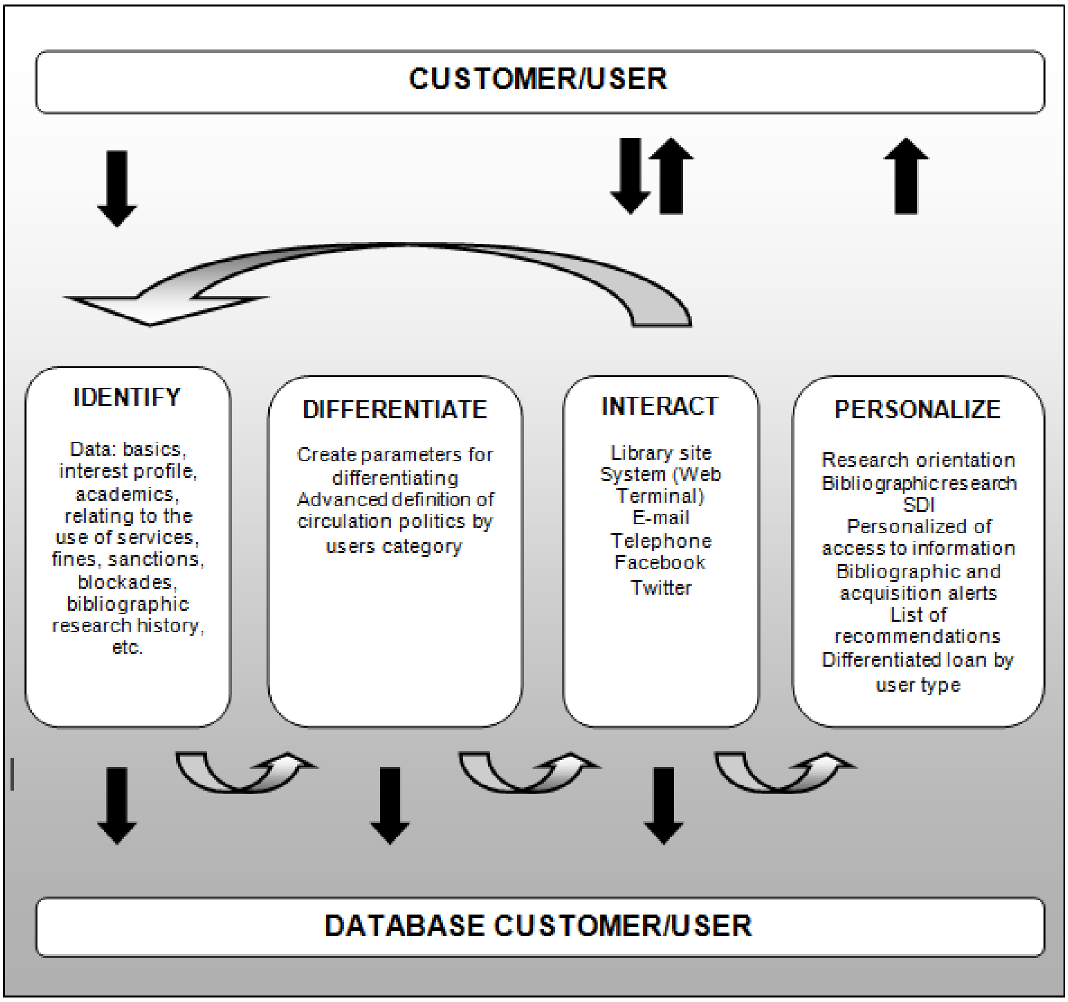

Figure 1 – CRM process in CEFET/RJ Central Library

Source – The authors (2013)

The management collections system (Sophia). Between the implementation of the vision of CRM and CRM implementation in fact, has a range that corresponds to the period in which the technology should be chosen, ie, the CRM system will be used. Wherefore, Madruga (2010) sets out the steps to hire a CRM solution. Neves, Souza and Lucas (2006) theoretically substantiate the relationship of the CRM four pillars (identify, differentiate, interact and customize) with user modules of the software used in the administration of BU. Similarly, we sought to determine which elements of CRM are covered by the system used by the library. It was found that many of the functions contained in the proposal are addressed by the system used by the library on the CRM Four Pillars Model, Peppers and Rogers

(2004). Thus, it was found that the Sophia fulfills the function of a CRM software in the light of the DDI Model and Four Pillars Model.

CONCLUSION

The results here presented showed that it is possible for academic libraries to adopt the focus on the user, through CRM. Thus, the CRM adoption by those organizations can bring greater user satisfaction, since, according to this study, it was demonstrated that it is possible to eliminate criticism regarding various aspects of the library, whether relative to services, assets, infrastructure, among others.

It was verified that the management system adopted by the CEFET/RJ Central Library, under the light of the CRM Four Pillars Model and DDI Model, fulfil the function of a CRM software. In relation to the technical and data warehouse and data mining technologies to be used in the development of a CRM software, one cannot say that it fulfils the function of CRM system because it was not considered that aspect. Therefore, if the library chooses to implement a CRM system itself, it will need to do some planning and budgeting before any kind of action for implementation of relationship marketing and infrastructure.

Another important point that was presented in the literature review is that CRM is not an initiative that has to be implemented as a single block. Besides being possible, it is indicated that the implementation must be gradual, for example, starting by a specific process with few customers, and then moving gradually as the culture is assimilated by the organization and the results are demonstrated. After all, once convinced of its philosophy, the organization can gradually begin to modify its behaviour towards customers.

In transposing the concepts of CRM business environment to the context of libraries and information units, it was found that marketing as a management philosophy for the units of information is not important for most librarians and managers. Thus, the adoption of marketing for libraries is still not seen as a must for their operations.

It is interesting to implement CRM in academic libraries, not in terms of financial returns, as happens with enterprise deployment, but to achieve greater user satisfaction and operational excellence. In addition, the library allows greater interaction with the customers, in order to best meet their requirements for use and access to information, improving the services offered, as well as in decision-making, by enabling better planning.

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