1ST Conference on Quality Innovation and Sustainability (ICQIS)

PROCEEDINGS

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Preface

We are very pleased to have you participate in the 1st Conference on Quality Innovation and Sustainability – ICQIS2019 in Valença, Viana do Castelo, Portugal. The conference is being organized together with Business Sciences School of the Polytechnic Institute of Viana do Castelo. It takes place in Valença on the 6th and 7th of June 2019. Our main goal is to join together in this event academics and practitioners from a variety of fields and the dissemination of knowledge and the exchange of good practices among in the main domain of quality management, but also in innovative practices and sustainability. We expect to provide a forum of debate for researchers and practitioners, contributing to support the sharing of experiences, to promote cross-knowledge and strengthen the academic-industry relationship.

This book compiles the papers presented at the 1st Conference on Quality Innovation and Sustainability (ICQIS2019)

The Editors would like to thank all the authors and reviewers for their valuable contribution and for making ICQIS2019 such a big success.

Thank you very much for your important participation and collaboration in ICQIS2019!

Quality control - Trends and Challenges

Miladin Stefanovic Faculty of Engineering, University of Kragujevac, Serbia

Advances in technology that form the foundation for Industry 4.0 will transform production: isolated, optimized cells will come together as a fully integrated, automated, and optimized production flow, leading to greater efficiencies and changing traditional production relationships among suppliers, producers, customers and between human and machine (Rüßmann et al 2015). These new technologies that form main pilars of industry 4.0 are (Rüßmann et al 2015, Lee et al. 2015, Brettel et al. 2014): Big Data and Analytics, Autonomous Robots, Simulation, Horizontal and Vertical System Integration, The Industrial Internet of Things, Cybersecurity, The Cloud, Additive Manufacturing, Augmented Reality. Industry 4.0 have large imapct on differnt areas so we have concepts such as: Quality 4.0 (Gunasekaran et al., 2019), Maintenance 4.0 (Franciosi et al., 2018; Scurati et al., 2018), Safety 4.0 (Badri et al., 2018), Cybersecurity 4.0 (Lezziet al., 2018), Operator 4.0 (Peruzziniet al., 2018), Logistics 4.0 (Barreto, et al., 2017), or influences and connections with SCM, Lean (Sanders et al 2014). Today we can state that future of Quality Control and Quality Management is in implementation of ICT technology following the road map of Industy 4.0. We need to prepare for concept of Quality 4.0 and QMS 4.0.

What is the biggest challenge in implementation of the Industry 4.0 or underlying concepts? Indsutry and acedemia have similar answers: Standardisation and Reference Architecture, Managing Complex Systems, Delivering a Comprehensive Broadband Infrastructure, Safety and Security, Work Organisation and Design, Training and Continuing Professional Development (CPD), Regulatory Framework and Resource Productivity and Efficiency (Liao et al. 2017). Even the industry have greater focus on workforce (knowledge and understanding), implemetation costs (where and how to spedt capital) and complexity of the system (sensor technolgies, digitalisation and automation).

It could be concluded that Industry 4.0 is a philosophical transformation of the society and Quality 4.0 proposes the adoption of advanced ICT to enhance quality efficiency and competency. The introduction of an Industry 4.0 based quality control necessitates integration steps within and outside the manufacturing company. Furthermore, company partners or customers have to be integrated into the development as they are all part of the overall value chain. Afer all two the biggist clalangies will be: Understanding and knowledge: both in industry and academy and Designing Quality / Industry 4.0 systems involves complexity, systems from the high dimensionality and complexity.

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Innovation is not an activity: Product development is the key for Innovation achievement

Enrique Mandado Pérez, University of the Basque Country, Spain

INTRODUCTION

The development of the technique in some Northern European countries, led to a climate conducting to the pursuit of knowledge of the physical phenomena behind it. It was precisely in those countries, where Science was born (from the latin “scire”, which means "know"), trying to get information about the physical principles behind the different existing artifacts (the water mill, the wheel, etc.) to improve their performance.

The most important concepts related with **Innovation** are the products defined as systems with the ability to perform a set of actions providing a service to people.

TECHNOLOGICAL DEVELOPMENT

Technological development is an activity including a set of systematic tasks, based on existing knowledge, acquired through scientific research or practical experience, and aimed at the production of materials, products or devices, or the establishment of processes, systems or services.

In the case of the products the most important target is the development of a prototype that can be manufactured in series to be sent to the market. It gives rise to specific products and/or specific production techniques, being protected by an utility model. Due to that **Innovation** is the result of technological development that has success when arriving to the market.

One often hears that technological development is a thing of the companies and the role of the administration should focus more on scientific research, but the example of several countries such as USA and Germany casts doubt on this theory.

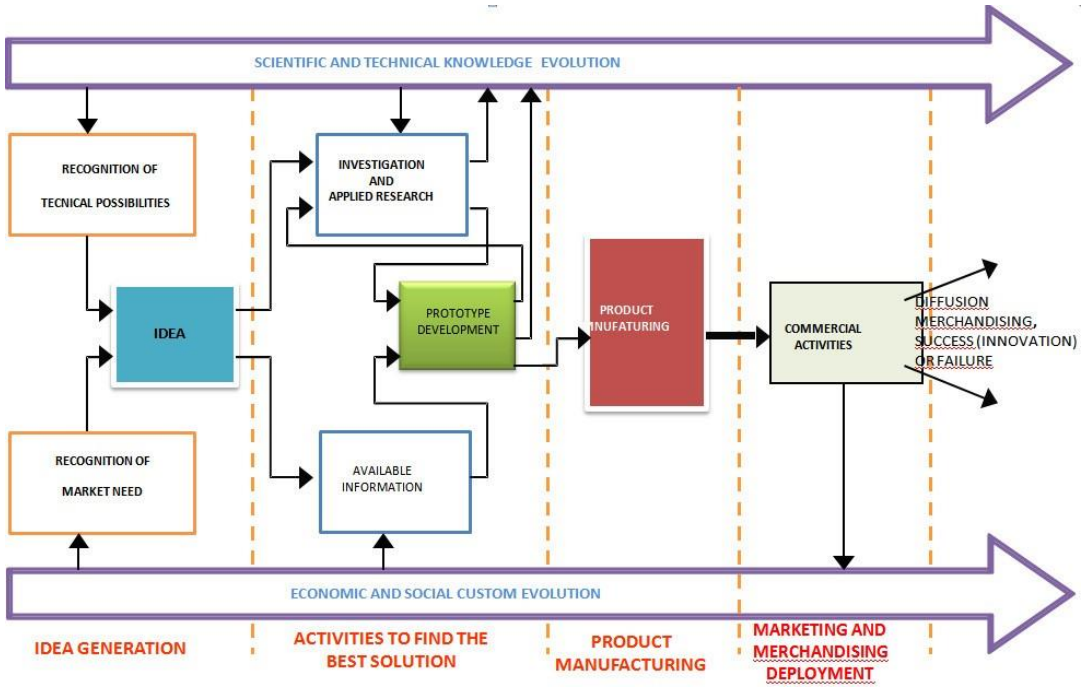
TECHNOLOGICAL CHANGE

It is the result of the Technological Development applied to a product, process or service to replace that existing until that time or to improve it with the aim to succeed in the market. It is based, at times, on the result of scientific research, as was the case of the transistors, but also gives rise to the product improvements through the changes introduced in the manufacturing processes by the technicians who work in them not needing scientific knowledge but experience in the process.

INTEGRATED MODEL OF THE PRODUCT GENERATION PROCESS AND MANAGEMENT

The set of the required activities to be able to introduce a product, a process or a service with success in the market gives rise to a complex integrated model of the product generation process and management. This process is shown in the drawing and it comprises four stages:

- Idea generation
- Activities to find the best solution
- Product manufacturing
- Marketing and merchandising deployment.



It is interesting to describe every stage.

Idea generation

It is the phase where the object of the improvement or generation of a product (Idea) is established. May be based on the recognition of a technical possibility obtained from the scientific knowledge, the technological expertise, a market need recognition or a combination of them. Creativity is generated by imaginative association at some point in the interrelation in perpetual change between Science, Technology and Market. It is usually inexpensive because well prepared persons, in contact with the problem, can be ready to bring the essential definition of the idea.

Activities to find the best solution

It comprises a set of activities to obtain available market information and investigation about applied research and technological development to find the best solution to the problem, reducing the uncertainties associated with the development of a product through tests of little cost.

There are still many uncertainties as well as, for example, the cost of the manufacturing process, the time required to do this, the price at which they can sell, the demand that will have on the market at that price, etc.. These uncertainties are delimited and the company scope established, and at this stage are involved in addition to the researchers, production technicians and those responsible for marketing (Business administration specialists), to carry out a strategy that receives the name of “Concurrent engineering" and leads to the concept of Total Quality Management (TQM).

Product manufacturing

It has the objective of industrial manufacturing of a prototype obtained in the previous phase. It is essential in the case of the products. Design methods and standards are properly modified. Tocarry it out should be used many times, constituting a process improvement. It is very important to take into account the quality criteria to ensure the maximum possible success in the next phase.

Marketing and merchandising deployment

It is the set of required activities to introduce a product, a process or a service with success in the market. Their costs are derived from market investigations, and comprise the costs of establishment or maintenance of distribution networks, sales and after-sales services, as well as those of the initial advertising campaign.

It is closely related to the brand image of the company because if it is good the costs of this phase are reduced and the success is ensured.

CONCLUSIONS

From the above integrated model we can conclude:

- A high level scientific system and a high degree of scientific originality is not a necessary condition, nor sufficient, for technological dynamism. It means that for a company or a country to be dynamic from a technology perspective, it is not always necessary to devote great efforts to the scientific basis strength.

- Any country wanting to play a relevant role in the world must promote basic research because of the benefits that can occur in the future but, above all, if it is a country that possesses a technological deficient state of affairs as the case of southern european countries (which translates into a trade deficit and lack of competitiveness), they must choose very well the fields of science to which they dedicate resources, and try to balance the effort made with public money between Scientific Research and Technological Development.

ICQIS2019 *(Sessions)*

06 June - SESSION 1 *(11:30/12:30)*	**06 June - SESSION 2** *(11:30/12:30)*	**06 June - SESSION 3** *(11:30/12:30)*
Session Chair – Marta Ferreira Dias (U. Aveiro) **room: lab.4**	***Session Chair – Mario Pereira (P. Leiria)*** **room: lab.6**	***Session Chair – Teresa Morgado (U. Nova de Lisboa)*** **room: lab.7**
Digitalization for sustainability: opportunities for medium density urban regions (ICQIS_2019_ID101) *Angélica Souza, Liliana Baptista, Maria Sarmento, Marta Ferreira Dias, Marlene Amorim* **Easing the retail store experience with digital technologies: discussing the promise of customer convenience vis-a-vis customer effort** (ICQIS_2019_ID105) *C. Borges, M. Amorim* **Wood furniture SMEs approaches towards Circular Economy: a literature review** (ICQIS_2019_ID107) *M. D'Anghela, L. Bravi, F. Murmura* **Main Benefits of Integrated Management Systems through Literature review** (ICQIS_2019_ID111) *S. Talapatra, G. Santos* **Circular Economy and Quality Management within the Furniture Sector: an exploratory study** (ICQIS_2019_ID108) *E. Savelli, M. Barbaritano, L. Bravi*	**Application of FMEA for improvement in the manufacturing process of mobile phones in a factory of the industrial pole of Manaus** (ICQIS_2019_ID113) *Samuel S. da M. Batista, Marcelo A. de Oliveira, Dercio L. Reis, Gabriela de M. Veroneze, Gisele A. C. Pedroso* **Six Sigma: Main Metrics and R Based Software for Industrial Quality Control and Teaching Purposes** (ICQIS_2019_ID119) *M. Rui Alves, A. R. Costa, C. Barbosa* **Mapping, identification and improvement of the productive capacity of the printed circuit board cutting sector: Case study in a board assembly company of the industrial pole of Manaus** (ICQIS_2019_ID114) *Patrick da F. Félix, Marcelo A. de Oliveira, Dercio L. Reis, Joaquim M. da C. Craveiro, Gisele A. C. Pedroso* **Running Small Lean Projects in Transport and Logistic Services** (ICQIS_2019_ID122) *Mário Lobo, Tiago Pinho*	**Quality Management Systems: Motivations Benefits and Barriers to the Implementation of the ISO 9001:2015 Standard in Italian Companies** (ICQIS_2019_ID115) *L. Bravi, F. Murmura, G. Santos* **The importance of ISO 9001: current perceptions** (ICQIS_2019_ID126) *F. Carvalho, J. C. Sá, L. Barreto, A. Amaral* **Renewable Energy for Sustainable Mining** (ICQIS_2019_ID110) *W. Alves, P. Ferreira, M. Araújo, J. Souza* **Improvement of the Volumetric Occupancy Rate of the Trucks in the Warehouse-Store Transportation in a Retail Food** (ICQIS_2019_ID103) *M. Enes, A. Silva*

06 June - SESSION 4 *(16:15/17:30)*	**06 June - SESSION 5** *(16:15/17:30)*
Session Chair – Rui Alves (IPVC) **room: lab.4**	***Session Chair Teresa Pereira*** **room: lab.7**
The main benefits of the Implementation of the Quality Management System (QMS) in Higher Education Institutions in Angola (ICQIS_2019_ID118) *Nicolay Africano, Ana Sofia Rodrigues, Gilberto Santos* **IPVC Student: Indices of Attractiveness, Loyalty and Student Satisfaction** (ICQIS_2019_ID104) *A. S. Rodrigues, J. Ferreira, P. Sousa, C. Quintas, M. Amorim, A. Carvalho, F. Carvalho, M. Rocha, L. Saraiva* **Quality assessment and Customer Satisfaction in IPVC Food Services** (ICQIS_2019_ID106) *Matos D.V., Rodrigues A.S., Pereira M.A.* **Study of the service satisfaction index of the Angolan banks** (ICQIS_2019_ID102) *Álvaro Cairrão, António Cardoso, Cesário Fançony*	**TRIZ and Lean Philosophies applied to Management Activities** (ICQIS_2019_ID123) *J. Sandiães, T. Morgado, H. Navas* **TRIZ Methodologies in Processes Improving of Lean Production** (ICQIS_2019_ID124) *A. David, T. Morgado, A. Sartal, H. Navas* **Lean Manufacturing - Adding Competitive Advantages in the Mould Industry** (ICQIS_2019_ID125) *A. M. Pereira, A.B. Bastos, M.A. Domingues, M.R. Silva* **Lean Philosophy and Management Assets applied to Industrial Valve Production Company** (ICQIS_2019_ID120) *J. Costa, T. Morgado, H. Navas* **Forensic phases in the Industrial Sector** (ICQIS_2019_ID109) *José Luis Rivas, Enrique Mandado*

Table of Contents

Digitalization for sustainability: opportunities for medium density urban regions

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ABSTRACT

The transformation of work and the urgent need for the regions to develop leads to a growing demand for highly skilled workers. It is important to realize what medium density urban regions are lacking in order to become competitive when compared to large cities with a much higher talent retention capacity. This article offers a contribution to develop knowledge about the challenges and opportunities for medium density urban regions, taking as an example the case of the region of Aveiro. Data was collected using questionnaires and interviews to graduate and undergraduate students of the University of Aveiro, a university located in a medium density urban region in Portugal. A total of 104 answers were collected aiming at understanding the main factors of attractiveness of the Aveiro region and the perception that students have about its labour market, as well as the main amenities that are crucial for the decision about working in the region in the future. This study is timely and relevant notably for local government, regional companies and higher education institutions of Aveiro region, since it points out key areas of concern, supporting the promotion of active strategies to retain highly qualified workers. Moreover, it identifies, according to prior literature and by auscultating students of the regional ecosystem, the main issues that will require attention by the local government in order to build the best conditions to seize a more efficient strategy to attract talent.

Keywords: Sustainability, Digitalization, Migration, High skilled human capital, Medium density urban region, Attractiveness of regions, Graduate and undergraduate students.

1. Introduction

Despite the enormous adversities and disadvantages associated with urban agglomerations, the world's population has increasingly been concentrating on major metropolises. Large cities offer a huge range of jobs and career opportunities that smaller cities tend not to do. Another important point is that most of the time, smaller cities may have a larger number of small and medium-sized companies that may not provide the same working conditions and growth opportunities that can be found in larger companies, that often are located in larger cities [1]. For medium density urban regions, today's challenge is not just how to create more jobs, but how to improve benefits, wealth creation, as well as quality of life and sustainability through new opportunities for its in habitants. In this perspective, it is necessary to rethink local policies and initiatives focusing on attracting and retaining highly qualified people in order to reach the need for development and sustainability of these regions [2].

The implementation of digitization presents itself as a great opportunity for developing regions, as it is a way of improving their competitiveness and creating new jobs and opportunities. There are several ways to understand what digitization is. According to the literature, it may be seen as the development of digital technology and the improvements introduced in the domains of production, leisure, living and care. The digitalization process is generating a series of activities, directly or indirectly linked to production, or to services, in all sectors with great impact on the economy, boosting innovation and changing production and business models [3]. The digital transformation creates new demands for highly skilled and creative people able to adapt and develop specific tasks. However, the ability if a region to attract such talent will be tightly linked with its ability to support individual in their qualification and integration strategies, in a labour context that is constantly changing. Digitalization is transforming industries and creating new work contexts, that allow for individuals to become more responsible for constructing their own careers and biographies. At the same time the range of opportunities, and the improvements in the possibilities for mobility and relocation in new territories is creating a more complex decision-making context for every individual, particularly for those that are initiating their careers. Over the last decade we have witnessed growing complexities in the locational choices of individuals, notably for those with high levels of education, that are experiencing increased work-related mobility. Identifying the factors that attract and retain talent has become an important research agenda. Moreover, because competences for this digital revolution are increasingly important for the citizens day-to-day life, it is necessary to develop them inside, but also outside the job contexts [4]. The great challenge that regions are facing associated with the digitization of work and life contexts is related with the attraction and retention adequate professionals, i.e. those that are either ready or more fit to be requalified and integrated in the new professions and work settings. Highly skilled workers tend to have higher mobility indices, so all the research focus on understanding the determinants of this migration are crucial [1]. Local labour market conditions influence mobility decisions; however, the intrinsic characteristics of a region, as perceived by the individuals, are also highly important. Therefore, it is necessary to investigate what are the characteristics of the regions that (highly skilled) workers value when making their decisions about choosing a region to work and live. Understanding the importance of the characteristics of region such as infrastructure, culture, leisure offer, accesses, cost of living and other amenities of cities, is the key point for the beginning of development [1].

From this point of view, regional decision makers and policy entities will play a key role in the creation of the right conditions for the attraction of human capital. Regional policy aimed at increasing the attractiveness of regions should therefore consider both the stimulus to the local economy and the improvement of the quality of life and the welfare of the population [5]. Better local policies will help establish more stable labour markets with more job opportunities [5]. Therefore, policy makers should concentrate on policies to strengthen the factors of attraction according to what their local determinants are. These policies should be developed in such a way that also include social inclusion, which is crucial for a sustainable and equitable regional growth [3].

Knowledge is the raw material for transforming and providing human capital with new opportunities. In this way, the role of universities is equally fundamental for regions since they have the power to attract new talents to region and, at the same time, to provide adequate training for all individuals [6].

If the region has a high ranked and well-known university that may be a positive factor to attract high skilled workers. However, student mobility will be determined, not only by the quality of universities, but also by the conditions of the local labor markets and the life conditions of a territory. Consequently, the decision of young graduates, when reaching the end of their university education, about the region that they will choose to live and to work may be a good indicator of the attraction power of that region [7]. Some regions grow, to a certain extent, because they are able to retain the graduates from local universities. When a region has a concentration of industries that can offer a stable demand for a university-

educated population, it is likely that that it will attract attracts graduate talent. Moreover regions with a large amount of highly skilled workers may also attract migrants with higher education because they will be more productive when they are close to other university graduates [8].

The interregional migration of university graduates in Finland and their results stressed that, although graduates are particularly mobile, most of them do not change from their region of studies in the first 10 years after graduation. The same study also concludes that this migration is much higher among graduates in more peripheral universities than in larger urban centers [6]. Moreover, migration is substantially more likely for those studying outside the region of origin than for those who study close to home. The larger or more developed the local labor market is, the more likely the newly graduates remain, especially in large metropolitan areas [6].

This article offers a contribution to develop knowledge about the challenges and opportunities for medium density urban regions. The remainder of the paper is as follows. Section 2 describes the main factors of regional attraction mentioned in the literature. Section 3 presents a brief note on the methodology used. Section 4 is dedicated to the main empirical results and section 5 concludes.

2. Factors of regional attractiveness

For a region to become attractive for skilled workers, it needs to create means and possibilities that meet the demand of these human resources. These have distinct capabilities that distinguish them relatively to unskilled workers and have the potential to leverage a region. Young university graduates are considered as skilled workers [1]. Several research results can be found in the literature mentioning the reasons for migratory flows and the variables that have a direct effect on workers' choices. The characteristics of the labour market, including the opportunities available and the expected wage levels are crucial factors for recent graduates to be attracted to a particular region. Graduates formulate the choices of migrating based on the opportunities offered by the labour market [7]. As for the accessibility aspect of a given region, this is also found relevant for skilled workers, but it is even more relevant for recent graduates, since these are closely linked to their family and its proximity [8]. Another favourable impact on the urban migrant balance of skilled workers is attributed to the affordability of housing and infrastructure, since workers will only change their location if the utility of the change outweighs the utility of staying [2]. Culture, leisure and occupations are other factors that the qualified workers take into account in the decision to move to a certain region, since these are associated with increased quality of life and well-being. The climate also proves to be significant as people look for pleasant places that can enjoy with good weather conditions [1], [9]. Finally, some factors present themselves as having negative influence such as: high crime rates, high pollution levels and high cost of living. These may alienate people because they want to be safe, healthy and they want accessibility [1], [9], [10]. In order to summarize the characteristics that make the regions more attractive, we identified several variables in the literature that allowed us to formulate the survey used in the data collection that informed the development of this study. All these factors and indicators may be used in policymaking. The following table offers a summary overview of the variables identified in the literature.

Table I. *Main variables found in the literature (elaborated by the authors)*

Author	Country	Data	Variables
Imeraj L., Willaert D., Finney N. & Gadeyne S. (2018)	Belgium	Inquiries regarding residential shift	Age, gender, origin, density, employment, nationality, Higher education, parents' education level
Busch T., Hamann S., Niebuhr A. & Rossen A. (2017)	Germany	Migratory flow, its causes and record of employers taken from	Salary level, employment/ unemployment rate, culture, leisure, diversity index, city's size, criminality tax, population's density,

		the Institute for employment Research	accesses transportation, climate, sun, pollution, regional prices' index
Caragliu A, Del Bo C. & Nijkamp P. (2011)	EUR - 27	Data from internal audict	BIP per capita, employment at the industry, accessibility, Public Transport's Network reliability, government and human capital
Betz, Partridge M. & Fallah B. (2015)	USA	Industry employment – NAICS and US community survey	Graduation, income per capita, industry's growth index, demographics and natural amenities' scale
Busch T., Hamann S., Niebuhr A. & Rossen A. (2014)	Germany	Annual information regarding migratory fluxes - NUTS3	Liquid migratory tax, salary level, populational density, criminal rate, price index, pollution, accessibility
Krabel S. & Flother C. (2014)	Germany	Probability of migration through graduated questionnaires	Age, gender, international mobility, mobility from the University to the job, salary level, area of studies
Dotti N., Fratesi U., Lenzi C. & Percoco M. (2013)	Italy	University enrollment of Italian students at provincial level (NUTS 3)	Origin, destination, distance, University, region's employment rate, region's income, housing price, job opportunities for pos-grads
Haapanen M. & Tervo H. (2012)	Finland	Data from the inquiries' panel and Employment statistics	Gender, age, level of education, employment, unemployment, distance from the familiar aggregate's characteristics. Region NUTS 3.
Garretsen H & Marlet G (2017)	Netherlands	Urban amenities, agglomeration and price of housing	Educational level, University in the City, salary level, free time occupation, criminal rate, job opportunities, proximity to railway stations, house prices, proximity to beaches

3. Methodology

The present article addresses the results from an exploratory study that aims identifying and contributing to understand the main factors of attractiveness of the Aveiro region and the perception that students have about the labour market of the region, as well as the main amenities that are crucial for the decision of working in the region in the future. The study involved the application of questionnaires and interviews to students of the University of Aveiro. It allows the collection of 104 responses obtained via online and by face-to-face application. The Likert type scale was used to classify from 1 (Not relevant) to 5 (Extremely relevant) the attractive factors of the regions, and 1 (Totally disagree) to 5 (Totally agree) some particular aspects of the labour market of the region of Aveiro.

3.1 Sample Characterization

Among the 104 questionnaires collected, from students of the University of Aveiro, it was possible to count answers from 61 (59%) female students and 43 (41%) male students. The age ranged from 18 to 54 years, with an average of 31 years.

The majority of the individuals are national students (N=87; 84%) and only 17 (16%) are international students. In relation to degree of study (see figure 2), the sample was divided into two groups to improve the quality of the results. The first group is formed by undergraduates 40 (38%), are composed of licentiate degree students, the second group is graduated 64 (62%), represented by advanced studies students 1 (1%), master degree students 54 (52%) and PHD students 9 (9%). The courses attended by the students are several, predominantly economy with 45 (43%) students, translation with 16 (15%) students and sustainable energy systems with 6 (6%) students.

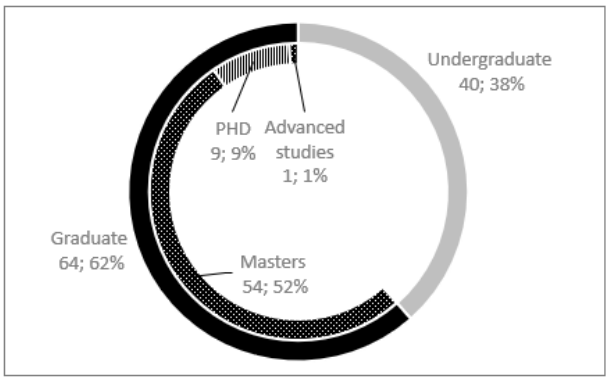

Figure 1. *Degree of Studies*

3.2 Statistical analysis

Data were analyzed through statistical analysis which were adapted to the several goals of this study. To do so, version 25 of the Statistical Package for the Social Sciences (SPSS) IT software was used to meet the necessary calculations regarding descriptive statistics and statistical inference. Concerning descriptive statistics, percentages, means, and standard deviations of the characterizing variables were calculated. Statistical inferences using parametric testes consisted of t student tests with independent samples to then compare among the two groups [11].

4. Results

4.1 Attractiveness of regions

The results show that the major aspect that influences the choice to work in a certain region is the "1-Cost of Living" (M=4.31, SD= 0.871), followed by "2-Accessibility/ Transportation" (M=4.21, SD= 0.952) and "3- Criminality" (M=4.08, SD= 1.031). The aspect "4-Infrastructures" shows up immediately after (M=3.98, SD= 0.907) and so does "5- Culture/ Leisure" (M=3.58, SD= 0.962). Lastly, "6-Pollution Level" (M=3.43, SD= 1.077), "7-Climate Characteristics" (M=3.27, SD=1.286) and "8- Population Density" (M=2.85; SD=1.031).

When we wish to assess which aspects are more valued by graduates and undergraduate students (see figure 3), results suggest that "Cost of living" (M=4.43, SD=0.958), "Accessibility/ Transportation" (M=4.38, SD=1.030), the "Infrastructures" (M=4.03, SD=.932), the Pollution Level" (M=3.68, SD= 1.023) and the "Population Density" (M=2.93; SD=0.917) are more relevant to undergraduate students than to graduate students. In turn, aspects related to "Culture/Leisure" (M=3.63; SD=1.000) and "Climate Characteristics "(M=3.39; SD=1.387) are more valued by graduate students.

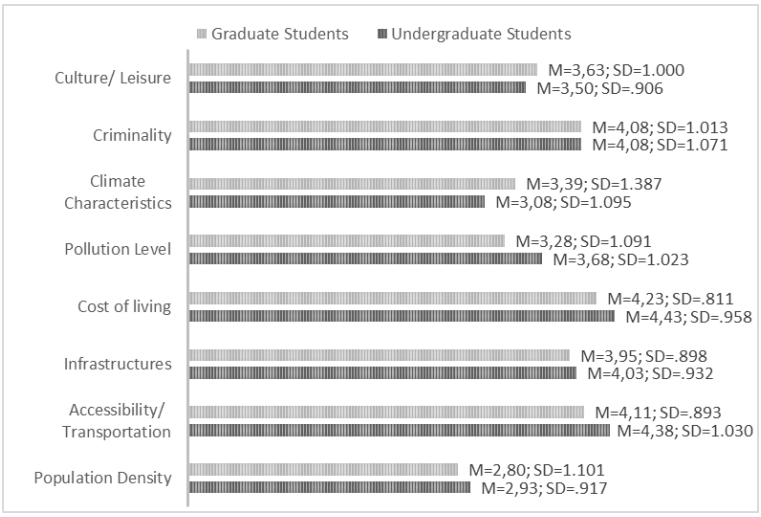

Figure 2. *Most important aspects of attractiveness in a Region according to graduate and undergraduate students' perspectives.*

4.2 Labor market in the region of Aveiro: Differences concerning graduate and undergraduate students' perceptions of the labor market situation in the region of Aveiro

Concerning the labor market in the region of Aveiro, four different parameters were assessed: Change easily – "I will be able to change to another job easily in Aveiro"; Salary in average – "I believe the salary for the job I want in Aveiro is within the average"; Employ easily - "I believe that I will find employment easily in Aveiro", and Job opportunities - "This region provides job opportunities for the newly graduates". Ultimately, and taking into account the full sample (N=104), students showed a higher average in the statement "This region provides job opportunities for the newly graduates" (M=3.19, SD= 0.946), followed by "I believe the salary for the job I want in Aveiro is within the average" (M=2.88, SD= 0.885). The statement "I believe that I will find employment easily in Aveiro" (M=2.87, SD= 1.015) shows up immediately after and lastly "I will be able to change to another job easily in Aveiro" (M=2.72, SD=0.806). Considering the perception of undergraduate students and graduate students regarding the parameters which characterize the labor market in the Aveiro region, by analyzing Figure 4 it is possible to notice that undergraduate students have a more positive outlook on the parameters overall (Change easily, Employ easily and Job opportunities) than graduate students. In turn, graduate students consider that wages in the region are more within the average than undergraduate students.

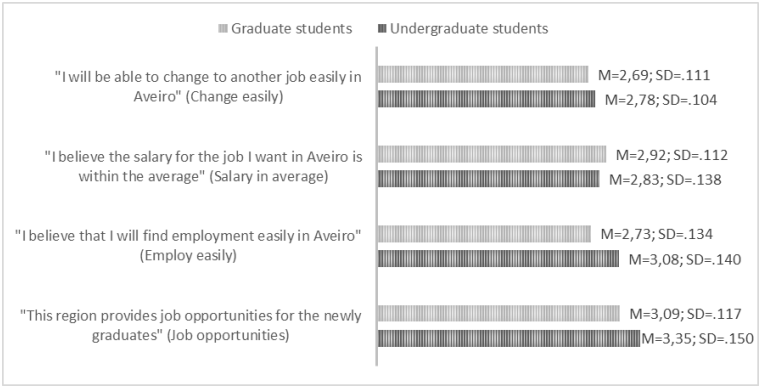

Figure 3. *Students' perceptions of the labor market situation in the region of Aveiro*

Concerning the division of the sample according to the graduation of the students, a random selection of 62% of the total graduate students (n=64) for statistical adjustment was performed. Thus, the first group of undergraduate students counts N=40 (47.3%) and the second group of graduate students N=43 (52.7%), as shown in table I. Results suggest there are significant statistic difference between graduate and non-graduate students when it comes to the statement "I believe that I will find employment easily in Aveiro".

This statement has a higher ranking amongst undergraduate students than amongst graduate students. Therefore, undergraduate students – those attending their first degree – believe they will find a job in the Aveiro region more easily than graduate students, in other words, students who are attending a master's or PhD degree.

Table II. *Differences between graduate and undergraduate students regarding the labor market situation in the region of Aveiro*

Labor market situation in the region	**Graduate students (N=43)**		**Undergraduate students (N=40)**		**Statistical test**	
	M	**SD**	**M**	**SD**	**T student**	**p**
"I believe that I will find employment easily in Aveiro" (Employ easily)	2.63	1.113	3.08	0.888	2.029	0.046

df=79

4.3 Willingness to work in the region after completing the course

According to the answers of those who were surveyed, it was possible to see that 27.9% of students would choose the region of Aveiro to work. Many students (51.9%) are unsure regarding this possibility. In turn, only 20.2% of students would not choose the Aveiro region to work. When analyzing Figure 5, it is possible to realize that 37.5% of students who wish to stay in the region are graduates and only 12.5% are undergraduate students. Out of those who do not wish to stay in Aveiro for work, 25% are undergraduate students and 17.2% are graduate students. Out of those students who still have not made up their mind, the majority are undergraduate students (62.5%) and 45.3% are graduate students.

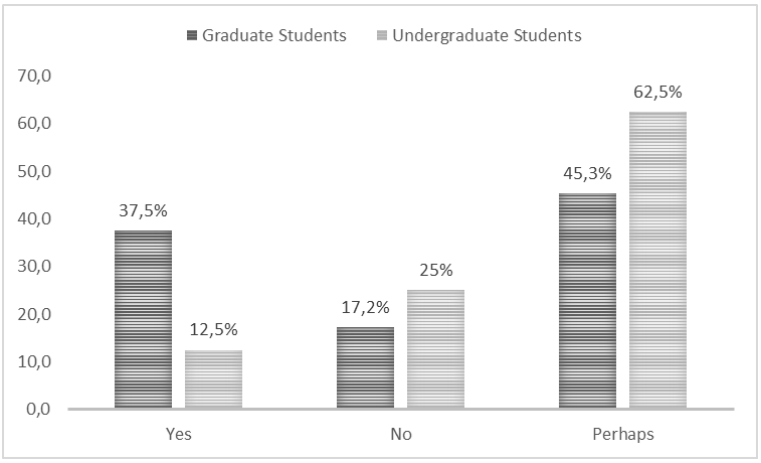

Figure 4. Willingness to work in the region after completing the course

4.4 Analysis of the profile and motives of students who would like to work in the region of Aveiro

Higher education students who wish to work in the region of Aveiro in the future – 27.9% of the sample – are mostly female (58.6%) and aged between 18 and 54 (M=25.76; SD=7.832). Most are national students (86.2%) and only 13.8% are international students. Approximately 75.9% are master's students, 17.2% are undergraduate students and only 6.9% are PhD students. The main factors which indicate that these students wish to work in the Aveiro region are the proximity to their social support network, good accessibility and transportation, lack of traffic, and the quality of life to living costs ratio. The calmness of the city and its entrepreneurial potential, the access to cultural events, as well as the existence of job opportunities in the desired areas were also important factors when choosing the Aveiro region to work.

On the other hand, when analyzing the reasons and the profiles of the students who do not wish to work in the Aveiro region after finishing their students, we can point out we are dealing with 25% of the total sample. Out of these, 71.4% are female and 28.6% are male, aged between 18 and 52 (M=25.29; SD=8.804). The majority are national students (85.7%) and only 14.3% are international students. 47.6% are undergraduate students, 38.1% are master students, 9.5% are PhD students and 9.5% are working towards advanced studies certificate. Overall, the reasons these students pinpoint as crucial when choosing another region to work that is not the region of Aveiro are the lack of proximity to their social support network, the lack of job opportunities, the inexistence of large companies, few leisure activities, low wages, and the wish to get some experience overseas.

It should be pointed out that the majority of the sample, 62.5%, is still unsure regarding the possibility of choosing the Aveiro region to work. Out of these students, aged between 18 and 36 (M=22.72, SD=4.253), 53.7% are female and 46.3% are male. Only 18.5% are international students and 81.5% are national students. Concerning their level of studies, most are undergraduate students (46.3%) and master students (44.4%). Only a small percentage is working towards a PhD (9.3%). The reasons students show regarding the possibility of working or not working in the region are both positive and negative. On the one hand, Aveiro is described as a calm and welcoming city with several leisure and cultural activities being offered. On the other hand, even though Aveiro has several job opportunities, it showcases not so many offers for specialized work in the area the students are interested in. Low wages as well as the lack of proximity to their social support system are also factor which may contribute to the fact that students do not remain in the region.

5. Conclusions

This study offers some insights about the attractiveness of regions from the perspective of young university graduates. The purpose of the study is to contribute to the understanding about the determinants of talent attraction and retention, notably for medium density territories. The results of this work are timely and relevant to inform the debates about the challenges of attracting high skilled work and talent that are considered crucial for the sustainability of digital transformation in industries and regions. The results of the study are aligned with the formulations that frame the factors of success of a region beyond the mere offer of a generous salary, but rather encompass a constellation of variables related to the quality of life and work of individuals. The study addressed a sample of undergraduates and graduates of a university located in a medium density urban region, considered representative of the universe of skilled workers that can be integrated in the region where they have conducted their studies The results show that the cost of living is extremely relevant in the work choices and work life decisions. When comparing the graduates with the undergraduates we may conclude that, as expected and studied by several authors before, the graduates have a more accurate idea about the broader motivations that may frame their specific decisions, as they mention a range of diversified factors to support their decisions, including the regional offers for culture and leisure. Undergraduates refer to the importance of the accessibility and mobility conditions because of their preferences to stay close to their family. When we analyze the answers of the question if they believe that they would find employment in Aveiro, most of them reply, "may be". We may understand from their answers that everything is linked to the opportunities they may find in the region, the proximity with the family and the friendly environment of region. These results and conclusions are important to understand the determinants of the reasoning and decision making of undergraduates and graduates concerning their work and mobility choices. For a region that needs high skilled human resources and is aware of what kind of workers they want to attract, it is crucial to know and understand what factors favor the attraction and repulsion. The local government should be able to keep investing on the characteristics that attract people and act to improve the characteristics that are making people go away, to be able, together with the private sector, to offer quality opportunities and to make these opportunities reach all. All these policies are particularly important in the case of a region that is undergoing a digitization process that is profoundly transforming industries and placing important demands for the provision of highly skilled workers. Therefore, our

conclusions can be used for the alignment of corporate strategies and public policies in order to generate greater efficiency and success in the search for sustainable growth in a medium-density urban region.

6. Acknowledgements

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Study of the service satisfaction index of the Angolan banks

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ABSTRACT

This empirical research has studied the quality of services and satisfaction of clients of Angolan banks, taking into account a group of representative banks of the country, making it possible to diagnose the situation and identify aspects to improve. In this task, the European Customer Satisfaction Index (ECSI) was implemented, analyzing the satisfaction relationship with its antecedents (image, expectations, quality and value) and consequents (complaint and loyalty) adapting it to the Angolan reality.Through the use of multivariate statistical techniques, it was possible to perceive and demonstrate that customer satisfaction is based on lead, recommendation and complaints, and a positive and significant impact of satisfaction with loyalty, claims. This is a pioneering investigation into the satisfaction with the services provided by the Angolan banks and may be of reference in future studies and help banks improve the quality of services provided.

Keywords: Marketing, Service Marketing, Quality, Satisfaction, Angolan Banking

1. Introduction

The election of a new government in 2017 led to the introduction of a set of political and economic reforms, taking into account the fall in oil revenues and the current macroeconomic imbalances. Governance measures aim to achieve macroeconomic stability, create an economic environment conducive to economic growth and job creation, and address major social problems. In this context, a set of short-term policies aimed at correcting the imbalances in the foreign exchange market and the trade balance, promoting fiscal consolidation, ensuring public debt sustainability and controlling inflation was implemented. In this context, Angolan Banking will also play a decisive role, namely by improving a set of services to its clients, such as increasing electronic payment means, increasing the number of branches and their employees, promoting (including the International Monetary Fund and the World Bank) in order to ensure greater comparability and transparency of the banks' financial statements on the international market and the continuous improvement of the information provided to users of the financial statements.

The main research problem is the quality and satisfaction of the services provided by the banks operating in Angola. In this sense, the following concerns appear: does Angolan banking have real concerns about its institutional image? Is loyalty a value that consumers have with the banks they use? Are not consumer expectations achieved? Do consumers recommend their own bank to others? What is the perceived value of your banks in Angola? And what is your perceived quality? And finally, how does the complaint handling service work?

The discomfort and ignorance about the above circumstances led us through this investigation to try to answer the research problem: Are the clients of banks operating in Angola satisfied with the quality of their services?

The satisfaction can only be achieved in some situations when taking into consideration some pure Marketing tools and Relational Marketing together. It is also important to highlight that the satisfaction study carried out in some representative banks of the sector in Angola on the quality of their services provided, allowed to identify aspects to improve.

The ECSI (European Customer Satisfaction Index) satisfaction model was that we used and implemented in the services provided by the Angolan banks to their clients. The model analyzes the satisfaction relationship with its antecedents (image, expectations, quality and value) and consequent (complaint and loyalty) adapting it to the Angolan reality.

Through the use of multivariate statistical techniques, it was possible to perceive and demonstrate that customer satisfaction is based on lead, recommendation and complaints, and a positive and significant impact of satisfaction with loyalty, claims, as we can demonstrate in this paper.

2. The importance of the quality in services

The recognition of quality in the services provided by a particular organization from customers is something that any company should have at the top of their concerns. This recognition is only possible if organizations are empathetic to their customers and provide a quality service that respects the desires of consumers and niche markets that suit them.

We live on a strong growth of the service sector, even in the countries not sot developed. It is the sector that developed the most and contributed about 65% of GDP in the most developed countries and consequently in the world economy (Paladini & Bridi, 2013). Services represent one of the fastest growing sectors in the world, with positive repercussions on the world economy.

A service can be understood as an action, a process, whose main characteristic is intangibility, regardless of the possibility of this service being connected to a physical product (Kotler, 1991). A service has an intangible value, that is, it does not translate into a physical reality (Fitzsimmons, 2000).

Another author who has a vast work on marketing services (Grönroos, 2003) identifies three basic characteristics of services, namely: 1) Being processes; 2) be produced and consumed simultaneously; 3) There is the possibility of customer participation in the production of the service. According to the same author the role of the elements that make up the service in the relationship with consumers is seen as strategic.

Marketing services are similar to product marketing because both are "products" intended to deliver value to customers, however the different nature of services requires differentiated attention from marketing professionals.

Traditionally marketing is more easily understood when it comes to products. When we transpose this reality to services there are some variables that change. The marketing of tangible products is done based on the traditional four "P's" namely Product, Price, Promotion and Distribution points. The marketing of services, in addition to the variables listed, adds three more "P's": the Person(s), Physical Presence and the Processes (Zeithaml & Britner, 2003).

According to the authors these last three elements complete the marketing services mix by describing them as follows: People; all human agents who play a role in the execution of the service; Fictitious physical presence; the Processes are procedures or mechanisms and effective route of activities through which the service is executed. These three elements are connected with the company because they directly influence the customer in acquiring a service, even at the level of customer satisfaction for the service purchased.

We live in times of economic recovery in general. And even in Angola, and despite some retraction, the truth is that the services market has been growing. In this way we believe that in the near future the economy, and due to globalization and the evolution of technologies, could be characterized by the majority of services with the highest possible quality and the required efficiency.

Any company, in order to succeed in its actions or activities, needs to be properly oriented to the marketing and also focused to the market. In order for this marketing orientation to be possible, organizations must focus their concerns on consumer needs and desires, but also on all processes inherent in presenting improvements to new products or services made available to potential customers in relation to such conduct evident. In this sense, companies should value the definition of strategies aimed at designing quality services in order to make them more competitive, with a qualitative requirement above average. And for this purpose to be achieved, it is imperative to use instruments appropriate to this reality for the satisfaction of the stakeholders (Kotler, 2000).

To Pires (2004) the quality has three main principles, namely: the quality of design; the quality of performance; and quality of operation. In the banking sector, the significance of quality manifests itself in offering a range of services that guarantee security and efficiency in meeting the needs and desires of the consumer.

In services it is the client that defines the quality, by the satisfaction of the perceived quality, as Costa (2006, p.63) refers "(...) has a variation according to the client's perception. Thus, the quality perceived by the consumer is the result of the evaluation performed on the services provided by the company ".

It is difficult to perceive the assumptions that customers base to evaluate the quality of a service and from there define the degree of satisfaction with the service provided by the company. The expectations-based setting is widely used and indicates that clients rely on their own expectations to evaluate the quality offered (Gianesi & Correa, 2006).

The concept of satisfaction is a subjective concept since it can assume different meanings in different contexts. It is a dynamic concept, with strong cultural values and for this reason subject to constant changes. One premise of marketing strategy is that if consumers are not satisfied, they usually do not come back, they do not repeat the purchase or become loyal. Consumers are highly focused on their buying momentum based on their experience, and if it pleases the buyer, satisfaction rates naturally increase. For services exactly the same thing happens.

In an increasingly competitive environment, organizations are called to meet and exceed their customers expectations. Consumer expectations must be met. And this satisfaction generates new expectations in the clients, which can influence new personal desires that, in turn, can influence the emotions experienced at the moment of service delivery, and which, influence customer satisfaction (Tinoco & Ribeiro, 2007).

According to the authors Kotler & Armstrong (2005), the best way to make a organization more competitive and to make it a top-level organization is to ensure a high level of satisfaction. That concept is dependent on the perceived product whereas value is relative to expectations. When product performance produces expectations, the buyer feels satisfied. When he exceeds expectations, he is astonished (Gronroos, 2003).

When consumers perceive a high degree of quality this can lead to even higher levels of customer satisfaction, with undeniable gains in profits for companies (Kotler, 2000). The intimate connection between quality and customer satisfaction requires companies to focus on quality management, namely with constant attention to the customer and improvement of relational processes.

What we have been seeing from the literature on the subject is that satisfaction is considered as a result of the difference between the expectations of customers and the performance of a product / service after use it.

Two models of customer service satisfaction analysis are highlighted in the literature: the model presented by Parasuraman, et al. (1988) - SERVQUAL - and that of Cronin & Taylor (1992) - SERVPERF. The difference between them is basically in the use of consumer expectations in satisfaction assessment. SERVQUAL evaluates the satisfaction based on perceived quality and expectations regarding the service provider and SERVPERF uses only perceived quality in satisfaction assessment. In spite of these differences, the use of similar items in the evaluation and option of the authors is worth noting, since it proposes a generic scale, capable of evaluating the different types of services (Bornia & Junior, 2011).

On the other hand, and in the scope of banking services, we still find authors with other approaches, namely Item Response Theory. This theory accurately provides the amount of information of an item on the latent trace and scale, that is, on a satisfaction scale we can assess what level of satisfaction the item evaluates and the volume of information it provides.

Based on the above, there are different views and models to analyze the satisfaction and quality of services, with different scales and measurement techniques. From this we infer that it is not a question of obtaining a single or peaceful choice, nevertheless, and as far as this research is concerned, we will use ECSI – European Customer Satisfaction Index, which is a quality measurement system of services and it measures customer satisfaction and applicable to various sectors of activity, including in the banking sector, and that we will explain better ahead.

Nowadays many companies already excel in the continuous conquest of new customers, in their loyalty as well as in the satisfaction, also, of their partners. The issues related to the evaluation of the perceived quality of the services rendered have received special attention from academia and researchers, with notable contributions, as already mentioned in this paper, since they are extremely important factors for the management of organizations and their market, and, in this way, create competitive advantages. According to Grönroos (2003), services perceived as high quality bring with them not only the potential to attract new clients, but also to keep existing ones captive, and this is exactly why this situation has become a business reality - quality management. This reality can only be achieved by measuring the quality of services. The banking sector in Angola can not ignore this situation and carry out studies on this reality, especially through theories already tested, such as those already mentioned.

There are several ways to measure customer satisfaction. And, with more or less objectivity or methodological deviations, the truth is that the information provided by these studies is often useful, and sometimes reliable. According to Skogland & Siguaw (2004), a good customer satisfaction study program should allow: i) Evaluate the degree of customer satisfaction of the company; ii) Monitor company performance over time; iii) Evaluate the company's performance against its main competitors; iv) Understand the aspects of greatest impact for the satisfaction of its clients; v) Evaluate the relationship between the management of the company and the expectations of its clients; vi) Define quality improvement strategy based on the strengths and points to be developed; vii) Optimize the investments from the definition of the degree of satisfaction, needs a quality strategy.

The information resulting from the above mentioned approaches serves to outline the quality improvement strategy and to implement actions that effectively improve customer satisfaction, generating the greatest return to the organization. Among the various methods (qualitative and quantitative) and tools for studying customer satisfaction, and some of which we have already mentioned, we present the ECSI, which measures several variables quantitativly.

3. Research design – methodology (hypothesis and objectives)

The methodology adopted in this study will be based on fundamental procedures for scientific research. It begins with a bibliographical survey in order to build an adequate theoretical framework and will focus on a research whose general objective is to evaluate the quality of services and satisfaction provided by banks in Angola, based on the European Customer Satisfaction Index and the works, in this area of knowledge, developed by Vilares & Coelho (2005).

In the case of the present investigation, we can define our study as descriptive, since it intends to investigate the reality in the banking sector and, thus, to understand the phenomenon of quality and satisfaction from the perspective of the clients. It is also intended to make comparisons, correlations and evaluate the impact of some variables on the others.

In another approach, we can also consider the present study as quantitative (Malhotra, 2004; 2005), since it will use the questionnaire as an instrument for collecting information.

In order to carry out this study, questionnaires were applied to the clients of the banks, however these questionnaires will be elaborated based on the critical appreciation of specialists, and later a pre-test will be carried out in order to verify the questions are clear and well perceived by the respondents.

The banks operating in Angola, demand, and expect more and better service delivery, that's why there must be a quick and efficient response in the agility of this process, opening access facilities that provide high standards of quality and satisfaction. In this context, this research will answer some doubts pasted on the question presented above in hypothesis forms:

H1: The image of banks has a positive and significant impact on customer satisfaction;

H2: Banking expectations have a positive and significant impact on customer satisfaction of banks;

H3: The perceived quality of service provided by banks has a positive and significant impact on customer satisfaction;

H4: The perceived value paid for services provided by banks has a positive and significant impact on customer satisfaction;

H5: Customer satisfaction with banks has a positive and significant impact on loyalty intent;

H6: The satisfaction of bank customers has a positive impact on the formalization of complaints about the services provided by banks;

H7: Banking customer satisfaction has a positive impact on the bank's recommendations to other people;

H8: The loyalty of bank customers has a positive and significant impact on the recommendations;

H9: Complaints, if answered, have a positive and significant impact on the loyalty of bank customers;

H10: Complaints when answered have a positive and significant impact on the recommendations of bank customers;

H11: The institutional image of banks has a positive and significant impact on bank loyalty.

In order to guide the work we define that the general objective is to evaluate the quality of the services provided by the banks in Angola, based on the ECSI model.

The general objective of this research is to evaluate the quality of the services provided by the banks in Angola, based on the ECSI model developed by Vilares & Coelho (2005), but modified by us adding another variable (recommendations) and in order to achieve the general objective, we identify the following specific objectives that are directly related to bank satisfaction, specifically in understanding the antecedents of this satisfaction (image, expectations, perceived value and quality perceived) and the consequences of satisfaction (loyalty, complaints and recommendations): i) Ensure that satisfaction with banks has some influence on the banques institutional image; ii) Ensure the customers satisfaction with the service provided by banks is influenced by the expectations they have of banks; iii) Ensure that customer satisfaction is influenced by the perceived quality of services provided by banks; iv) Check that customer satisfaction is influenced by their evaluation of the price/quality (value) of services provided by banks; v) Check that the presentation of complaints by customers is related to their degree of satisfaction; vi) Check that the recommendations given by the clients are related to their degree of satisfaction with the banks; vii) Understand the intensity and the relationship between the antecedents of satisfaction (image, expectations, perceived value and perceived quality); ix) To perceive the intensity and the relation between the consequences of satisfaction (loyalty and complaints).

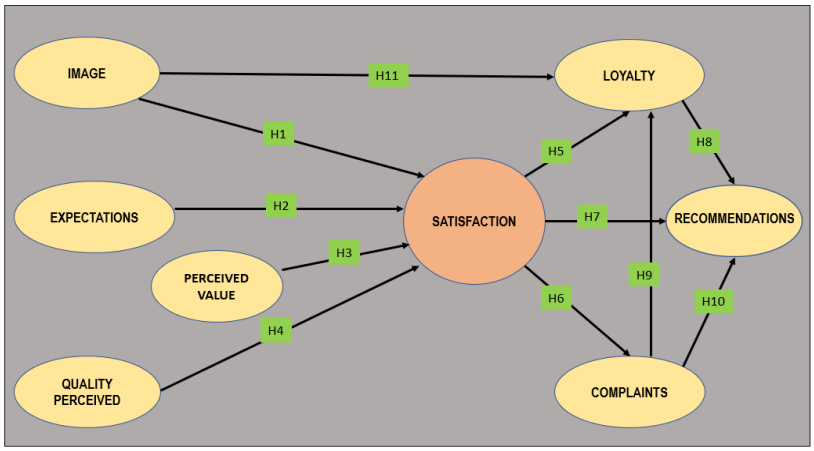

Figure 1. *ECSI model modified by authors*

4. Analysis and discussion of the results

The results analyse of the quantitative data gathered in the survey conducted among bank customers in Angola between November 2018 and January 2019 has done with SPSS software.

The population studied fell on Angolan citizens who had bank accounts and had commercial relations with the banks in Angola. The sample was composed by 184 respondents, of which 96 (52.2%) were female and 88 (47.8%) were male. In terms of age, the sample varies from 20 to 70 years of age, most of which belong to the age group of "31 to 40 years" (48.4%) and to the "20 to 30 years" (32.1%).

The majority of the respondents are single (90.1%), with only 33 married (8.8%), with a majority of respondents, with 56 (30.4%) having a bachelor's degree and 52 (28.3%).

The data will be presented according to the variable in analysis (Image, Expectations, Quality, Satisfaction, Preciousness, Complaint and Loyalty) arranged in the same order of the questionnaire. Each dimension was being subject to an analysis univariate analysis using descriptive statistics (frequencies, means and standard deviation), a reliability analysis using Cronbach's Alpha, factorial analysis using the ACP (principal component analysis) method and, for the purpose of hypothesis testing, correlation and regression analysis. The reliability analysis for all the items that make up the scale was good, with a Cronbach alpha of 0.907.

Regarding the preferential bank of the respondents, the study identified 10 banking institutions (table 1), with a large majority of respondents linked to BMA bank (30.4%), BFA bank (26.1%) and BIC bank (10.9%). The least-referenced banks were Banco Keve and Banco BPA, both with only 4 responses.

Table I. *Preferencial relationship Bank*

Banks	Frecuencies	%
B. Keve	4	2,2
BAI	16	8,7
BCA	8	4,3
BCI	8	4,3
BFA	48	26,1
BIC	20	10,9
BMA	56	30,4

BPA	4	2,2
BPC	12	6,5
SOL	8	4,3

Respondents reported that they had long relationships as their preferred bank for more than a year (table II), 84 (45.7%) indicated having relationships between "1 to 5 years" and 56 (30.4%) between " 6 to 10 years ". Only four respondents (2.2%) reported having had relationships for less than 1 year.

Table II. *Relationship duration with the bank*

Duration	**Frecuencies**	**%**
Less then a year	4	2,2
1 to 5 years	84	45,7
6 to 10 years	56	30,4
More than 10 years	40	21,7

The channels of relationship with the bank (table III) are mostly through Internet Banking (56.5%) and attendance at the balcony (41.3%). Only four respondents reported that they use "Mobile Banking" (2.2%), which is a sign of lack of confidence in this form of communication or mismatch to the communication channel itself.

Table III. *Relationship channels with the bank*

Channels	**Frecuencies**	**%**
Balcony	76	41,3
Internet Banking	104	56,5
Mobile Banking	4	2,2

In terms of mean time of service (table IV), respondents indicated a period longer than 12 minutes (45.7%) and, at the other extreme, still much lower values, between "3 to 5 minutes" (26, 1%).

Table IV. *Average service duration*

Duration	**Frecuencies**	**%**
3 to 5 min	48	26,1
6 to 8 min	32	17,4
9 to 11 min	20	10,9
Above 12 min	84	45,7

Data analysis by dimension (image, loyalty, expectations, perceived value, perceived quality, complaints and recommendation) was exhaustively treated with correlations for each item of each dimension and its reliability through Cronbach's Alpha, and through the extraction method of the main components retained the component that explains the total variance. A matrix of correlations between the dimensions was then performed with Bartlett and Kaiser Meier Olkin (KMO) analyzes to verify the factorial analysis. However, its complexity and space limitation, we only present, in this paper, the final results related to the confirmation or infirmation of the operative hypotheses presented.

For the first hypothesis (H1) (it can be affirmed that there is a positive linear relation with a low linear association (R = 0.268) and significant (P <0.000), since according to Pestana and Gageiro (2005) an "R" with a value less than 0.2 indicates a low association. H1 is confirmed, since the institutional image has a positive and significant impact on overall satisfaction.

The second hypothesis (H2), it can be affirmed that there is a positive linear relationship with a moderate linear association (R = 0.366) and significant (p = 0.000), so it is possible to confirm this hypothesis as well.

For hypothesis third (H3 - Perceived quality has a positive and significant impact on overall satisfaction), it can be affirmed that there is a positive linear relation with a moderate linear association (R = 0.651) and significant (p = 0.000). It is possible to confirm H3, since the perceived quality of the service provided by the bank has a positive and insignificant impact on the satisfaction of bank customers.

Hypothesis fourth (H4) can be affirmed that there is a positive linear relation with a moderate linear association (R = 0.555) and significant (p = 0.000), thus confirming H4, since the perceived value of the service provided by the banks has a positive and significant impact on bank satisfaction.

For hypothesis fifth (H5), it can be affirmed that there is a positive linear relation with a moderate linear association (R = 0.364) and significant (p = 0.000). It is confirmed, therefore, H5, since satisfaction with banking has a positive and significant impact on loyalty.

For hypothesis sixth (H6), it can be affirmed that there is a positive linear relationship with a moderate (R = 0.489) and significant (p = 0.000) association, which confirms this hypothesis as well.

Hypotheses seventh (H7) can be affirmed that there is a positive linear relationship with a moderate association (R = 0.436) and significant (p = 0.000), and the hypothesis is confirmed as well.

Hypothesis eighth (H8) can be affirmed that there is a positive linear relation with a high linear association (R = 0.880) and significant (P <0.000), therefore, H8 confirms the loyalty has a positive impact on the recommendation.

For the nineth hypothesis (H9), it can be affirmed that there is a positive linear relation with a moderate linear association (R = 0,442) and significant (P <0,000), therefore confirms that loyalty has a positive and significant impact on claims.

Hypothesis tenth (H10) can be affirmed that there is a positive linear relation with a moderate linear association (R = 0.468) and significant (P <0.000), so H10 is confirmed too.

For the eleventh hypothesis (H11), it can be affirmed that there is a positive linear relation with a high linear association (R = 0.667) and significant (P <0.000), it is confirmed, since the image complaints have a positive impact and significant in loyalty.

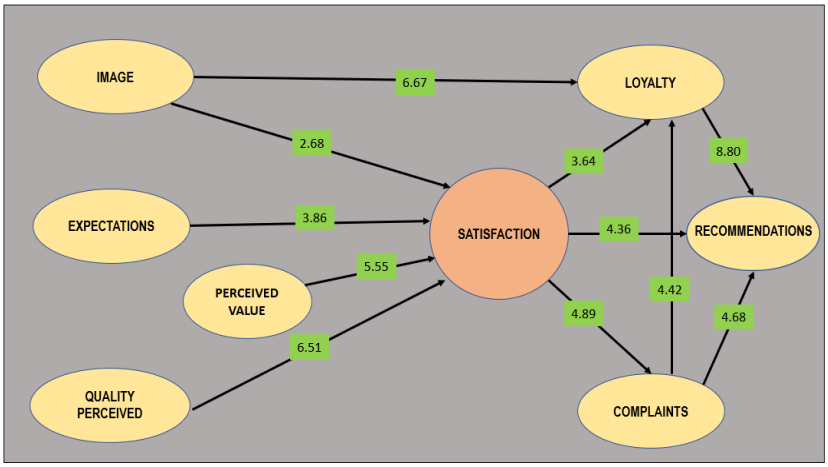

Figure 2. *Hypotheses confirmation (R of Pearson).*

In this investigation, eleven hypotheses were defined in order to evaluate whether, globally, there were significant differences in the antecedents and consequent of customer satisfaction with the services provided by the banks operating in Angola.

Based on the previous point, all hypotheses formulated were confirmed by the results of the empirical study, and the results obtained in this research work are in agreement with the conclusions presented in the literature review (Vilares & Coelho, 2005) and with the assumptions of the ECSI model applied to the banking sector.

For all dimensions of the model used, the research also revealed agreement with studies conducted by Neves (2002), Costa (2006), Fitzsimmons & Fitzsimmons (2005), Gopalakrishna & Chandra (1998), and Cardoso (2008).

5. Conclusions

The present study was developed based on the ESCI model and, in general terms, was guided by the studies developed to evaluate customer satisfaction in different organizations (Vilares & Coelho, 2005), having been applied in several sectors and activities by others authors

All eleven hypotheses were confirmed, confirming that there is a positive and significant impact of the image, the value, the expectations and the perceived quality (determinants/antecedents) with the satisfaction of the services provided by the banks.

It was also verified that the consequences of the satisfaction are loyalty, recommendation and the complaints, and it has been verified that there is a positive and significant impact of the satisfaction with loyalty, the recommendation and the complaints.

About research limitations, the sample of the study was restricted. Thus the generalizability of the findings is rather limited. Based on the results and limitations of the work, it is necessary to admit that for future research it will be interesting to investigate, in large scale, what factors influence customer satisfaction in Angolan banks. Since this is a one-time study, the results may change over time as a result of changes in the organizational policies of the banks, so it would be interesting to follow its evolution over time.

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Improvement of the Volumetric Occupancy Rate of the Trucks in the Warehouse-Store Transportation in a Retail Food Company

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ABSTRACT

This project was developed in a food retail company with a complex distribution system, with several distribution centres located in Portugal, different temperature requirements for their products and different dimension store formats. The aim of the work was to analyze procedures to increase the height of loading units to improve the volumetric occupancy rate of the trucks, which depends mainly on the relationship between the number of pallets transported in each vehicle and its volume. After analyzing and diagnosing the picking, loading and unloading operations, it was found that the volumetric occupancy rate of the vehicles was 48.5%, which means that more than half of the truck is empty. To increase this indicator, two strategies were proposed to be implemented: the revision of the current volume and weight limits; and the consolidation of different categories in the same pallet for the small format store. After conducting pilot tests, it was estimated, for each of these strategies, an increase of 0.8% on volumetric occupancy rate, and an increase of a potential gain was obtained of more than 577,908 €/year.

Keywords: Transportation, Vehicle Volumetric Occupancy, Units Load Height

1. Introduction

The great demands of an increasingly competitive market have made logistics an essential part of all companies, so one of the biggest tasks of managers is to direct all activities that contribute significantly to better customer service and the lowest cost [1].

According to Thomas & Griffin [2], the largest cost component of logistics is transportation cost, usually accounting for 50% of the total logistics cost. At a time when the global economic and financial environment forces organizations to manage their resources in the most efficient way possible, and the retail market segment is highly competitive, demanding and complex, cost management is vital to success and sustainability of the company under study.

At present, the loading units prepared in the warehouses of the company under study to transport to the stores do not have a standard height and the average of this is low. Due to this factor and to the differences in the typologies of boxes packaged in the pallets, it is not possible to overlap them, with only a floor occupancy of the vehicle and not in height, when loading and conditioning the loads on trucks. Thus, because the load units have an average height of 1 meter and since they cannot be stacked, there is a low occupancy rate of the trucks in height, resulting in high transport costs. In this sense, as transport is as more economical as the greater the capacity utilization of the vehicles, it became crucial to identify measures to improve the height of the load units.

This project was developed mainly considering a case study research strategy. The purpose of the project was to analyze the current process of picking, and loading, conditioning and unloading of trucks operations used in the warehouse-store transportation, identifying the factors that influence the height of load units, and the study and evaluation of measures to improve it.

2. Literature review

The state of the art is designed for areas such as logistics and supply chain management, transportation activity and management, and vehicle volumetric occupancy rate.

2.1 Retail supply chain configuration

Transformations in the retail supply chain have led retailers to see a restructuring of the logistics network: switching from "passive recipients of products" to "manufacturers with anticipation of demand", which currently control, organize and manage the whole chain (from production to consumption) - the current essence of retail logistics [3]. In a functional perspective, the internal retail supply chain is predominantly divided into three logistical subsystems: (a) distribution center (b) transport and (c) store (Figure 1). Since each subsystem, although with its own working and planning mechanisms, depends on the requirements of other systems, the result is a complex interrelated structure that must be considered in planning operations [4].

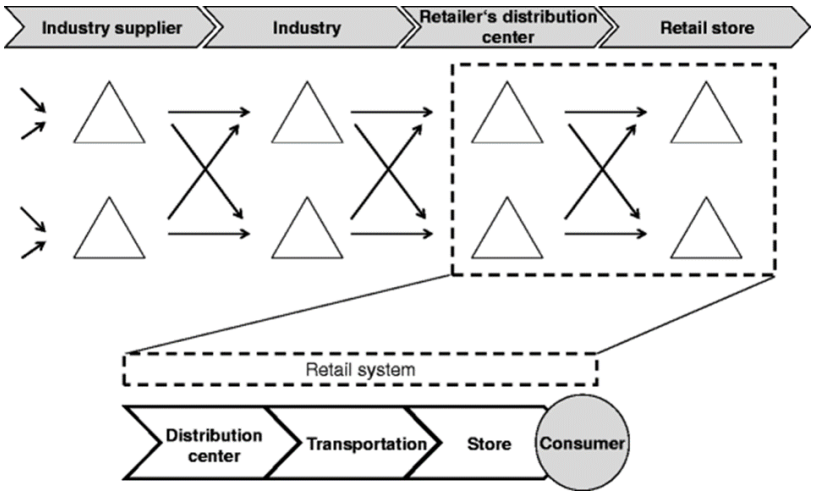

Figure 1. *Configuration of the retail supply chain (Adapted from [4])*

In the literature, there are different approaches to analyze and improve warehouse efficiency and to optimize the different processes related to the flow of material and information in the supply chain. Kłodawski et al. [5] presents problems of designing and organizing logistic processes in warehouse facilities, highlighting the need of improving logistics facilities actions as a key aspect to increase productivity, flexibility and reliability of supply chains. Shepelev et al. [6] developed a procedure for determining the optimal parameters of transport and warehouse complexes. The performance of equipment and means of internal transport and its impact on the implementation of warehouse processes was studied by Pyza et al. [7]. In their work the role of warehouse in the supply chain and its importance in the effective flow of material goods was discussed. Other authors [8] refers that it is possible to increase the efficiency of the transport-warehouse relationships in the logistics chain by determining the optimal volume of transportation and storage of goods in the logistics chain. The movement of material flow in supply chain is impossible without transport involvement.

Transport activity management can be defined as the process of planning, implementing and controlling the most effective and efficient procedures and techniques with the goal of achieving cost reduction, increasing the level of customer service and increasing optimization of the company's resources [9,10].

Thus, Lambert et al. [9] summarizes the main functions of transport managers, stating that they should select the most appropriate mode and type of vehicles, select the vehicle fleet and manage it and, on a more daily basis, plan routes, loads and vehicles. In order to ensure an efficient and logistically efficient transport subsystem, it is necessary to take into account a set of factors that influence the physical distribution of load from the warehouses to the stores, such as the distance to be traveled, time of delivery, quantity transported, non-existence of return load, dimensions and morphology of the load, degree of fragility of the load and restrictions at the point of sale.

The goal of day-to-day planning should be vehicle optimization. The Transport Optimization Report [11] identifies three main areas of improvement in terms of transport optimization: improving vehicle occupancy, reducing empty kilometers and increasing productive time as a proportion of the total time available, and stressing that each of these areas can be affected by one or more factors previously mentioned. There is a set of key performance indicators (KPIs) that can be used to measure and target each of the areas:

- Percentage of occupancy of vehicles;
- Percentage of kilometers in empty space;
- Productive time as a percentage of total available time.

2.2 Volumetric occupancy rate of vehicles

Improving vehicle volumetric occupancy rate is one of the most attractive sustainable delivery measures for companies as it provides substantial economic and environmental benefits, hence the importance of their maximization in the success of a company [12].

Traditionally, companies measure vehicle occupancy considering only the relationship between the weight of the load transported and the maximum weight of the vehicle [12]. However, as in the food retail sector products have an increasingly lower density, the weight-based occupation underestimated the true level of utilization [13]. In this sense, the occupancy of the truck is limited much more by the floor area or height of the vehicle than by the weight. A measure of occupancy that results from the product between the percentage of floor occupancy (equation 1) and the percentage of height occupancy (equation 2) is more appropriate to calculate the percentage of volumetric occupancy [13, 14]:

$$\%floor\ occupancy = \frac{number\ of\ pallets\ transported\ to\ the\ ground}{Maximum\ number\ of\ pallets\ to\ the\ ground\ on\ the\ truck} \quad (1)$$

$$\%height\ occupancy = \frac{Load\ units'\ average\ height}{Maximum\ truck\ height\ available} \quad (2)$$

When there are tight limits to the height of a load unit and when it is low and variable, the truck occupancy is usually restricted by the floor area rather than by the height of the vehicle and can be completely occupied on the floor by pallets with a height of 1.5 meters, leaving a meter or more of wasted space above them [14]. The study made by McKinnon and Edwards [15] reveals that companies often overuse their vehicles as a result of minimizing total logistics costs by making perfectly rational trade-offs between transport efficiency and other corporate goals such as minimizing stocks, optimizing

storage space use, or maximizing productivity preparation of orders. However, Mckinnon [14] and McKinnon and Edwards [15] examined the possibility of improving the use of vehicles, including potential economic and environmental benefits.

One of the opportunities indicated was the increase of the load units' height. Generally, there are tightness volume and weight limits that restrict its height, so the increase of these limits can reduce the number of trucks required per year. This was one of the measures analysed and that will be described in the present work.

3. Study context and Critical Analysis

The company studied is one of the largest food retail companies in Portugal, with a set of distinct formats that offer a wide range of products. It essentially operates with three major players in its logistics chain: suppliers, distribution centers and stores.

It has strategically two large logistics centers, where the warehouses are located that operate in a specialized and independent way. Both platforms supply different regions of the country, with food products at ambient, fresh and frozen temperature, covering the entire national territory and the islands. In these logistical platforms two types of flows are implemented: PBL (Picking by Line) and PBS (Picking by store). The main distinguishing characteristic of these flows is the lack of storage in the PBL warehouse due to their dispatch in less than 24 hours, which means the products are received and distributed immediately by the stores, while in the PBS the products are collected of their picking locations, existing stock. The division of the articles between PBS and PBL is performed considering the rotation of the products, the quality of service of the supplier and the validity of the product itself.

Comparing the warehouses of different temperatures, there is a higher dispatch volume in the ambient temperature warehouses. For this reason and for the elaboration of this research project, the analyzed warehouses were the PBL and PBS at ambient temperature in both platforms.

In order to be able to define strategies for improvement, it became essential to frame the current situation of the company regarding the current volumetric occupancy rate of trucks and a diagnosis and analysis of the operations under study. Currently, in the company, only the percentage of floor occupancy is monitored monthly, including only the trucks of 33 pallets since the fleet is composed mostly by this type of vehicles. Thus, this indicator is used to measure vehicle occupancy efficiency, although it is not very robust since a truck can occupy 100% of the floor by load units with a height of 1 meter, leaving a lot of empty space.

In this way, the project began with the calculation of the current volumetric occupancy rate of the trucks. With an average floor occupancy rate of 84.0% and a height occupancy rate of 57.7% in 2017, an average value of 48.5% was obtained, as shown in equation 3:

$$Volumetric\ occupancy\ rate = 84.0\% \times 57.7\% = 48.5\% \quad (3)$$

Thus, it is proven that more than half of the truck is air, reinforcing the importance and necessity of improving this measure. As the variable that causes the greatest negative impact on the volumetric occupancy rate is the height occupation, the objective of the project was focused on the improvement of the latter.

Shipment to stores can be done on four types of handling units: picking pallets (euro or half pallet) and complete pallets (euro or half pallet). The picking pallets are originated by the preparation activity in the warehouses, while the complete pallets are shipped with a single item and are delivered to the store exactly in these quantities, with no preparation in the warehouse. As the picking pallets, in total, represent 68.1% of the pallets transported, it became necessary to focus the analysis on this type of handling unit to understand the factors that influenced its volume and, therefore, its height.

Both in PBL and PBS flows, when preparing load units for stores, it may break down by two factors: volume or weight. For each product category, the system has defined the maximum limit of volume and weight that a load unit can reach so that whenever an order reaches one of the limits, the picker needs to continue the preparation in a new pallet.

Currently, the volume limit, in the same flow, is the same for all categories, with the PBS limit being 15% higher than the PBL limit. Regarding the weight limit, this is the same for PBL and PBS in all categories. In this sense, it was important to compare the average volume of each category with the respective limit to identify differences and to understand the impacts of changing the parameterized limits in the system. An improvement to be implemented has gone through the revision of the current volume limits and the adjustment of it according to the average weight per box (strategy 1).

Besides that, picking pallets have, for each store format A, B and C, a weighted average volume of 1.38 m^3, 1.13 m^3 and 0.99 m^3, respectively. The small stores (format C) are those with the lowest average volume value, and some factors have been identified that contribute to this fact. The reduced daily volumes demanded by contemporary retail, with frequent deliveries of increasingly smaller orders, associated with the fact that the company is looking for a "store friendly " logistics, preparing by category, means that only 1 pallet is prepared per day and per category, with a low volume of products. As the expansion of these stores is expected, instead of preparing the orders by category on different pallets, it has been suggested that all the categories of each flow could be consolidated on the same pallet (strategy 2).

4. Improvement Proposals and Results

The two proposed strategies and their expected results are presented below.

4.1 Revision of the current volume limits based on average weight per box

With the previous diagnosis, in particular the percentage of picking pallets, for each category, which breaks by volume, by weight or by neither of those and the average weight per box, the need arose to evaluate the impact that would have occurred if the limits parameterized changed. For the categories that mostly broke through the volume and the weight, the adjustment of the limits was studied. A change in these can enhance the placement of boxes at a higher height, so an adjustment to the average weight per box was the criterion used to consider the ergonomic conditions of the operators. Thus:

- For the categories with the smaller value of average weight per box, compared to the other categories of the same flow, increase the volume limit;
- For the remaining categories with the highest average weight per box, maintain the volume limit.

Through several pilot tests, it was possible to measure the impact of these changes in each one of the actors of the chain: warehouse, transport and store operations. By increasing the volume limits of the load units, it is possible to place more boxes on the same pallet which can consequently result in a reduction in the number of picking pallets prepared and shipped. This reduction has an impact on the floor space occupied in the warehouse and at the backroom store, on the time of loading and unloading of the trucks, as well as the associated transportation cost. Also, this increase in the limits may or may not result in an increase in the productivity of operators because, although more boxes are placed per pallet, it also increases the difficulty in the construction of the stowage, which can cause the operator to waste more time in the quality assurance.

Based on the data obtained through pilot tests, the number of picking pallets that would have been prepared were simulated by category, store and date of delivery to the store, if the limits remained the same as the current ones, and this value was compared with the number of pallets generated during the pilot tests with the proposed limits. It was found that for PBS, instead of 7,492 pallets being prepared with the current limits, 7,325 pallets were generated in the week of the pilot test, corresponding to a reduction of 2.2% in the number of pallets and so a reduction of 18,264 pallets per year. Likewise, in the PBL, instead of generating 4,976 pallets, 4,818 pallets were generated during the test period, equivalent to a reduction of 3.2% in the number of pallets and to less than 25,889 pallets per year. In total, an average reduction of 2.7% of picking pallets was estimated.

Still with the results of the pilot tests, the relation between the picking productivity and the number of boxes per pallet was analyzed to understand if the proposed changes had a significant impact and whether it was positive or negative. There was an approximately linear behavior, allowing to conclude that the bigger the number of boxes per pallet, the greater the productivity of the operators.

Finally, the impact of this scenario on the volumetric occupancy rate was estimated, corresponding to an increase of 0.8%, resulting from an increase in the percentage of height occupancy rate (+0.9%).

After calculating all the impacts of this strategy, the annual benefits in euros, associated with the changes in the proposed scenario (Figure 2), were estimated by logistic subsystem (warehouse, transport and store).

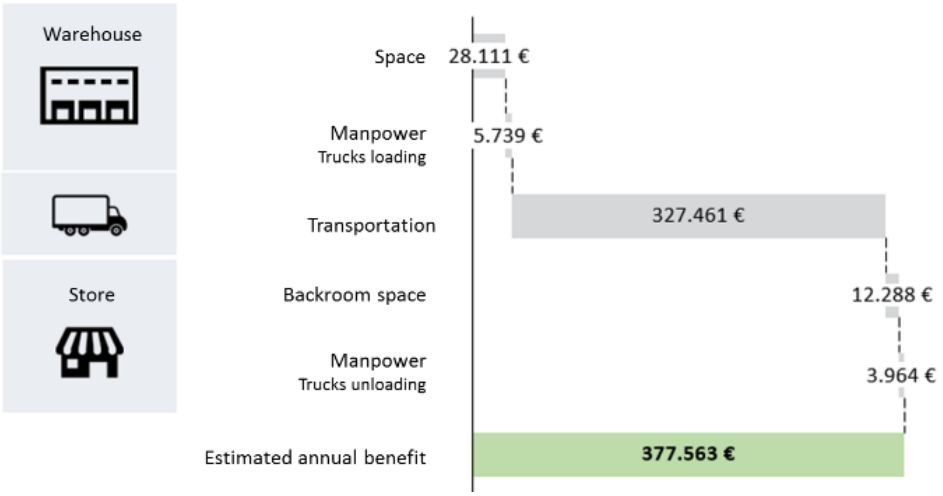

Figure 2. *Estimation of the potential annual benefit of strategy 1*

Observing Figure 2, this proposal has a potential benefit of 377,563 €/year, being that the transport logistics subsystem is the largest part, approximately 86.7%. This proves that, in fact, transport has a high weight in the logistics cost structure, so any solution that seeks to reduce the air inside the truck, results in a very significant impact.

Due to its enormous potential, in May 2018, this strategy was implemented, provided that its results were monitored through to a cockpit chart. Table I shows the results obtained for the indicators whose changes are directly related to the implementation of this strategy, as well as the percentage variation obtained between January and September 2018.

On indicator 2, a 2.7% increase was achieved. It is not an increase as significant as the one achieved on the indicator 2aa because, as there are four handling units and since complete pallets, due to its low average volume, negatively influence the indicator 2a, an increase in the percentage of complete pallets (euro and a half) contradicts the positive impacts of this strategy.

Regarding indicator 2b, the average reduction target of 2.7% of picking pallets previously estimated has been met, translating into a potential annual benefit of 345,104 €/year.

Table I. *Presentation of results obtained (January vs September) by the implementation of strategy 1*

Nº	Indicator	January	September	Variation (%)
2	Height Occupancy rate (%)	56.2%	57.7%	+2.7%
2a	Average volume per pallet (m^3)	1.10	1.11	+0.9%
2b	Reduction in the number of picking pallets (%)	-	2.6%	+2.6%
2aa	Average volume per picking pallet (m^3)	1.14	1.19	+4.4%

4.2 Consolidation of the categories in the same pallet for the stores of the format C

As mentioned above, the format C stores are those with the lowest average volume per picking pallet, which is related to the fact that 1 pallet per category per day is dispatched to these stores. As the expansion of small format stores is expected, some changes have been suggested in the picking process of these stores: to increase the average volume of the pallets to these stores and, thus, increase its height, instead of these orders being prepared by category on different pallets, all categories of each flow would then be prepared on the same pallet, until one of the volume or weight limits is reached.

A pilot test was made on PBS for one store of format C. As the strategy in the previous subsection, this solution entails placing more boxes on the same pallet and therefore can reduce the number of pallets prepared and shipped to stores. This reduction has an impact on the floor space in the warehouse and at the backroom store, on the time of loading and unloading of the trucks, on the shelf replacement time in the store and on the associated transportation cost. Warehouse productivity can increase with more boxes on the same pallet, but this effect can be offset by the fact that the operator loses more time in stowage quality assurance.

With the pilot test data, the reduction in the number of pallets was calculated. For this, it was simulated, by category and date of delivery to the store, the number of pallets that would have been obtained if there was no consolidation, comparing this value with the number of pallets shipped during the test period. The impact of this solution on warehouse productivity was also analyzed, comparing the average productivity obtained in boxes per hour from January to May with that obtained in the test week, considering only the store submitted to pilot test. Finally, a visit to the chosen store was made to quantify the impact on shelf replacement time.

A reduction of 17.4% was observed in the number of pallets prepared and shipped to format C stores, which corresponds to less 24,284 pallets per year. This represents a reduction of 1.5% in the total number of picking pallets prepared.

Regarding the warehouse productivity, it was verified that it did not suffer any impact, presenting the same value without and with consolidation. With consolidation, the difficulty of constructing the stowage is increased, but the number of setups can be reduced, so the operator places more boxes per pallet in the same task, justifying this behavior.

About the shelf replacement time, with consolidation, the products of the different categories are mixed, not separated by layer. However, this additional manipulation of separating the boxes of different categories is not significant in the total shelf replacement time per pallet (0.7%).

It was also calculated the impact of this solution on the volumetric occupancy rate, with an increase of 0.8% in it, resulting from an increase in the percentage of height occupancy rate (+0.9%).

Finally, considering these impacts, it was possible to estimate the annual benefits per logistic subsystem associated with this solution (Figure 3).

This strategy has an estimated annual benefit of 200,345 €/year, and in the same way as strategy 1, it is in the transport logistics subsystem that the greatest benefit is found, approximately 89.6% of the total parcel. Since this solution presented great potential, which was recognized by the company, this strategy was extended to 20 stores and its impacts are still being evaluated, in order to have a more significant sample and, therefore, more robust results.

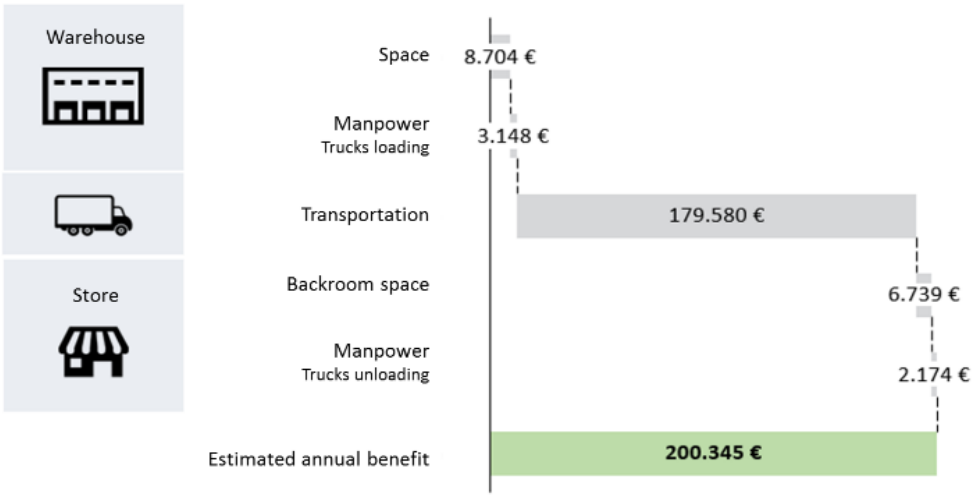

Figure 3. *Estimation of the potential annual benefit of strategy 2*

5. Conclusions

Since transportation is responsible for absorbing between one-thirds to two-thirds of the total logistics cost, and as often involves trade-offs between customer responsiveness capacity (greater frequency of supply) and chain efficiency (more trips, lower vehicles occupancy, and therefore higher transport costs), any decision-making in its management is reflected along the logistic chain.

Through the methodology of the case study, a study was carried out on the vehicle's occupancy in the warehouse-store transport, in a retail food company. Although this project involved only one study explaining the current state and future state and a comparison of costs versus benefits, strategies were identified to be implemented in the short term.

In this way, the project started by measuring the performance of the current situation, that is, by calculating the value of the volumetric occupancy rate, equal to 48.5%. This low value is due to the low height occupancy, which is around 57.7%. After a detailed analysis of the current picking, loading, conditioning and unloading operations, one of the main causes of this waste were identified: the low average volume of the transported pallets.

Thus, the improvement proposals, studied in order to measure their impact and quantify their potential, were focused on the improvement of the picking pallets height: the revision of the volume limits according to the average weight per box (strategy 1) and the consolidation of the PBS categories in the same pallet for the small stores (strategy 2). Both proposals had benefits in the floor space occupied in the warehouse and in the backroom store, in the time of loading and unloading of the trucks, as well as in the associated transport cost. Considering the estimated results for each strategy, it was obtained a total of:

- Reduction in the number of picking pallets (%): 2.7+1.5=4.2%
- Increase in height occupancy rate (%): 0.9+0.9=1.8%
- Increase in volumetric occupancy rate (%): 0.8+0.8=1.6%
- Estimated annual benefit: 377,563+200,345=577,908 €/year

Although the increase in the percentage of height occupancy is not very significant, it translates into a very high annual monetary benefit, proving that in fact any small improvement in transport has a very significant impact on the efficiency of the chain. Strategy 1 was accepted and implemented by the company, while strategy 2 is being evaluated for 20 small format stores to validate these benefits. In order to monitor the results of strategy 1 on a monthly basis, a cockpit chart was constructed. It has been very advantageous because it has allowed a monitoring of the volumetric, in height and floor occupancy indicators, which until the beginning of this project was not possible and the results have been very positive, especially regarding the average volume per picking pallets and the height occupancy rate. Comparing January and September, there was an increase of 4.4% and 2.7%, respectively.

6. Acknowledgements

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IPVC Student: Indices of Attractiveness, Loyalty and Student Satisfaction

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ABSTRACT

Attractiveness and student loyalty are determinant for the sustainability of Higher Education Institutions as it contributes to the number of students who seek and preserve their connection to the institution.
The main objective of this study is to analyse course attractiveness and student loyalty, in the last five years, in the Instituto Politécnico de Viana do Castelo (IPVC).
The demand, student dropout rate and pursuance of studies and satisfaction with teaching and services were analysed, linking them to student profiles and organizational context.
Dropouts in Professional Higher Technical Courses (CTeSP) and Bachelor's Degree occur mainly within the masculine gender and in the first year; in Masters', this occurs mainly in the 2nd year and in the feminine gender. In 2013/14, dropouts reached their highest level and students' enrolment in National Call reached its lowest number of the last 8 years, coinciding with the peak of the economic crisis. 60% of CTeSP graduates go on to Bachelor's and 25% of graduates carry on to Master's.

Keywords: demand, student profile, dropout, student loyalty, pursuance of studies

1. Introduction

In the last few decades, the system of higher education in Portugal has undergone profound, structural changes with a substantial increase in the number of Higher Education Institutions (HEI) [1]. Public funding of HEIs has been reduced, being partially based on the number of students. Attractiveness and student loyalty are crucial to having key performance indicators (KPIs). By applying the appropriate strategy, offering resources to improve the quality of activities that are important to students, administrators can increase the value offered and contribute to student loyalty by ensuring the institution's sustainability [2]. Standifird [3] refers that reputation management is also considered very important in attracting and retaining students.

Student loyalty is generated by overcoming expectations in relation to the received experience. Identifying the reasons for non-retention allows for the implementing of solutions to mitigate the causes and maintain the student-client [4]. Retention is the "ability of HEI to successfully graduate students who enrol" [5]. Abandonment is one of the major problems of HEI, and it is fundamental that strategies be implemented in order to reduce it [6, 7]. Student loyalty is influenced by "psychological attachment" and a feeling of institutional pride [8]. Satisfaction and institutional reputation contribute strongly to loyalty [9, 10]. According to [9, 11-13], loyalty is maintained through the development of values between the institution and the individual, driven by personal relationships guided towards maintaining long-term relationships.

The relationship between HEI and students is fundamental, as well as with candidates, graduates, parents, companies and partner schools, teachers and employees. The HEI must carefully manage these relationships, as each one is a potential multiplier in the dissemination of the institution [14]. Parents are the ones who often choose the HEI [15]. Future employers create close relationships with HEI through their immersion in student training and hiring of graduates.

Kotler and Fox [16] state that "retaining enrolled students is as important as attracting them for registration." Satisfaction is defined by student experience at the institution and satisfied students are motivated in maintaining their relationship with and defending the name of the HEI, as well as in attracting new students by conveying positive information and even returning to the HEI to undertake other courses [14, 17-19].

It is imperative that strategies of loyalty be implemented and not simply those of prospecting; gaining new students is not enough, it is necessary that they be retained, by winning their loyalty in the short, medium and long terms. Student satisfaction must be sustained by the following four variables: course, services, people and environment, which should be evaluated in an integrated way for the continuous improvement of satisfaction, loyalty, recommendation and engagement. HEIs are confronted with increasingly competitive and commercial environments, with strategic planning and management focused on the quality of education and its services, the means to gain recognition and a more competitive advantage [20]. Martensen *et al.* [21] report that students have very high yet inexplicit expectations, which makes analyses more complex. The measurement of satisfaction is unreliable if it is based solely on one variable from the perspective of consumer behavior [22, 23].

Teaching and course organization are the main determinants of student satisfaction and student loyalty among the more academic components of the educational service [24]. [25] confirms the assertion that student satisfaction is the most effective factor that influences positively on students' loyalty, meaning the more satisfied students are, the more loyal they will become.

1.1 Methods

The aim of this study is to analyse the results obtained with the indicators of attractiveness, student loyalty and satisfaction, used in the IPVC Management System, within organizational and socioeconomic contexts and its impact on institutional performance. It was applied to the courses of CET-Course of Technological Specialization (until 14/15), CTeSP since 15/16, degrees and masters, of the 6 schools of the IPVC (ESA-Agrarian School, ESCE-School of Business Sciences, ESDL-School of Sport and Leisure, ESE-School of Education, ESTG-School of Technology and Management, ESS-School of Health).

In order to study attractiveness, the demand for Bachelor's degrees between 2010/2011 and 2017/2018 were analysed, as well as potential and real occupation of vacancies, admissions (particularly the 1st phase and 1st option), actual registrations, and entry grades. In the CET / CTeSP and Master's degrees, only enrolments were taken into consideration.

In order to study student loyalty (indicators of belonging and engagement) data on dropout rates between 2013/2014 and 2017/2018 were analysed, as well as the rate of the pursuance of studies at the IPVC. Dropouts (withdrawals or non-

renewal of enrolments) and the results of surveyed, dropout students were studied to assess the causes and verify the possibility of reversing this decision.

In relation to the pursuance of studies, CTeSP graduates who go on to do Bachelor's degrees in the IPVC were analysed as well as those Bachelor's degrees that go on to do Master's Courses at the IPVC.

An analysis was also made of the survey results: student satisfaction with quality of teaching and support services; Bachelor's degree satisfaction with courses and contribution to employment.

2. IPVC Attractiveness and Student Loyalty

2.1 IPVC Attractiveness: Candidates and enrolees

The period with the lowest number of National Call (CNA) candidates and enrolees, as well as Masters and CET / CTeSP enrolees occurred between 13/14 and 15/16, coinciding with the economic crisis (Table I). Similar to the GDP's recovery, there was also an increase in the demand for courses, with 82% of vacant CNAs being occupied in 2017/18. In 2013/14, the % of students enrolled (CNA) reached its lowest value (61% occupancy). The percentage of candidates for 1st option/1st phase increased, with emphasis on Tourism, Management and Nursing with higher rates of attractiveness. The % of candidates from the District of Viana do Castelo to Higher Education, which apply to the IPVC is circa 23% and is seen as an opportunity to attract more students from the district.

Table I. *IPVC admissions, placements and enrolment in degrees between 2010/11 and 2017/18.*

Total IPVC	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Bachelor Enrolees								
No. Vacancies	936	941	991	956	932	956	956	973
No. Candidates 1st phase/1st option (CNA)	622	505	428	354	310	292	332	407
No. Candidates 1st phase (CNA)	3244	2725	2239	1768	1701	1949	1837	2404
No. Candidates (Total CNA)	4741	4409	3383	2687	2651	2835	2823	3717
No. Enrolees CNA	409	385	315	288	262	277	281	298
No. Enrolees in Special Contests	722	653	556	502	516	548	598	656
No. Enrolees CNA + Special Contests	985	921	874	739	776	796	882	973
Placements 1st phase CNA/CNA vacancies	77%	69%	56%	53%	55%	57%	63%	67%
Placements 1st op/1st phase CNA/CNA vacancies	44%	41%	32%	30%	28%	29%	29%	31%
Enrolees CNA/CNA Vacancies	83%	80%	64%	61%	63%	64%	70%	82%
Enrolees Spec. Contest/CNA vacancies	24%	21%	20%	45%	24%	40%	20%	23%
Candidates 1st phase 1st op/CNA vacancies	66%	54%	43%	37%	33%	31%	35%	42%
Candidates 1st phase/CNA vacancies	347%	290%	226%	185%	183%	204%	192%	247%
Average entry grade 1st phase CNA	121.8	118.4	126.1	117.6	119.7	118.5	118.2	118.5
CET/ CTeSP Enrolees	-	-	413	330	305	300	403	389
Master's Enrolees	-	-	438	375	314	275	336	292

2.2 Student loyalty: Dropout rate

In the analysis carried out in relation to course dropout vs IPVC dropout rate, there is a significant reduction in the last 5 years (Chart 1). Only 1 to 2% of students who leave an IPVC course go to another IPVC course, meaning that students who leave the course leave the IPVC.

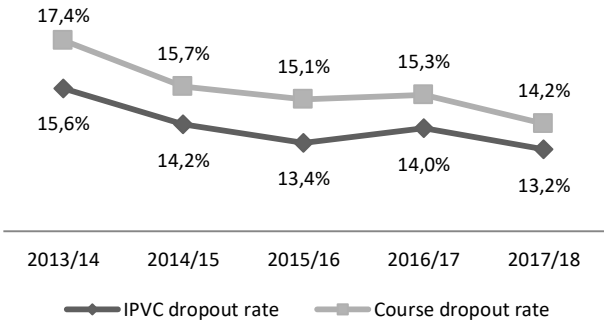

Chart 1. *Evolution of dropout rate in the IPVC from 2013/14 to 2017/18.*

Taking into consideration gender, the dropout % is higher among males (Chart 2), in accordance with Bourdages [26]. In the CET/ CTeSP and Bachelor's degrees male dropout rates are higher whereas in the Masters it is the female gender.

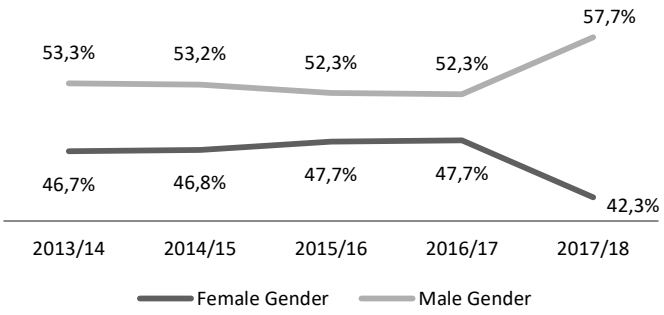

Chart 2. *Evolution of IPVC dropout rate by gender.*

Dropouts occurred more in CET courses, followed by Masters and CTeSP (Chart 3). The CTeSP that replaced CET courses tend to have a lower dropout rate than the latter.

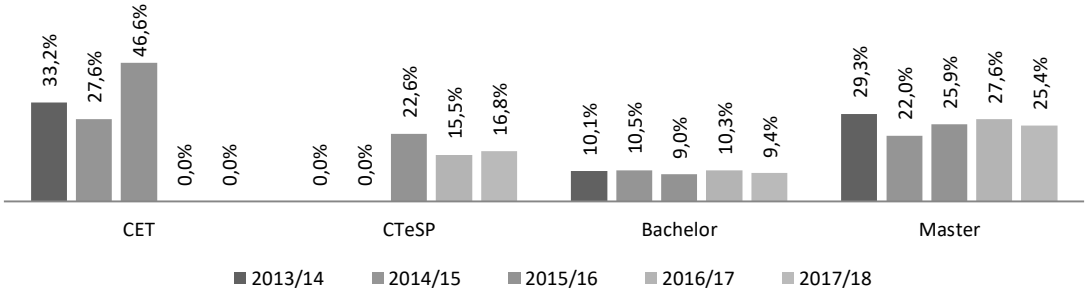

Chart 3. *Evolution of IPVC dropouts by types of training (CET,* CTeSP*, Bachelor's Degree and Master).*

The average dropout rate in IPVC Bachelor's degrees (9.9%) is lower than the national average (29%) [27]. It is worth highlighting low dropout rates in ESE's Master's degrees and ESS Bachelor's degree. [26] also refers to reduced dropout rates in health courses. Dropout occurs mainly in the 1st curricular year in CET and Bachelor's Degree Courses (Table II), which coincides with studies by UTAD [28] and Rego *et al.* [29]. The highest dropout in the first year may be due to difficulties or problems in the transition and adaptation to HE or rejection of scholarships [30-33]. In the Master's degree, there is a trend towards greater dropout in the 2nd year. Bourdages [26] states that in doctorates (the same can be applied to Master's degree thesis), the difficulties that arise around the drafting of the thesis are related not only to students' choices, but also to their supervisors' commitment and the HEI's strategy in guidance management of theses and connection to lines of research. Sternberg [35] explains that dropout during the thesis - Mah's Attrition Process Model occurs in students who are more distant from the course and whose obtaining a diploma no longer constitutes a priority in their life project.

Table II. *Evolution of the dropout rate per curricular year (distribution %).*

Typology	2013/14			2014/15			2015/16			2016/17				2017/18			
	1	2	3	1	2	3	1	2	3	1	2	3	4	1	2	3	4
CET	100,0 %	-	-	100,0 %	-	-	100,0 %	-	-	-	-	-	-	-	-	-	-
CTeSP	-	-	-	-	-	-	100,0 %	-	-	78,3 %	21,7 %	-	-	70,1 %	29,9 %	-	-
BACHELOR'S DEGREE	61,2%	15,2 %	23,5 %	65,4%	15,8 %	18,8 %	56,2%	22,2 %	21,6 %	51,0 %	20,9 %	27,6 %	0,6 %	68,4 %	15,0 %	16,3 %	0,3 %
MASTER	50,2%	49,8 %	-	47,8%	52,2 %	-	43,1%	56,9 %	-	43,7 %	56,3 %	-	-	38,4 %	62,3 %	-	-
	65,7%	**23,4 %**	**10,9 %**	**67,4%**	**22,2 %**	**10,3 %**	**60,4%**	**28,8 %**	**10,8 %**	**53,1 %**	**32,6 %**	**14,1 %**	**0,3 %**	**60,4 %**	**31,5 %**	**8,1%**	**0,2 %**

The number of scholarship holders (DGES-MCTES scholarships) increased (Table III), representing 41% in 17/18 of IPVC students, which shows a student profile with needs in terms of financial support applying for the institution. Out of the total number of scholarship holders, between 4.5% and 5.5% drop out.

Table III. *Evolution of dropout rate in IPVC scholarship students.*

Course Dropout with Scholarship	2013/14	2014/15	2015/16	2016/17	2017/18
% of scholarship holders at IPVC	34,8%	35,1%	37,7%	39,2%	41,0%
% DGES scholarship dropouts	5,3%	4,5%	5,5%	5,3%	5,0%

Students housed in IPVC residences are around 12%, with a low dropout rate and a tendency to decrease (from 6.5% to 2.7%) (Table IV).

Table IV. *Evolution of dropout rate in students housed in IPVC residences.*

Student dropouts with Student Housing (%)	13/14	14/15	15/16	16/17	17/18
IPVC Students with housing	12,9%	6,8%	12%	12,5%	12,1%
Dropout with housing/ with housing	6,5%	3,1%	2,9%	4,1%	2,7%
Dropout without housing/ without housing	16,8%	14,9%	14,7%	15,3%	14,5%
Dropout with housing/ IPVC dropouts	4,7%	1,4%	2,3%	3,3%	2,2%
Dropout without housing/ IPVC dropouts	95,3%	98,6%	97,7%	96,7%	97,8%

The lowest dropout rate in scholarship holders and IPVC lodgers concurs with [36], who report that students who are financially supported by scholarships have a lower risk of dropout, and with [37,38] who conclude that financial support for students is decisive for course completion and the time it takes to complete said course. There are less dropouts in students whose parents have a HE, in particular the mother (Table V), in agreement with Lassibille and Gómez's results [36].

Table V. *Evolution of dropout rate according to parents' schooling.*

Parents' Schooling	13/14		14/15		15/16		16/17		17/18	
	F	M	F	M	F	M	F	M	F	M
With Higher Education	7,2%	11,2%	7,0%	9,7%	7,5%	11,5%	7,4%	11,9%	9,1%	12,6%
Without Higher Education	92,8%	88,8%	93,0%	90,3%	92,5%	88,5%	92,6%	88,1%	90,9%	87,4%

The number of students enrolled with student worker status (SW) is around 10% and the number of SW who leave the IPVC has also been decreasing (Table VI), being 17/18 at 13.1%.

Table VI. *Evolution of dropout rate in student workers.*

Dropout rate in student workers (%)	13/14	14/15	15/16	16/17	17/18
SW at the IPVC	11,4%	10,2%	11,1%	8,5%	10,2%
SW dropouts / dropouts total	12,6%	13,4%	14,9%	8,5%	9,5%
SW dropouts / total enrolled	2,2%	2,1%	2,3%	1,3%	1,3%
SW dropouts / SW enrolled	19,2%	20,6%	20,4%	15,4%	13,1%

In the Bachelor's degree courses, it was established that the dropout rate is significantly lower when the student enters the course as a first option in the CNA and increases (Chart 4).

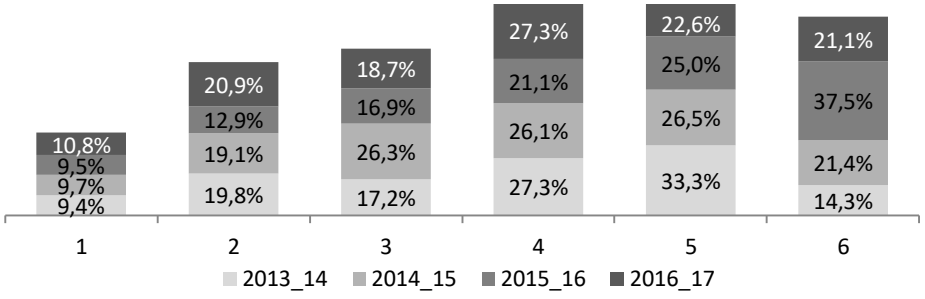

Chart 4. *Evolution of dropout rate due to application options 2013/14 and 2016/17.*

Dropouts are also related to the admission phase and are lower in students of the first phase of the CNA. Those who enter by >23 years present a higher dropout rate (Table VII). Lassibille and Gómez [36] verified that HE students coming from vocational schools leave more than those from regular schools. They also concluded, as in the IPVC study, those students who enter their 1st option and with parents with HE were also less likely to drop out.

Table VII. *Students enrolled in the IPVC who left the courses in the year of admission.*

Admission Bachelor's Degree regime vs. dropouts 1st curricular yr	13/14	14/15	15/16	16/17	Average
% 1st phase CNA Enrolees who dropped out in 1st year	10,9%	11,9%	10,5%	14,0%	11,8%
% 2nd phase CNA Enrolees who dropped out in 1st year	17,7%	23,5%	19,4%	22,1%	20,7%
% 3rd phase CNA Enrolees who dropped out in 1st year	37,9%	28,6%	23,8%	20,0%	27,6%
% CNA Enrolees who dropped out in 1st year	14,1%	16,1%	13,2%	16,2%	14,9%
% CET Enrolees who dropped out in 1st year	18,5%	17,6%	8,9%	7,1%	13,0%
% >23 Enrolees who dropped out in 1st year	26,4%	32,1%	31,2%	20,8%	27,6%

Relating dropouts to the admission grade, we can ascertain that students who enter the Bachelor's Degree course with lower grades are more likely to drop out (Table VIII).

Table VIII. *Evolution of dropout rate in Bachelor's degrees by admission grade.*

Admission grade	13/14	14/15	15/16	16/17
≥ 90,0 < 110,0	17,6%	25,0%	32,0%	17,2%
≥ 110,0 < 130,0	15,2%	18,4%	15,5%	15,8%
≥ 130,0 < 150,0	13,5%	13,6%	9,0%	17,4%
≥ 150,0 < 170,0	9,7%	7,4%	2,9%	11,4%
≥ 170,0 < 190,0	0,0%	0,0%	66,7%	0,0%

2.3 Student loyalty: Pursuance of studies at the IPVC

The pursuance of studies is used by the IPVC as an indicator of student loyalty, in addition to "non-abandonment". There is a trend of increasing enrolment in Bachelor's degrees by CTeSP graduates.

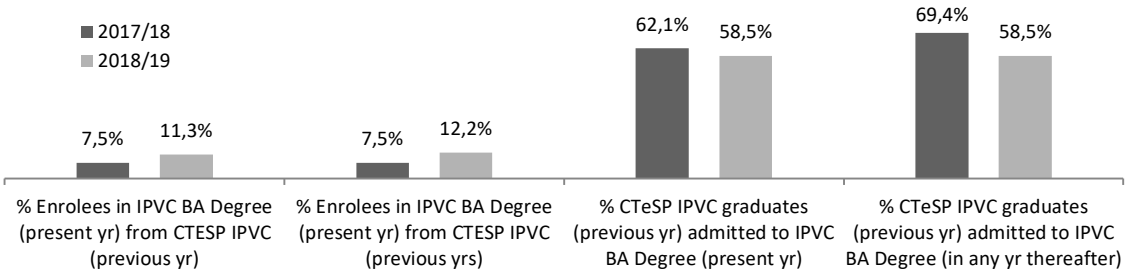

Chart 5. *Evolution of the pursuance of Bachelor's Degree studies to IPVC Masters.*

On average, in the 5 years under analysis, 25% of IPVC graduates enrolled in IPVC Masters, 20% of those enrolled in IPVC Masters are IPVC graduates, the remaining 80% in other HEIs, and 17% in each year in IPVC Masters are IPVC graduates from the previous year. The year with the lowest level of pursuance of studies was 15/16.

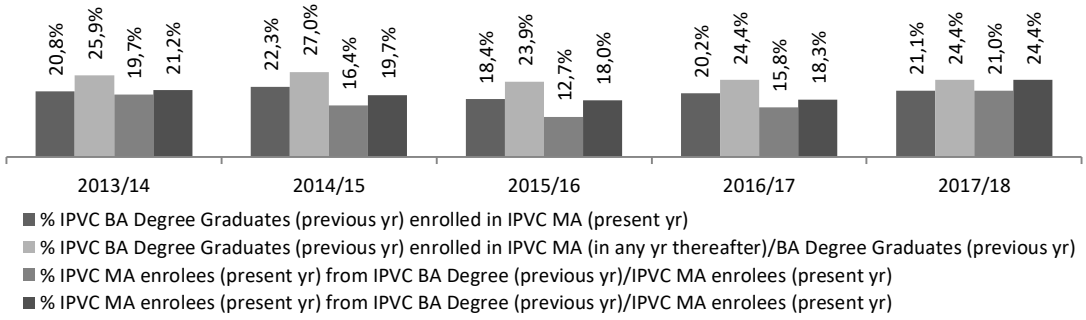

Chart 6. *Evolution of the pursuance of Bachelor's Degree studies to IPVC Master Courses.*

Most graduate students continue their MA studies in the same school, such as ESE, ESDL and ESTG (Table IX).

Table IX. *Transition between schools in pursuance of Master's Degree.*

		MASTERS					
		ESA	**ESE**	**ESS**	**ESCE**	**ESDL**	**ESTG**
DEGREES	**ESA**	91%	0	0	0	0	1%
	ESE	0	99%	17%	11%	2%	5%
	ESS	0	0%	83%	0	2%	0
	ESCE	0	0%	0	64%	0	4%
	ESDL	0	0	0	0	91%	0
	ESTG	9%	1%	0	25%	5%	90%

In the survey carried out among graduates, the main reasons for the pursuance of studies in the IPVC were: proximity to home, satisfaction with training (quality of teaching staff, school organization, teacher-student relationship), complementary training offer. More than 83% of the 1st cycle graduates responded that they would recommend the course they undertook in the IPVC.

2.4 Student satisfaction

The average degree of course satisfaction of IPVC students is 3.02 (on a scale of 1 to 4), an average of the four academic years from 13/14 to 16/17, with the lowest average in Bachelor's degrees (2.89) and the highest in the CTeSP (3.11) (Table X). Satisfaction with teaching staff has the highest rates.

Table X. *Student satisfaction with quality of education, obtained through survey (IASQE-IPVC).*

Evaluation criteria for Teaching satisfaction	**13/14**	**14/15**	**15/16**	**16/17**	**IPVC Avg. Overall**	**Average**		
						CTeSP	BA degrees	Masters
School	2,9	2,7	2,8	2,9	**2,8**	2,9	2,6	2,9
Integration, services, communication	2,9	2,7	2,9	3,0	**2,9**	3,0	2,8	2,9
Course	3,0	3,1	3,0	3,0	**3,0**	3,1	2,9	2,9
UC's 1st semester	3,1	3,0	3,0	3,1	**3,0**	3,1	2,9	3,1
UC's 2nd semester	3,0	3,1	3,1	3,2	**3,1**	3,2	3,0	3,1
Teacher 1st semester	3,2	3,1	3,2	3,3	**3,2**	3,2	3,0	3,3
Teacher 2nd semester	3,1	3,0	3,2	3,3	**3,1**	3,3	3,0	3,2
Average	**3,0**	**3,0**	**3,0**	**3,1**	**3,0**	**3,1**	**2,9**	**3,1**

Satisfaction with services is, in general, very positive, especially the Health and Cultural Offices (Table XI). There has been a slight decrease in the last year, in relation to food and scholarships, and in this last item the main reason being the delay in allocation, which is unrelated to the IPVC.

Table XI. *Satisfaction with Support Services, obtained through Surveys.*

Survey of Services (scale 1-5)	**13/14**	**14/15**	**15/16**	**16/17**	**17/18**	**TOTAL**
Housing	3,3	3,2	4,0	3,7	4,0	**3,6**
Food in Canteens	3,8	3,7	3,4	3,5	2,7	**3,4**
Food in Snack bars	–	3,6	3,6	3,1	2,9	**3,3**
Social support scholarship	–	4,2	3,7	3,8	3,4	**3,8**
Scholarship	3,9	3,6	3,7	3,8	3,1	**3,6**
Academic BUS	–	–	4,0	3,6	3,9	**3,9**
Sports' Centre	–	–	4,2	3,5	3,8	**3,8**
Health Office	–	–	–	3,9	4,2	**4,0**
Cultural Office	–	–	3,9	4,4	3,7	**4,0**
Employment support	–	–	3,3	3,4	3,5	**3,4**
Libraries	3,9	3,7	3,9	3,9	3,9	**3,9**
TOTAL	**3,7**	**3,7**	**3,8**	**3,7**	**3,5**	**3,7**

The satisfaction with teaching quality and support services has not charted the trends of demand and dropout rates, remaining stable and with a very positive average. In the CTeSP, although the dropout rate is higher than in the Bachelor degrees, the levels of satisfaction with the course are even higher. On the other hand, in 2017/18, service satisfaction fell slightly but dropout rates also continued to decline.

3. Conclusions

During the period from 2013/2014 to 2015/2016, coinciding with the country's greatest economic impact, there was a sharp fall in the main indices that measure the attractiveness of IPVC courses and pursuance of studies; a situation which led to a sharp fall for demand in 2013, below the 49000 candidates, when in 2008 there were more than 61,000 candidates for HE [39]. The crisis began to take effect in 2009 but hit its lowest GDP in 2013, of capital stock, consumption and investment per capita, and the highest unemployment rate (16.6%) [40] was reached. In that year, the IPVC dropout rate was 17.4% (19% in the TE) and has since dropped to 14.2% (13% in the TE) in 17/18. The main causes mentioned in the survey for dropout were financial problems /personal conditions, followed by proximity from home and academic failure. Studies that identify factors from the students' perception enable HEI to attract more students and make them highly satisfied as well as loyal [25]. This integrated information allows the IPVC to identify unfavourable contexts, unmet needs and expectations of students, signal situations of risk, as well as opportunities that trigger corrective actions or improvement in institutional marketing processes, communication plans, and review of training offers and integration of students, particularly those who are at higher risk of abandonment.

4. Acknowledgements

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Easing the retail store experience with digital technologies: discussing the promise of customer convenience vis-a-vis customer effort

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ABSTRACT

This study offers innovative insights about the contexts, drivers and barriers to the adoption of digital mobile technologies to support customer tasks in retail contexts. Despite the existence of an ample research about the determinants for the adoption of technologies in service contexts, there are still many open questions regarding customer use of mobile technologies in retail, notably for supporting the in-store experience. This paper offers a contribution to address this gap by identifying some key determinants that explain the resistance of customers in the use of mobile technologies to assist their service journeys in physical retail contexts.

Keywords: food retail, customer oriented- technologies, customer satisfaction

1. Introduction

In an era where the adherence of consumers to online shopping is consolidating its momentum, companies need to continuously revisit their strategy for the operation and sustainability of brick and mortar stores. Despite the increasing use of the online alternatives by retail customers across an expanding range of goods, in some domains, such as grocery shopping, a significant majority remains loyal to in-store shopping services. However, store operations can no longer be designed apart from the possibilities offered by digital technologies [1].

Nowadays, the sustainability of the store model is far from being restricted to the variables of price or proximity and is increasingly determined by the ability of companies to integrate online and offline channels, as well as to integrate technology in the activities to be performed in store. Retail companies have been at the forefront of experimentation of technologies for services delivery, embracing the introduction of self-service kiosks, automated checkout systems, digital price tags, among others, in order to improve customer convenience and efficiency when conducting in store tasks [2]. Nevertheless, despite the promises of gains in service convenience, the pace of adoption of such innovations often faces significant resistance from customers. Research results suggest that the key determinants for the effective technological sophistication of the in-store experiences will not be restricted to the availability of technologies, but rather will depend largely on the ability of companies to understand the specificities of customer adoption contexts and requirements [3]. This article offers a contribution to develop knowledge about customer motivations and requirements for using digital technologies to support in store service activities, for grocery retail processes. The article discusses the results from an exploratory study that investigated the contexts of use and the barriers associated with the utilization of mobile technologies to support the in-store purchase journey for customers of a large Portuguese retail chain.

2. Literature review

The delivery of services involves the setup of processes that require multiple interactions between the customer and the companies' resources, including its employees, and the service facilities and interface technologies. Often, as it happens in many retail contexts, customers are so engaged in the delivery process that they spend substantial amounts of time in the companies' facilities, and perform several tasks, to a great extent co-producing the service with the provider. In such a context involving intensive interaction and participation of customers, the quest for productivity gains is on the top of management concerns, and, for this reason, technology is often being used to facilitate a wide range of service encounters, and to leverage the interaction between customers and providers. From self-scanning options, to virtual fitting rooms, the number of technological choices for retailers to improve the in-store experience have been increasing impressively. While the drivers for the implementation of technology solutions are strong, the effective customer adoption of such delivery alternatives can be slow and subject to many resistance. Not only the technology must meet the capabilities of the target consumers, but also a variety of personal, motivational and contextual factors can affect customers' willingness to adhere to the technology options.

2.1 Contexts, and shopping values associated with technology adoption

The characteristics of the service context, along with the customer profile and capabilities play a substantial role in the adoption of technologies. In retail the adoption of technologies can be associated and explained by the of the shopping value that it enables, notably: the role of the technology for achieving reductions in consumer effort or cost during the purchase process; and the importance of the technology for enabling utility benefits as well as hedonic or symbolic benefits [4]. The role of technology in reducing costs or efforts is associated with the value that is created when the technology allows the consumer to achieve a gain in the effort required to obtain a service (e.g. making a task faster or more automated) or to capture a such gain by means of reductions in the service price. The willingness to adopt a technology, based on the expectation of reduction of effort or cost, has, therefore, been related with the variables of convenience and price expectations. Utilitarian benefits, in the context of a service experience, refer to the functional, instrumental, and practical benefits that the customer can obtain in a delivery context. In retail setting, technology, can, for example, allow customers to the access to product information, and product comparison, using the mobile phone, therefore improving attributes such as service accessibility, privacy and convenience. Likewise, for in-store contexts, mobile technology can allow for gains in the deployment of information about store layout and services, product information and also support complementary services such as order placement and payment. Moreover, technology can expand enormously the scope for providing personalized recommendation and customization services. The term hedonic or symbolic benefit, refers to the aesthetic, experiential, and enjoyment-related benefits of consumption. When referring to retail technologies, this translates into the potential to create value be means of fun and positive feelings enable by the use of technology alternatives during the shopping experience. The possibilities entailed by new technologies to this end are very ample, and include, for example the possibility of implementing responsive systems that can highlight certain products, e.g. by using interactive screens that capture the customers' attention and give him/her some inspiration.

2.2 Technology adoption vs. service quality and performance – customer perceptions

Nowadays technology is highly connected with humanity daily life, process optimization and the constant decrease of implementation costs began to make it gain more followers and expand faster. Its growing potential and the way it eases operations makes it fundamental for the good functioning of any organization. While human-based service delivery has been prevalent over the years [5], the implementation of technology alternatives that asks the client to perform a task, which was normally performed by the employee, can be challenging. The path towards replacing a company's employees in providing services is still embryonic, however it has been gaining in popularity, since it reduces labor costs and allows the store to expand its working hours [6]. The transference of tasks traditionally performed by store employees to the hands of consumer is often supported by the so-called, self-service technologies. Examples include ATMs, gas pump payments, automatic hotel checkouts, online transactions, among others [7]. In practice, the implementation of self-service requires an adequate alignment of the roles of the companies' employees, technology systems and customers. A prevalent strategy is to offers customers with service alternatives, with varied degrees of technology intensity, allowing them to choose to a more human or more automates, self-service service experience and adjusting to different shopping circumstances, depending of the nature of the product or service being purchased. Such multi.interface, or multichannel service offering has evolved to be a dominant strategy [8]. Multi-channel service delivery is seen as a competitive strategy, allowing for flexibility regarding what tasks are effective transferred to the customer to meet their own needs, and it can lead the organization to a greater margin to expand its offer by customizing the delivery process [9].

Service literature has acknowledged that the introduction of technology alternatives in the delivery processes, cab bear substantial implications for the quality of service experiences. A pioneering approach to address this was developed by Dabholkar in 2002 [10] in the proposed Attributes Model. According to the author, the Attributes Model is based on an approach to support the decision-making process in which consumers evaluate self-service technologies to create certain expectations about the service [10]. This model applies to consumers who already have a predefined idea about how to evaluate the service and consumers who are new to the process and who want to analyze it in a relevant way so that service quality can improve [11]. Figure 1 shows the Attributes Model advocated by Dabholkar, considering the aspects known as enhancers of customer adoption to self-service technologies.

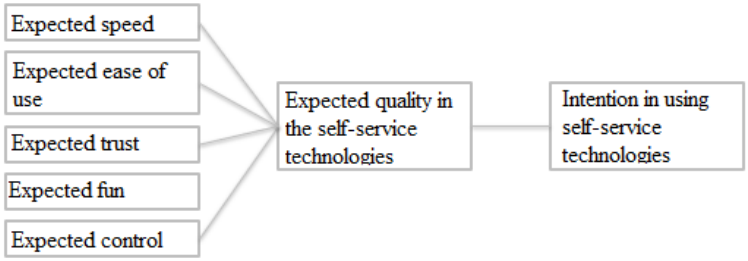


Figure 1 Dabholkar Attributes Model

Several authors have observed that the variable time is preponderant to explain consumer loyalty to the use of self-service technologies. The concept of time is seen as the combination of waiting time and service time (time it takes to be completed service) [12, 13]. Consumers have also an expected wait rate, i.e. a prediction about the time necessary for obtaining the service [14]. In this vein, some consumers are willing to switch to self-service alternatives because they believe this is the best way to reduce waiting time [15]. Busy or unoccupied waiting has a great impact on consumers' time perception. Busy waiting is perceived to be faster and less unsatisfactory, which is why several establishments have opted to pass videos and news on services where there is a queue [16]. While in traditional channels, the service delivery time depends only on the agility of the collaborator; in self-service technologies, the speed of service delivery is more tightly connected to the customers' own performance and ability. The speed with which a service is delivered is crucial to the time optimization when making use of self-service technologies. It is advanced ad one of the most important factors in the adoption of these technologies by the consumer [17]. The convenience of self-service technologies is a decisive factor in its adoption by the various consumers. When it comes to choosing the service channel, clients weigh the effort required for attending a particular service. Ease of use is very important for users of self-service technologies, since it reduces the effort expended and reduces social risk [18, 19]. Social risk is described as the fear of potential users face difficulties when using a specific technology and consequently feel ashamed and embarrassed around other users. The opposite occurs when users believe that it is a simple method, and therefore see it as a high-quality option [20]. The perception of a high quality option lays on reliability, which is based on the ability to obtain a good systematic performance in delivering a service in an accurate and reliable way [21]. Inherent to reliability comes the reduction of risk perception which increase trust in the service provider. Increased trust in the service provider leads to reduced uncertainty and a sense of security in users [22] [23]. Confidence gives consumers a guarantee that leads them to perceive risk and anxiety in a more optimistic way [24].

3. Data and Methods

This study offers several contributions that derive from a set of methodological steps. Building on the review of the types of digital technology utilization in retail shopping, it sets up to discuss the nature of the determinants for customer resistance, building on recent research results and debates. The paper presents and discusses the results of the empirical observation and enquiry of in-store shoppers about the use of mobile technologies to support their shopping experience. The study involved the application of a short questionnaire addressing the users of mobile functionalities and applications developed by a large Portuguese retailer, with the purpose of identifying specific determinants that can explain customer resistance in such settings. The sample of customers addressed in the study were frequent hypermarket and supermarket shoppers which had contact with service based digital technologies almost daily. The investigation addressed firstly the use of in store technology, with the purpose of understanding the value, the importance and the knowledge that customers hold regarding those systems. This was followed by an exploration of consumers experience with interactive apps designed to ease the shopping experience.

The enquiry was conducted in the facilities of in two popular supermarkets in the north region of Portugal. Consumers were approached in person be the researcher while queuing for checkout so that they would be more comfortable to answer the different questions. A total of 50 valid answers were collected. To enrich the data quality, after asking all the proposed questions, we asked the consumers to tell us the most impactful aspects of the technology studied and why did they considered them as critical.

4. Results

The grocery retail sector in Portugal is largely dominated by commercial groups who manage networks of hypermarkets and supermarkets. The retail sector has evolved as a pioneering domain for the experimentation of self-service technologies, multichannel services, with a consolidated offer of online-shopping services, and more recently with a proliferation of supporting apps that promise to ease the shopping effort of customers. Despite the online technological alternatives, in-store shopping is still preferred by a large number of customers, driven by reasons that are related with price perceptions, the possibility of buying everything in a same setting and often the general in-store experience attributes. Nevertheless, the consumers have evolved toward more sophisticated and educated decision making in what concerns the management of their time and money, and this is making them more demanding about the way retailers perform when combining technology with in store services. Technology is perceived as particularly important for achieving improvements in the time, in particular waiting time, spent in each store visit. A typical customer shopping experience, in a supermarket or hypermarket context can involve substantial time, and often fragmented waiting times. Portuguese hypermarkets and supermarkets offer fishmonger, butchery, bakery, cold meats and take-away services inside their stores. Such services can increase, and multiply, the instances for customer service time and service wait. As customers are extremely sensitive to time issues in the shopping experience the management of such in-store service spots has become a critical area of concern for retailers to come up with a set of solutions to ease their operation. This is therefore a setting that where technology/digital solutions have been advanced and experimented, but for which the results and effectiveness of the technology, on the eyes of the customer, remains unclear. In order the gain understanding about this, this study included an inquiry to customer experience with the use of technology solutions to support their tasks and overall experience in the in-store services. In Table 1 we describe the various technology solutions addressed in the study, that were present in the supermarkets considered in this study.

Table I *Types of in-store technologies addressed in the study*

Technology	Category	Shopping value addressed	Description
Shopping app to support overall shopping process	Self-scanning	Cost and effort reduction	-Shopping lists -Scan items in the store -Payment at self-checkout zones
Digital receptionist, placed at store entrance	Queue management	Utilitarian benefits	-Queue number ticket for every service in the store
Mobile app for consumers to take their turn for in store services	Queue management	Cost and effort reduction	- Queue number ticket for every service in the store in an app -Notification about the user's turn
Take your turn system	Queue management	Utilitarian benefits	- Queue number ticket for ONLY the service point where it is placed.

In-store technologies for supporting customer service allow customers to check their discount coupons by reading their client card and allow them to print a ticket for in store services so that they can be included in the supermarket queue systems. The service ticket is valid only for fishmongers, butchers, bakery, take-away, cold meats and client support. As for the available apps, the study focused on those directly connected to support the shopping experience. The App for supporting the overall shopping process allowed the user to create his/her shopping list at home and share it with other users. When in the store, the consumer has to scan the products on the shopping list and finish payment through a QR code which will be read by the self-checkout point of sales. This app gives the user a greater sense of autonomy in their purchases and improves the checkout since the scan of products is not concentrated in the final point of sale but deferred throughout the shopping journey.

The enquiry included direct questions, such as those related to characterize the type of supermarket they were used to visit (smaller or bigger formats), the frequency of visit and which services they prefer. After the characterization of the sample, it was important to guarantee the accuracy of all answers. For the first enquiry 120 individuals were enquired, 66% were predominantly clients of hypermarkets, whereas 24% were clients of supermarkets and the others preferred visiting convenient stores. Regarding the age of the inquiries, the majority were between the age range of 20-30 (38%), following 31-40 (28%). When asked about the type of services they were used to visit, we gathered that 80% of the customers are prone to buy fresh products in the services mentioned above over packed ones. Furthermore, when in the supermarket, customers visit normally two of the services (fig. 2).

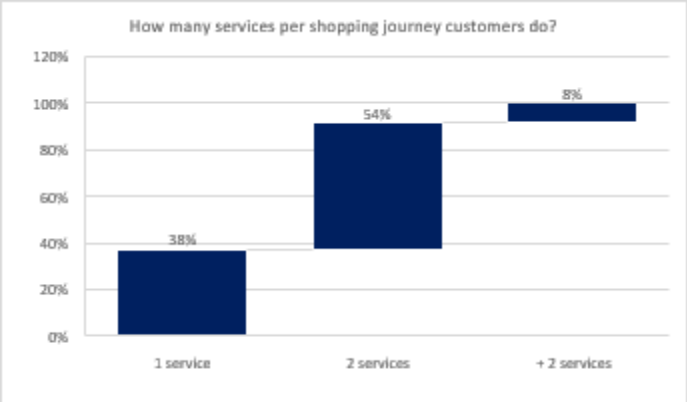


Figure 2 *Number of services attended per supermarket visit*

To use such services, the consumer has to take a ticket representing his/her turn. This action can be done by using the equipment in the store, or the customer app. As illustrated in fig. 3, there are service points, that include a printer, where you can get your tickets representing your turn, either in the traditional format near the service point, or at the entrance of the store, via a digital receptionist. In the context of the supermarkets addressed in the study most of consumers still preferred the traditional option.

Figure 3 *Traditional "take your turn"; Entrance screen (digital receptionist); Mobile app to "take your turn"*

For the retailer, the digital receptionist and the apps were systems implemented in order to increase customer satisfaction and ease queues in service points. The digital receptionist was developed to offer an easy way for customers to consult their coupons, take their turn for all services available and reduce waiting time. The app presents itself as user friendly allowing customers to choose whether they want to stand in the line or shop while the other orders are prepared. Both technologies had low penetration rate, which means users were not adopting it as their preference. After talking with frequent clients, some clusters were created in order to understand which factors weighted more regarding the adoption of these newer technologies (illustrated in fig. 4). The main reason for not using the store entrance technology was surprisingly attributed to the lack of habit to interact with a technology before starting the effective in-store journey. Customers are used to take their turn next to the service points which makes them forget to do it as soon as they get in the store. Many customers explained that for them there is no need to use this type of service, because they prefer to do it when they are the service point (lack of need). Others stated that when they are in the store they only decided to pursue the fresh product services when they see them exposed at showcases (in-store decisions). While 15% of customers admit the only cause of not using the entrance screen is because they forget, a small group state that it creates a sense of unfairness. To analyze this

perception, we asked more questions to these individuals, understanding that as the entrance screen is the first thing you see as you enter the store your turn will be first than the other people that enter the store first and then headed to the service point to take his/her turn. Bearing this in mind, customers believe that if a person arrive first to service point they should be served first, which makes them feel uncomfortable if it is done in a different way. Regarding the app, the main reason for the not adopting this method was the lack of knowledge. About 35% consumers were not aware of the existence of the app, while other 35% claimed that it was pointless because they always visit service points when there are little queues. For the ones that already used the app, 18% state that tech failures were constant which made them uninstall the app. A small percentage of enquiries do not want to download the app due to the lack of space and the perception of higher quality when using the in-store equipment for the effect. When the client finishes his/her order, the preparation starts. At the time of enquiry the preparation was done in front of the customer allowing him to guarantee and follow the preparation of the order. Only 31% of the customers consider watching the order preparation as a key factor to guarantee the job is done adequately. This tendency increases in services as butcher and fishmonger, this because consumers are more careful to details as origin of the product, freshness, expiry date, etc. To address the problem of large queues next to service points in peak hours, the supermarket chain placed a TV, so people would have an occupied wait and consequently perceived it as shorter as mentioned on the theoretical background. Nevertheless, only 5% were able to remember any commercial or video played on that TV. Enquiries supported that they usually look to the TV, however they do not pay it too much attention.

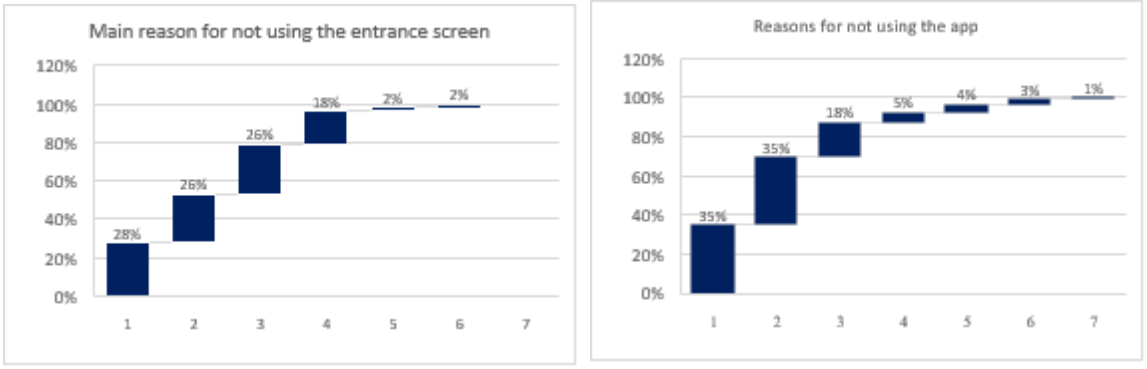


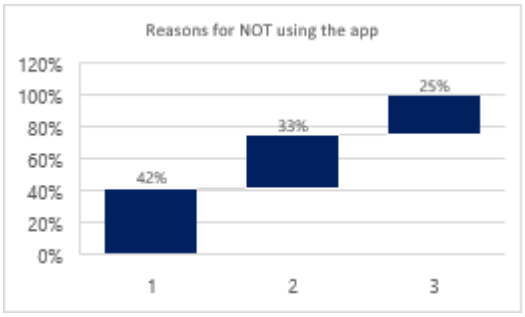
Figure 4 *Reasons for not using the technologies in the store*

Legend: 1-Lack of habit; 2- Lack of need; 3- Never heard; 4-Forgetfulness; 5-In-store decisions; 6-App;

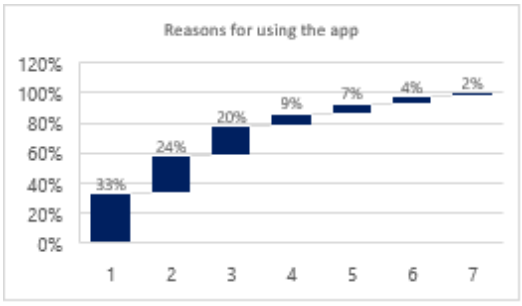
Legend: 1-never heard; 2-no need; 3-lack of understanding; 4-tech failures; 5- app not download; 6-in store equipment; 7-lack of phone memory;

The main reasons for the low usage rate of the mobile app and the digital receptionist are the lack of knowledge and habit that can be solved by a broader communication. When talking about the in-store shopping app, the criteria for adoption differs since its final goal is different. While other technologies only focus on in-store services and establish no tie to the final purchase, In-store shop app houses that functionality. This new app supports the shopping experience from the shopping list till the payment, all this path is performed by the user autonomously. The in-store shopping app is a recent app with little time in the market, so when customers were enquired the main goal was to understand their perceptions and feelings towards this new technology. After interviewing some customers, it was clear that the use of their personal mobile phone was an issue since they are afraid of dropping it or get stolen while searching for a specific product (as illustrated in Figure 5). Furthermore, many clients stated that the app consumed a large amount of battery and occupied much space in their mobile's phone memory. Bearing that in mind, the use of mobile phone gains popularity for frequent grocery shoppers, which are usually associated with small basket sizes and for short time in store. Although the In-store shop app presents itself as innovative, the retailer studied offers a similar experience with fewer features through self-scanners which allow consumers to register all their purchases and pay in checkout areas. As this option is fully supported by store equipment, some consumers feel that self-scanning is more comfortable and safer, ultimately ruling out the in-store shop app. The interviews analysis was supported by the use of Qualitative Data Analysis software (QDA miner). After developing some cluster joining consumers with the same perspective patterns we gathered what were the main reasons for using and not using the app.

The app provides its consumers a fast path-to-purchase which makes it gain popularity among clients. Nevertheless, self-scanning clients are resilient to change since they are used to the method and they believe it is most suitable for big purchases. Statistics show that clients are 4,4/5 satisfied with the app. The main critics were regarding the period audits that the employee has to perform so it certifies that people are in fact buying everything which is placed on the cart. In addition to that, there are 72% who feel dissatisfied with the fact that invoices can only be made with a store employee assistance. Given the rate and the number of clients satisfied with this emerging method of shopping, it is believed that this method will redefine how Portuguese do their grocery shopping.



Legend: 1- Dislike using personal phone; 2-Not suitable for big basket sizes; 3-Used to self-scanning equipment;



Legend: 1- Fast; 2-Easy; 3- Avoid queues; 4-Convenient; 5-Pratical; 6-Intuitive; 7- Useful for small purchases.

Figure 5 *Customer satisfaction and dissatisfaction regarding the app*

5. Discussion and conclusions

Digital technologies for assisting customer experience in retail services are gaining popularity. The demand of customers for more comfortable and easy ways to shop made retailers come up with solutions like apps, interactive system inside their stores, in a way where there is a higher proximity between the digital world and the consumers. When talking about in store services there are many problems to address. The perceptions about the time spent in store is a critical element for the customer. Moreover, we have learned over previous research that active time is perceived as less lengthy as passive waiting time. Bearing this in mind, the study acknowledged the use of a TV display in waiting areas but for which costumers expressed that it was not serving its purpose. The results also suggest that the provision of clear information to the customers about the available technologies must not be disregarded. New initiatives developed should be communicated to the client, not only on their embryonic state but throughout the time. Regarding mobile apps it is fundamental to understand its value before launching them. The added value must be such that future users have the willingness to download it and keep it in his/her private device. Furthermore, when developing an app is important to offer a range of useful activities so that the user keeps it in his/her mobile phone. In a recent study be TechCrunch it was found that 29,1% of Android users uninstalled it after a day, in iOs case users the percentage decreases to 25,5%. Bearing this in mind, when the app is released to the market it should be in its best version, the technical failures represented 5% of the causes for not using one of the apps offered by the retailer. It is believed that the reason why this percentage is not higher is because about 35% of customers have never heard of this application. Updates are an unavoidable aspect of digital systems. However, they should be easy to update and comport no bugs or issues.

The analysis offered in this paper was informed by primary data collected in different supermarkets belonging to a large food retail chain. As at the time of the enquiry and the interviews, the app in use at the stores was recent, and for this reason some evolution in the results could be experienced shortly, suggesting a need to conduct further extensions of the study. Nevertheless, the study offers interesting insights that can inform managerial action in the process of stimulating customers' trial of new technologies and innovation. Previous research results indicated that the process of trial and continued use of technologies is explained by different motivations, and that it may take some time until individuals get over some initial skepticism and fully understand the benefits provided by new technologies [25].

It would also be useful to get information about the sense on the utility from the employee's perspective, company profit and how it impacts the loyalty to the store. Although there are many improvements to be made, given the positive outcomes of the technologies both in store and personal, we believe the consequences of moving towards a more digital experience may lead to a possible competitive advantage and offer disruptive ways to deliver supermarkets services, expanding the retailer customer network. Considering the growing potential of digital technologies for assisting and augmenting the customer experience in retail services, it is necessary to conduct specific research about how ready customers are to handle different types of technology approaches. The domain of mobile applications raises very specific challenges regarding customer ease of use and motivation to adhere to the proposed solutions, often developed by the retailers. This paper offers exploratory insights about the challenges involved in the combination of interactive digital functionalities with in store physical actions, on the perspective of the customer. Moreover, it offers evidence about the importance of the used introduced variability that results from the joint effects of differences in customer effort, motivation and capabilities, as well as differences in the perforce of customer mobile devices and digital proficiency that are beyond the control of the service provider.

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Quality assessment and Customer Satisfaction in IPVC Food Services

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ABSTRACT

The Social Services of the Polytechnic Institute of Viana do Castelo (SAS-IPVC) provide, among others, food services to the IPVC academic community. The IPVC has its Quality Management System (SGQ-IPVC) certified by ISO 9001, which include Food processes (canteens, snack bars and vending machines).

This study shows the monitoring and evaluation of the SGQ-IPVC at the level of Food Processes of the SAS-IPVC between 2008 and 2016, as well as a critical analysis of the results obtained from the evaluation of the performance of said process. It also shows the effectiveness, suitability and proposals of changes in order to eliminate or reduce the causes of detected occurrences and identify opportunities for improvement and innovation.

It was established that customer satisfaction indexes were always above average value, showing a positive trend in satisfaction with canteen and comfort of snack bars, as a result of interventions that have been duly carried out.

Keywords: canteens and snack bars in higher education, quality, customer satisfaction

1. Introduction

With the constant changes brought about by globalization and increasing technological and scientific capacity, customers have become progressively demanding, which has led to a constant need for improvement of the service provided, to meet and / or exceed customer expectations [1]. Against this background, the increase of customer satisfaction is crucial to the success of the organization. According to ISO 9000 standard of the International Organization for Standardization (ISO), this is possible by maintaining a quality management system that allows for continuous service improvement, in order to increase the satisfaction of all stakeholders. The proposal to implement the SGQ Management System according to ISO standards is reinforced by several entities; Rosa, Sarrico & Amaral [2] refer to the use of ISO 9001 as a good guide for the implementation of QMS in HEIs. Abbadi, Bouayad, & Lamrini [3] report that HEIs increasingly use this reference for their QA Management Systems. Quality is an integral part of the IPVC strategy and since March 2009, the SGQ-IPVC Management System has been internationally certified according to NP EN ISO 9001: 2008. In 2013, it became the first Polytechnic Institute to obtain certification of its QA Management System by the Agency for Assessment and Accreditation of Higher Education - A3ES[4]. The organization should not only ensure compliance with legal or regulatory requirements for certain processes and time periods, but also that the improvement of services be continuous and innovations be incorporated [5].

The present study focused on the Evolution of the Quality Assurance Management System in the field of Food (ALI) of the SAS-IPVC and main process performance indicators between 2008 and 2016. Thus, the following aims were established: assess the evolution of the QA-IPVC Management System at the level of the SAS ALI process between 2008 and 2016; describe the main causes of nonconformities (NC) and complaints; analyse the factors that influence the quality of the service provided by the food supply area of the SAS and the degree of user satisfaction; and propose solutions to eliminate or reduce the causes of identified occurrences as well as new actions for improvement.

2. Methodology

The Annual Quality Plans, Reports and Accounts of the SAS, which include a 'tableau de bord', surveys and annual reports of the processes, external and internal audit reports of the ALI sub processes were analysed, as the NCs were grouped according to the requirements of NP EN ISO 9001: 2008. The NCs referred to in inspections, supervision and filled-in fact sheets were also analysed, including complaints between the years 2008 and 2016.

In order to obtain conclusions from the analysis of the information collected, quality techniques were applied. The first technique used was the Pareto Chart that allowed for the grouping of the causes of the NCs verified during the audit. Another quality tool used to analyse and group the possible causes of complaints was the fishbone diagram (Kaoru Ishikawa diagram). These groups can be associated to the 6M Method for Cause and Effect analysis, namely, Manpower, Machinery, Materials, Method, Mother Nature and Measurement. With regard to the analysis of internal controls, microbiological hygiene control of operators, surfaces and food, as well as equipment and pest control.

Two annual surveys are conducted for users of the SAS-IPVC regarding food - one for canteens and another for snack bars. The parameters established for canteens are "Service", which includes friendliness, hygiene, promptness and queues (the latter was only introduced for evaluation from the year 2013 onwards); "Facilities and Equipment" which addresses hygiene, comfort, schedules and means for acquiring food stamps; and "Meals" in which the quality /preparation, food temperature and variety are queried. The questionnaire applied to snack bars is similar to that of the canteen but, taking into account the specificity of this service, it comprises: "Service", which includes the criteria of friendliness, hygiene, promptness and queues (the latter has only been taken into consideration since 2013); "Facilities / Equipment" specifying requirements for hygiene, comfort, schedules and means of payment; "Products" distinguishing quality and variety; and "Vending equipment", where between the years 2008 and 2012 only a global assessment was undertaken and from 2013 onwards has been characterized by the following indicators: hygiene, quality, variety, global functioning.

Two complementary types of analyses were undertaken: SWOT (Strengths Weaknesses Opportunities Threats) and PESTEL (acronym for Political, Economic, Social, Technological, Environmental and Legal). A SWOT analysis done by observing the internal environment and with the definition of strengths (skills, resources and competences), aims to implement strategies that allow for the elimination or reduction of the effects of the weaknesses (limitations that reduce the achievement of aims). Likewise, in the analysis of the external environment, which is not controlled by the organization and with clearly

defined opportunities, threats are to be curbed. This definition allows for the improvement of organisational strategies through the identification of competencies taken from the collected information [6]–[9].

The PESTEL analysis, for scenario analyses, aims to study the external, environmental factors of the organizations, in order to identify opportunities and threats according to the political, economic, social, technological, environmental and legal tendencies that influence the organization, allowing for a preview of future situations [10], [11].

3. Results and Discussion

3.1. Audits and Non Conformities

Since 2008, SGQ-IPVC Management System audits have been performed annually and the requirement with the highest incidence of Non Conformities was "7.1 Product elaboration planning" with 52% of NCs in external audits and "7.5 Production and Service delivery" with 19% in internal audits.The causes that have contributed the most to those NCs that were previously pinpointed are related to the non-compliance of the provisions for food supply foreseen in the guidebook of good practices as well as in the HACCP (Hazard Analysis and Critical Control Point) Handbook.

3.2. Evolution of Satisfaction

The overall analysis of the overall satisfaction with SAS canteens and snack bars, obtained from surveys (on a scale of 1 to 4), showed without exception and during the period of 2008 to 2016, a value higher than the average (2.0) and than the defined goal (2.7 for canteens and 2.5 for snack bars), and so we conclude that the academic community is, in a general way, satisfied. However, it was ascertained that the level of satisfaction in canteens has fluctuated, with a marked decrease in satisfaction between 2010 and 2012 and 2015 and 2016, which, according to the context analysis, was due to higher absenteeism (about 20 %), employee stress and systematic equipment malfunctions. Chart 1 shows the variation in satisfaction between the years 2008 and 2016 in relation to canteens.

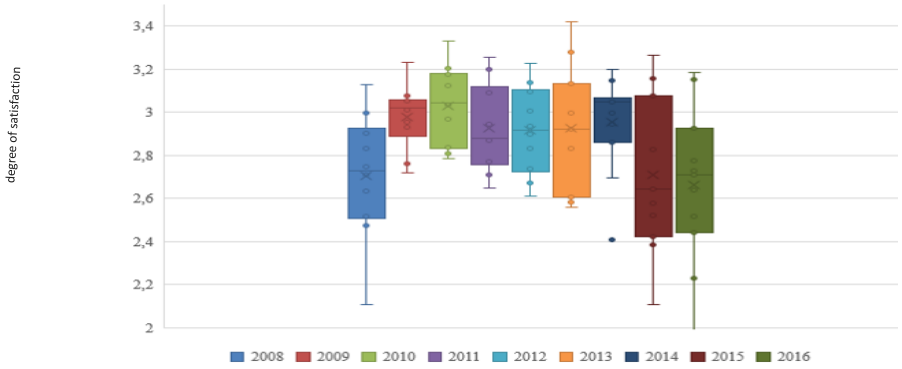

***Chart 1**. Overall satisfaction of canteens between 2008 and 2016*

The level of satisfaction in relation to snack bars increased between 2009 and 2012, and then fell again in 2013, with a slight increase in 2016. However, between the years of 2011 and 2013, the level of satisfaction evolved inversely, that is to say, when the level of satisfaction with snack bars increased, that of the canteens decreased and vice versa. From 2013 to 2014, the level of satisfaction of snack bars and canteens remained constant. However, since 2014 the level of satisfaction has been decreasing, with the exception of 2016, where there was a slight increase in the canteen level of satisfaction. It should be noted that there has been a notable trend towards a positive increase in the level of satisfaction with the canteen facilities and the comfort of the snack bars, resulting from measures that have been previously introduced.

3.3. Complaints

Complaints are an important source of information to identify opportunities for service improvement. The correct and real determination of the causes, coupled with an effective implementation of measures, allows the organization to improve its service and consequently the level of satisfaction of its consumers. Chart 2 shows the evolution of the number of

complaints between 2008 and 2016. The causes of the complaints are shown in chart 3, however it should be noted that the number of complaints from 2011 to 2012 increased by 2.35 times, particularly due to deficiencies in vending machines.

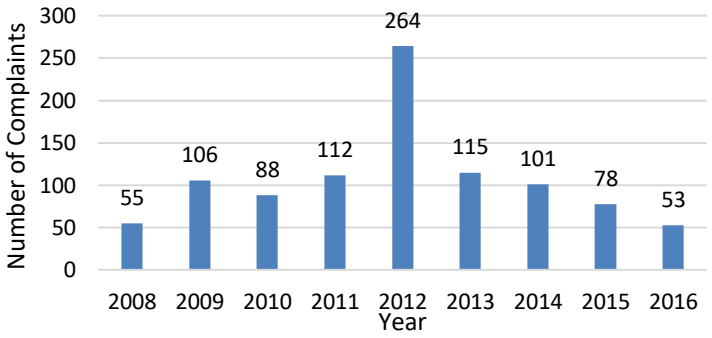

***Chart 2**. Evolution of the number of complaints between 2008 and 2016*

In general, it is easily establishable that the level of satisfaction with the canteen service is directly related to the number of complaints made - whenever the level of satisfaction increases in a given year, the number of complaints made decreases. This also shows that when the number of complaints increases, the level of satisfaction of canteen customers tends to decrease.

In addition, there also appears to be a connection between the content of complaints and the criteria assessed in the level of satisfaction in canteens since most complaints referred to long waiting times in 2009 and 2010 and food temperatures in 2010, which coincide with some of the lowest satisfaction criteria in the surveys of those same years.

Regarding the vending machine service, the low satisfaction ratings in 2013 and 2014 coincide with the high number of complaints related to this service. Chart 3 shows a Fishbone diagram for the main causes of complaints between 2008 and 2016 in all food services.

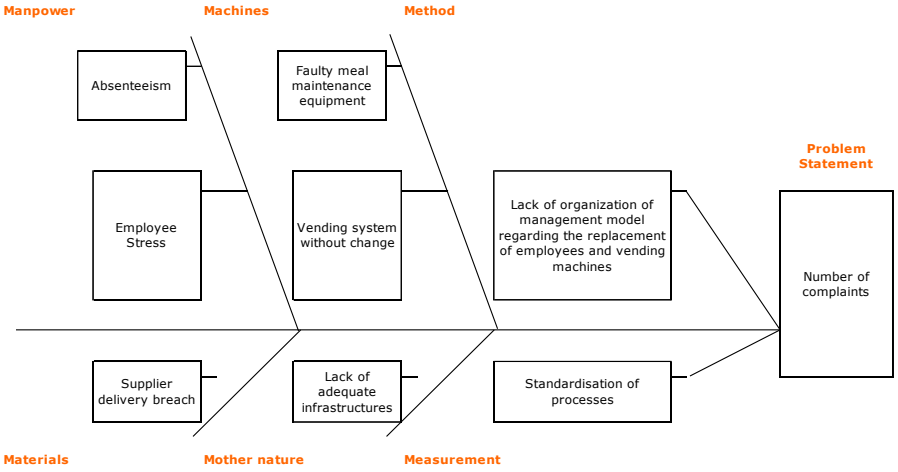

***Chart 3.** Fishbone Diagram concerning the main causes of complaints (from 2008 to 2016)*

4. Conclusions

After the analysis and discussion of the results, a SWOT and PESTEL analyses were undertaken. Table 1 shows a SWOT analysis with the strengths, weaknesses, opportunities and threats pointing toward the QA-IPVC Management System of the SAS food supply area.

***Table 1**. SWOT analysis of the SAS food supply area*

Strengths	Weaknesses
Internal clients. Food units located in schools. Reduced prices. Diverse services including light meals, "suggestions" and SIVE.	Lack of qualified personnel. Elevated average age of employees in the food supply area. Reduced team. Instability of supply service.

Hygiene and cleanliness. Quality of food. Friendly service. New facilities. Professional training of employees.	Delayed service. Limited financial resources. Communication.
Opportunities	Threats
Increase in the number of foreign students (international student status, Erasmus +, Portuguese-speaking countries' policies to increase higher education of the population). Consumer trends (Variety of sensations / sense of pleasure (due to the exoticism, sophistication, natural / healthy / vegetarian products) More demanding customers. ISO 22000 implementation or HACCP certification. Only public HEI in the upper-Minho region.	Packed lunches and meals brought from home. Restaurants in the immediate vicinity (shopping centre, fast food chains). High fluctuation of prices of raw materials and services. Restrictions on hiring.

The strengths and weaknesses identified represent the internal environment; the opportunities and threats represent the external environment. Combining the strengths with the opportunities allows the strengths to take advantage of the opportunities. Students state that hygiene criteria has been increasing, which has also been verified in the analyses carried out; in this sense the implementation of ISO 22000: 2005 or HACCP certification has been proposed in order to better the image of the service and to continue to guarantee the level of satisfaction. As the number of foreign students has increased, the introduction of foods according to their customs is proposed, for example the inclusion of meals with Asian ingredients and / or recipes in order to increase the satisfaction of Chinese students. Another factor to take into account are the consumption trends referred to in the Euromonitor International's Top Global Consumer Trends for 2016 [12] , or 10 major trends in the agrifood sector for 2016, indicated by business intelligence from the PortugalFoods Observatory [13]since they are important sources of opportunities.

With regard to combining strengths with threats, it is intended to identify measures to eliminate or minimize identified threats. Taking into account the consumption of meals prepared at home or in restaurants in the immediate vicinity of the schools (in Viana do Castelo, Valença, Melgaço and Ponte de Lima) where there is an increase of catering services and similar accommodation companies between 2010 and 2014 [14], as well as the existence of food units in schools with reduced prices and the high quality of the meal, this threat is intended to be minimized. With regard to the fluctuation of raw materials and services costs [15] strict cost control and consumption scheduling is necessary, particularly in favor of seasonal products.

The 50 Best College Dining Experiences' ranking in the United States of America reference is made to the main factors of students' choice of versatility, since mealtime is not intended to be monotonous, with themed meals and a constitution of "do-it-yourself" menus; nutrition and wellness with nutritional information, choice of local and healthy products; sustainability, taking into account the environmental impact of reducing waste and increasing recycling; and finally the accessibility of special diathetic solutions [16]. By analysing weaknesses versus opportunities, we aim to reduce the effects of the weaknesses in relation to the opportunities identified. The lack of qualified personnel, the elevated age average, the reduced number of staff and absenteeism leads to the delay and instability of the service. In order to minimize these factors, an increase in professional training of employees is proposed as well as an increase of internal and external communication, availability of a greater variety of products, namely international meals according to the provenance of foreign students, vegetarian options, other types of meals, light snacks (pies, pizza, sushi, a larger variety of salad ingredients) and increased space for greater comfort. According to Ng (2005) [17], in addition to food quality, quality of service, price and value, convenience and atmosphere, which are decisive factors in customer satisfaction, those responsible for the food supply of HEIs (Higher Education Institutions) should ensure hygiene of facilities, level of comfort, the environment of the meal rooms, and employee training so that they can offer a better service to the academic community. In addressing weaknesses and threats, both are expected to diminish. The strategy of the SAS-IPVC feeding area should prevent a shortage of qualified staff with an elevated age average as well as reduced number of staff to prevent consumers from choosing to bring their meals from home or to have their meals at nearby restaurants. Restrictions in hiring also hinder the consistency of the service; however, the hiring of service providers to the food supply area must have

a series of requirements, namely the professional training of employees, speed in the provision of the service upon request, among others.

Table 2 presents the PESTEL analysis with the political, economic, social, technological, environmental and legal variables. With this analysis, a projection of the possible variables to be taken into account in the coming years for the QA Management System of the food supply area of the SAS was intended.

***Table 2**. PESTEL analysis of the SAS food supply area*

Political Variables	Economic Variables
Changes to the social action system in higher education. Change to the RJIES (HEI law)	Cost of raw materials. Qualification of employees. Partnerships and protocols with other institutions. Consumption in the food area. Availability of funding sources.
Social Variables	**Technological Variables**
Changes in dietary habits in the choice of products with certain health characteristics (eg gluten and / or lactose free, special for sportspeople), vegetarian food, preference for traditional and local products and presentation of products. Impoverishment of the population. Changes in consumption capacities. Concerns about health and healthy lifestyles. Decrease in birth rates. Aging of employees. Number of foreign students. Number of students in junior and senior academy.	Changes in consumer needs. Use of vending machines. Optimization of production. Use of different sources of energy. Replacement of obsolete equipment. Innovative procedures and new products.
Environmental Variables	**Legal Variables**
Changes in eating habits, choice of products with concerns about sustainability. Use of renewable energy. Consumption of packaging and disposable materials. Environmental audits and certifications. Waste Management. Consumers with environmental concerns.	Changes in food legislation. Changes in labor legislation.

Governmental changes can strongly influence the models implemented, for example with changes in the social action system. Regarding economic variables, factors such as the oscillation of the cost of raw materials, the existence of synergetic partnerships with other institutions and suppliers, as well as the IPVC being the only public HEI in the Alto Minho region. It is also important to highlight the financing of the service either with own revenues, namely from services provided in the food area, or by state budget (also associated with political variables). Social variables are related to changes in eating habits, due to health issues or market trends, fashion or income (both for consumption in restaurants and for consumption of meals brought from home). Another aspect is related to the possible decrease of students due to the decrease in the birth rate, which can be filled with measures to increase the number of foreign students through mobility programs or increase the number of activities for junior and senior academies. Taking into account the increase of the retirement age, employees of the food supply area have an elevated age average, which can give rise to some constraints like the decrease in productivity and increase in absenteeism. Technological factors are associated with the increase in the supply of food products in vending equipment associated with changing consumer needs. The optimization of production with different energy sources, replacement of obsolete equipment with that which has more functionalities and is more energy efficient (also associated with environmental variables) and the implementation of an innovative process in the sector as well as new products. Environmental variables include the use of renewable energy sources, awareness of the use of packaging and disposable materials such as cutlery packaging, disposable cups, among others, selection of residues including food remains for further evaluation. Another aspect concerns the evidence of environmental audits or certifications and the increasing awareness and concern of the population for environmental causes, such as waste management and waste reduction and energy efficiency, using alternative energy and equipment that is more efficient at the same level of energy consumption. The carbon footprint in relation to the type of raw materials and their origin in terms of a more sustainable production and transport of goods.

Finally, the legal variables reflect the legislative aspects of the sector, namely, on the one hand, the requirements of food safety and hygiene and safety at work, and on the other, restrictions in hiring.

The use of the data collected through questionnaires allowed to identify the factors that most influence the quality of the service. According to Saglik *et al.* (2014) [18]when HEIs food services transmit quality, they increase the preference for the HEI concerned. In the same sense, Hasan *et al*. (2008) [19] report that satisfaction is related to the quality of service and that in the case of private HEIs the choice will focus on those that reveal a higher level of quality. Thus, quality of service substantially affects satisfaction [18]. According to Magalhães (2012) [20] food services regarding the importance of aspects related to processes and service satisfaction of Portuguese higher education students reflect a value of 7.2 and 7.1 in 10, respectively, in snack bars and canteens. They are more valued than other social supports such as sports facilities, student organizations and nuclei, housing in student residences, student health services, cultural programs and financial support in fourth place, only surpassed by "Place for study" (7.6), "Support for students with special needs" (7.5) and "Internet site" (7.5).

One of the factors identified is the prolonged waiting time in the service queues. This factor is also related to rapidity, since the evaluation refers to a low quotation, and it can be concluded that the waiting queues are directly related to the rapidity of service. The high turnout to services in certain moments due to class schedules and insufficient number of sale points creating long queues. On the other hand, it was possible to prove that the satisfaction factor was the friendliness of the employees in the food area. This result is based on a study carried out in 2014 at the University Restaurant of the Federal University of Uberlândia, where more than 80 % of the respondents are satisfied with the "quality of employee attendance" and with the hygiene of the facilities [21].

It should be highlighted that the year 2012 was an unusual year as it was the year with the highest number of complaints; hygiene indicators concerning operators also showed the highest number of positive results, generating a lower level of satisfaction and participation in surveys, as well as a decrease in the number of meals served.

Mechanisms should also be put into place to encourage participation in surveys, as there has been a decrease in participation. These measures may include the computerization of surveys (a measure that has already started in 2015) or the reporting of results through the SAS mobile application, website, table markers or board wipes.

The determination of causes associated with NCs referred to in both internal and external audits revealed that they were associated with non-compliance of the requirements stipulated in the good practices and HACCP manuals, such as failure to complete records. With this work it was possible to delve into the causes of the detected NCs, yet the most important aspect is to determine measures to eliminate these, so that the problems detected do not arise again. Continuous training in food safety is suggested, fostering the importance and the reason for completing records and compliance with the HACCP and good practices' manuals; scheduling of structural changes in food areas; standardization of processes through working instructions with indication of alternatives in case of failures; greater availability for the handling of complaints, so that the complainant realizes that the complaint was taken into account and that the actions taken were actually carried out. The muscular stretching and strengthening program implemented for the prevention of musculoskeletal and stress-related diseases should also be maintained and improved.

This work let us establish that the process of continuous improvement does not end, as, in addition to the suggestions above-mentioned, there should be a constant evaluation of all the indicators and processes of the food area and an analysis of the needs and expectations of the users.

In 2017, new products were introduced to promote healthy living habits in canteens and bars, such as replacing soft drinks with infusions and flavored waters in canteens, providing low-fat products like lean milk in bars. Also introduced were products for the vegetarian community such as dehydrated fruit and soy drinks. In October 2018, the remodeling of ESA's food space was completed, which is expected to reflect an increase in the satisfaction of service users, as space became more attractive and comfortable. In 2019, the "Health" process was implemented in SGQ-IPVC, which aims to manage occupational risks for the promotion of Health and Hygiene at Work, thus contributing to the improvement of employee well-being. In this sense, it is expected that the causes of nonconformities and complaints associated with employees (stress and absenteeism) tend to reduce. Included in this process should be maintained and improved the stretching and muscle strengthening program implemented to prevent musculoskeletal and stress-related diseases.

There is also a concern about the choice of products with respect to sustainability; in this sense and as a consequence of the implementation of the Resolution of the Council of Ministers 141/2018, which promotes a more sustainable use of

resources in public administration by reducing paper consumption and plastic, products were replaced - plastic cups and coffee spoon from vending machines by paper cups and bamboo spoons. At events, water was made available in glass bottles or mugs, instead of water in a single use plastic packaging. The policy of recycling of all recyclable materials and the recovery of food waste for composting systems is maintained.

In the short term, there is an intention to improve the system of maintenance of work equipment, namely in the prioritization of preventive maintenance in order to reduce curative maintenance. The intention is to keep the training plans implemented, since they are key parts in the continuous improvement of the performance of employees and the service. Regarding the non-fulfillment of suppliers, it is intended to detail the specifications in order to reduce the failures presented.

In 2014, the IPVC created a framework regarding its food management to then share it with its counterparts, like the Polytechnic Institute of Cávado and Ave (IPCA), the Polytechnic Institute of Porto (IPP), the Polytechnic Institute of Bragança (IPB), the University of Minho (UM) and the University of Trás-os-Montes and Alto Douro (UTAD) concerning some indicators, namely: occupancy rate (number of students per canteen), the existence of audits to verify food safety requirements; the existence of methodologies for the assessment of satisfaction; the existence of some type of certification; the implementation of the HACCP - Hazard Analysis and Critical Control Point system; the existence of a HACCP manual; the existence of a complaints' management system and to determine the 3 main typologies of complaints.

The HEI with the highest rate is the UM (15.7%), followed by UTAD (15.2%), and the IPVC in third place (13.8%); as such, it is the polytechnic with the highest occupancy rate

All of the above-mentioned HEIs have food safety concerns and, as such, carry out audits on food safety requirements and have a HACCP system in place. It was shown that all HEIs have methodologies for the assessment of satisfaction levels; these methodologies are based on surveys, just like the IPVC.

All HEIs have a complaints' management system, although at IPCA this system is of the responsibility of the service provider. The three main types of complaints presented comprise the variety of products, waiting time and service.

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Wood furniture SMEs approaches towards Circular Economy: a literature review

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ABSTRACT

The interest towards Circular Economy is growing among academics, government and enterprises. This works analyses the existing literature on companies approaches towards Circular Economy, focusing on the behaviours of the SMEs of the wood furniture sector. For this study, Web of Science, Scopus and Science Direct databases have been used in order to collect the main contributions on the topic of the last 10 years. The results have shown that there is a relevant number of articles about barriers and opportunities of SMEs towards CE, while the researches focused on wood furniture sector are still limited among academics and the main contributions are given by practitioners.

Keywords: Circular Economy, SMEs, Wood Furniture Sector

1.Introduction

The interest towards Circular Economy (CE) is growing fast among the academics, governments and enterprises and the Small and Medium-sized Enterprises (SMEs) are becoming aware of the opportunities deriving from this new model [1-2] and the possibilities of investing in it.
As the role of SMEs is central in the European economic context, the main opportunities and barriers deriving from the implementation of CE have been analysed in the literature. While the research has highlighted that the European SMEs are mostly conscious of the opportunities deriving from Circular Economy [3], some barriers to this new model have been identified in literature. In particular, while the main advantages are linked to the possibility to increase profits and take new opportunities from the market [4] the main disadvantages identified are related to the financial capacity of SMEs, the lack of competences and the insufficient support by institutions [2]. In fact, SMEs appear to be influenced by legal context and sector related factors in the decision of implementing sustainable activities [4].
The wood furniture sector results to have an important role from an environmental point of view due to its processes and product characteristics. In this sector, the opportunities related to the Circular Economy model are mostly linked to eco-design, use of renewable materials, reduction of emissions and use of environmental certifications [5] but there are some challenges such as the quality of products, additional costs related to recycling, lack of support from government and some consumer related factors that can limit companies of wood furniture sector in implementing the circular approach [6].
The aim of this paper is to develop a literature review study, identifying the existing literature on companies approaches to this new business model focusing on the behaviours of the SMEs of the wood furniture sector. In particular the work tries to answer to the following questions:
RQ1. Which are the main approaches identified in literature about wood furniture SMEs towards Circular Economy?
RQ2. Which are the main barriers of Circular Economy implementation in wood furniture SMEs?
RQ3. Which future research areas can be identified in order to contribute to the expansion of this topic?

2. Theoretical Framework

For the purpose of this paper it is useful to introduce the concepts of Circular Economy and SMEs contextualized in the wood furniture sector.
The model of linear economy based on the process “produce, use and dismiss” has being replaced by the model of Circular Economy. Despite in the available literature there is not a univocal definition of this new model, there is now a strong acknowledgement of the concept among scholars and practitioners [7] because it is seen as an instrument to implement sustainable development and to increase the efficiency of resources [8].
The essence of CE, which aims through technological innovation and better management to make economic activities more efficient and less impacting on the environment, has two dimensions. Upstream, it is about managing resources more efficiently increasing their productivity in production and consumption processes, reducing waste, keeping the value of products and materials as much as possible. Downstream, it is necessary to avoid that all the wastes that intrinsically possess some utility are not disposed in landfills, but are recovered and reintroduced into the economic system [9].
The Circular Economy has been defined by Ellen MacArthur foundation (2012)[10] as a more sustainable model based on the re-use of waste and the use of renewable sources [1] that can guarantee an “harmony between economy, environment

and society" [8]. It is the so called "regenerative economy" in which the wastes are intentionally reincorporated into productive cycles [11].
In order to provide a more complete definition of Circular Economy, it is useful to cite the work of Kirchherr et al., [12] based on the analysis of 144 definitions of CE. According to them, the Circular Economy can be considered an "economic system that replaces the *end-of-life* concept with reducing, reusing, recycling and recovering materials in production/distribution and consumption process" [12]. In this way, the CE is a system that involves different levels of society: companies and consumers, industrial parks and the nations and it is aimed at creating "environmental quality, economic prosperity and social equity" [12].
As Small and Medium-sized enterprises (SMEs) represent the 99% of the enterprises in Europe [13] their role is central in the European economic context and for this it is important to investigate the link between SMEs and CE, since the development of CE strategies by these companies can contribute to make the European economy more competitive and sustainable [3].
A research on SMEs and Circular Economy commissioned by the European Commission conducted on 10,618 SMEs highlighted that SMEs are mostly aware of the opportunities deriving from Circular Economy and have started some activities related to that [3]. As the researches on Circular Economy have shown, there are still some barriers on the implementation of this new model that regards political, economic, and technological issues [14] that become more relevant for SMEs due to some firm specific characteristics.
The main barriers identified on the basis of the literature review are related to i) environmental culture, ii) financial availability, iii) lack of government support, iv) lack of information and technical skills, v) lack of support from the supply and demand network [1-2].
Considering in detail the wood furniture sector, this is a dynamic sector composed by SMEs and micro companies characterized by a high level of competition and a growing necessity of innovation to respond to new trends and demands [13]. Furthermore, the wood furniture sector results to have an important role from an environmental point of view because of the characteristics of wood based products that involve the use of adhesive, colour and coating materials for furniture production [15] and the management of waste material.
In this context, Circular Economy could provide an opportunity to create new value for the sector combining the resource efficiency, consumer value and profitability with new innovative solutions.
Hence, it is useful to investigate which are the main opportunities and the main barriers that SMEs of this sector have to face in implementing the circular approach.

3. Methodology

In order to perform a literature review on the approach towards CE of SMEs, a computer search of the Web of Science, Scopus and ScienceDirect databases on the literature available on Circular Economy, SMEs and Wood furniture sector has been conducted. Data collection consisted of searching the keywords "Circular Economy" AND "SMEs" or "Circular Economy" AND "Wood furniture sector" and all the combinations of them on titles, abstracts and keywords and with the only restriction of the period of publication (10 years from 2009 to 2019). It has been decided to start from 2009 despite the fact that the researches on CE have been developed in more recent years, to have a larger range of time and include the works that, even though do not use the expression "Circular Economy" are focusing on SMEs approaches to sustainability in general.
The results of the research are shown in Table 1.

***Table I**. Literature search on the main search engines.*

Keywords	***Database***		
	Web of Science	***Science Direct***	***Scopus***
Circular economy [AND] SMEs	35	589	44
Circular economy [AND] wood furniture sector	2	258	1

An additional research, using the same keywords, was conducted on *Google research tool* in order to catch the works commissioned by Institutions that have been included in this research, being businesses and policy interested in supporting this new model.
After an analysis of the topics and abstracts of the previous articles, 30 papers considered coherent with the topic, the keywords and with our research questions were selected. The paper selected included literature review studies, case study analysis, quantitative researches and reports commissioned by Institutions at national and European level. The works that included in the title related concepts like eco-innovation, sustainability, eco-design [14], and were coherent with the topic were considered in the sample.

The others works have not been included in the sample because these were not aligned with the purpose of the research. Through the analysis of the titles and the abstracts, the works not aimed at investigating the approaches of wood furniture SMEs and SMEs in general towards Circular Economy have been excluded. In particular, are not included in our sample: i) the works not aimed at discussing the CE from the SMEs points of view, ii) the works that propose methodologies, methods and tools in this topic, iii) the works aimed at analysing CE focusing on the practices, processes and waste treatment methods, iv) the works that approach the CE processes from a chemical and physical point of view.
As it is shown in the research through keywords, CE is a topic of great interest in the different fields and this evidence is highlighted from the high number of articles that are available in the consulted databases. On the contrary, the number of articles that can provide a contribution on SMEs approaches to CE and those that are focused on the analysis on the wood furniture sector is still limited.

4. Discussion of Results

In this section the main contributions found through the literature research are presented and the discussion of the results are commented in order to meet the objectives of this work.
Table 2 shows the results of the literature review analysis focused on the concepts of CE, SMEs and wood furniture sector.

Table II. *Profiles of the selected works.*

Topic	***Summary***	***Journal***	***Authors***
SMEs and Circular economy	This group involves the articles that analyse the approaches of SMEs towards CE, the main sustainability drivers and some data of the level of implementation of European SMEs.	*Waste Management and the Environment*	Thorley et al. (2019) [16]
		Sustainability	Pigosso et al. (2018) [17]
		Report by European Union	Flash Eurobarometer 441 (2016) [3]
		Journal of Manufacturing Technology Management	Ünal et al. (2018) [18]
		Journal of Industrial Engineering and Management	Ormazabal et al. (2016) [19]
		IOP Conference Series: Materials Science and Engineering	Fatimah et al. (2018) [20]
		Amfiteatru Economic	Ceptureanu et al. (2018) [21]
		Procedia CIRP	Soroka et al. (2017) [22]
		Procedia CIRP	Kleine-Moellhoff et al. (2018) [23]
		Sustainability	Oncioiu et al. (2018) [24]
		Journal of Cleaner Production	Seth et al. (2018) [25]
		Journal of Cleaner Production	Patricio et al. (2018) [26]
		Energy Policy	Killip et al. (2013) [27]
		Journal of Cleaner Production	Matinaro et al. (2019) [28]
		Journal of Cleaner Production	Daddi et al. (2017) [29]
		Sustainability	Zamfir et al. (2017) [4]
Barriers and opportunities for SMEs	This group provides the main researches about the challenges and the barriers of	*Procedia CIRP*	Ritzén et al. (2017) [30]
		Amfiteatru Economic	Ghenta et al. (2018) [31]

	implementing CE activities for SMEs. The main barriers identified regards the managerial environmental culture, the lack of information and technical skills, the lack of support from the government and the supply chain.	*Journal of Industrial Engineering and Management*	Ormazabal et al. (2016) [19]
		Journal of Cleaner Production	Caldera et al. (2019) [32]
		Journal of Cleaner Production	De Jesus Pacheco et al. (2019) [33]
		Journal of Cleaner Production	Franco M. (2017) [34]
		CEPS Working Document	Rizos et al. (2015) [1]
		Sustainability	Risoz et al. (2016) [2]
Wood furniture sector and Circular Economy	This group involves researches that are focused on wood furniture sector analysing the main approaches and the barriers that can limit the implementation of CE activities. The main opportunities are related to eco-design, use of renewable materials, cascading use of wood waste and energy saving. The main barriers are related to quality and design of materials, the profitability of the operations and the availability of policy and supply chain support. Other barriers encompassed other market factors.	*Journal of Cleaner Production*	Husgafvel et al.(2018) [35]
		Resources, Conservation and Recycling	Oliveira et al. (2018) [36]
		Journal of Cleaner Production	Daian et al. (2009) [37]
		Procedia-Agriculture and Agricultural Science	Azizi et al. (2015) [15]
		European Environmental Bureau	Forrest et al. (2017) [6]
		Federlegno e Fondazione Symbola Report	Federlegno (2016) [5]

As it can be seen in the previous table, the works developed in the literature panorama can be categorized into three groups: the works that analyse the relation between Circular Economy and SMEs in terms of impacts, approaches and practices. The second group involves the contributions of the authors that analysed the enablers and barriers to Circular Economy for the SMEs. The third group is composed by the works that try to define which are the approaches and the main difficulties that the wood furniture sector companies have to face in implementing Circular Economy. All the works selected have been realized from 2015 to 2019; just 1 article [37] dates back to 2009.

While it is recognised that the furniture sector is not only relevant from an economic and social point of view but also in terms of environment and sustainability [15], the research showed as in the available literature there is not a relevant number of works framed in the European context that analyse this topic and the main contributions are given by practitioners and institutions.

De Oliveira et al. [36] identified in methodologies like life-cycle assessment, cleaner production and eco-design some of the possible approaches to CE. Another promising approach is the cascading opportunities of reuse of wooden packages and furniture [35].

The main contribution in this field is given by a study conducted by Federlegno (2016) based on a qualitative research on 30 Italian companies of the wood furniture sector. According to this research, one of the approaches towards Circular Economy is eco-design, that is designing in a sustainable way, taking into account the impact on the environment that a product has during its life cycle, from the extraction of raw materials to disposal. This is a Circular Economy approach that many Italian companies in the wood furniture sector are adopting to raise the quality standards and to be more competitive in a market that is increasingly attentive to environmental issues, critical consumption and energy efficiency [5].

Other circular activities implemented by companies are based on the attention on materials: in particular the use of biomaterials and renewable materials is an approach used in the furniture sector [5].
The approaches emerged in the Federlegno report, in addition to those that contribute to make the products eco-compatible, are focused on practises oriented to make the production phase more sustainable; in particular, companies are making more attention on reducing, reprocessing raw materials reducing pollution and on indoor air quality issues [5].
Many companies approach to Circular Economy by investing in energy savings, even more when containing production costs can make the difference in the balance sheets, as well as reducing the environmental impact.
The possibility of reconfiguring and reusing even complex products is another topic of great interest [5].
Another trend that emerged among wood furniture companies is the use of environmental certification: there is a large number of environmental and sustainability certification schemes applicable to furniture, which represent at the same time a real barrier given the cost involved to apply such a complex and varied set of certifications. Very often, these schemes also do not take into account the economic and technical implications related to their respect, making it difficult to be adopted especially by Small and Medium sized Enterprises [5].
Other barriers more focused on the products characteristics, the role of policy and some demand features have been identified by a research commissioned by European Environmental Bureau (EEB). This research, based on the analysis of data sets (EUROSTAT and PRODCOM) and a qualitative analysis on stakeholders, was aimed at identifying the existing opportunities and main barriers that companies of wood furniture sector have to face in implementing CE approaches.
The most important issue regards the quality of materials and the design of products: in fact, the use of cheaper materials reduce the possibility to give a second life to products [6] therefore the phase of design of products is fundamental.
A key role in implementing Circular Economy approaches is given by policy drivers: in fact, the investment in reuse and recycling influence the possibility of furniture to be managed according to the principles of the Circular Economy [6]. Furthermore, the sector is characterized by a lack of information regarding the Regulation on the substances contained in products and this make the operators of the sector unaware of the way to manage them.
The research has shown as the role of customers is central: in fact, the demand of second-life furniture is low due to the weak difference between the price of new furniture and second-life furniture; this factor do not stimulate the demand of sustainable products by customers [6]. In addition, consumers are not aware of the advantages associated with the use of sustainable furniture products.
By investigating 30 companies of the forest sector in Finland (both Large and Small sized enterprises), Husgafvel et al. [35] identified some barriers related to the cascading use of wood and the use of recovered wood in the furniture sector. In particular, the main barriers identified are related to the quality issues, the availability of recovered wood and to the profitability of the use of cascading recovered wood, that seems to be the most controversial aspect [35].
Other aspects regarding geographical location and market barriers have been identified in the research. In particular, the level of knowledge and cooperation in the value chain is a factor that can influence the implementation of sustainable approaches among companies [35].
Oliveira et al., [36] have also underlined the aspect of cooperation in order to provide CE solutions. In fact, according to them one of the opportunities for the wood furniture sector is the implementation of partnerships with policies and other local companies in order to stimulate the diffusion of best practices for pollution prevention and waste management [36].
Daian [37] identified other barriers for the implementation of waste reduction by SMEs: considering these results there is a weak awareness from firms of the benefits of wood waste management and a limited knowledge of procedures of waste recycling .

5. Conclusions

This study was conducted with the aim of investigating the main contributions by academics and practitioners on wood furniture SMEs approaches towards CE. As it is shown in the results section of this research, there is a relevant number of contributions about the barriers and opportunities of SMEs towards CE; in particular, 24 articles have been included in the sample because they gave a contribution on this topic. On the contrary, the research has shown as there are few studies that are conducted for the wood furniture sector companies. In fact, 6 of the selected articles have investigated the approaches of wood furniture companies focusing on enabling factors and barriers related to sector characteristics. In particular just 1 articles focuses on wood furniture SMEs' practices to increase sustainability [37] while the others have analysed the sector considering both Large and Small firms [15-35-36]. Two important contributions are given by the works of experts [5-6]: they have analysed the main approaches and the barriers in implementing CE practices for wood furniture companies. Their researches, are not focusing on SMEs, but are conducted in the European context that is composed for the 99% of SMEs [13].
The main barriers identified in literature focused on SMEs of wood furniture sector are mostly in line with the barriers identified by the literature about SMEs and CE. In fact, it is evident that the support of government and of the supply network, is an essential element in the decision of implementing CE approaches for the SMEs of all the sectors. In addition, another relevant aspect regards the lack of knowledge about the benefits of CE and the availability of financial support for the implementation of sustainable activities that is related to some firm specific characteristic.

The evidences identified, show that there is the need for a deeper research in this area that includes the possibility to analyse the impacts of CE activities on SMEs of wood furniture sector, and the main barriers to its implementation. There are in fact, different opportunities for SMEs, but the barriers emerged could influence negatively the possible transition to CE strategies.

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Circular Economy and Quality Management within the Furniture Sector: an exploratory study

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ABSTRACT

This study aims at exploring whether and how furniture companies know about Circular Economy (CE), what they concretely do for implementing CE practices and what factors motivate, support or hinder their adoption. The role of product and process certifications has been also investigated, since they can be particularly helpful for implementing an environmentally sustainable approach, which, in turn, is critical within a circular business context. The research method is based on a qualitative multiple case-study carried out on four Italian companies operating in the furniture industry. A moderate degree of awareness and knowledge of CE principles emerged from the analysis. However, furniture companies are still little involved in CE practices, especially regarding reuse and recycle activities, which are particularly important within this perspective. Similarly, a scarce use of process and product certifications emerged from the study. Therefore, a potential gap arises between the positive attitude towards CE practices and their actual implementation, which suggests implications for both companies and public institutions.

Keywords: Circular economy, sustainability, furniture Industry, quality certification, Italy.

1. Introduction

In today's society growing attention is paid to global environmental risks and related consequences, which are threatening both companies' competitiveness and humanity's survival [1-3].

In this context, the concept of Circular Economy (CE) has gradually raised and received growing importance among firms and Governments [4] in order to achieve a sustainable development and a fair society [5-10]. CE practices, in fact, can improve the prevention of resource depletion, the maintenance of materials and products in cycles, and the recycling of potential waste [11]. Moreover, their adoption can also enhance the companies' financial performances and the overall society's wellbeing [12].

These opportunities could be particularly important within the furniture industry, given its economic relevance [13] and environmental impact [14]. In 2017, the global furniture market was valued at around USD 331.21 billion and it is expected to reach approximately USD 472.30 billion by 2024, growing at a compound annual growth rate (CAGR) of around 5.2% between 2018 and 2024 [15]. Moreover, the furniture industry appears to be particularly important from an environmental standpoint, since it intensively uses virgin raw materials and adhesives, dyes and coating materials, which can result in large volume of volatile organic compound and waste production [14]. As concerning the waste issue, in particular, in 2017, the EU28 total amount of furniture waste equates to 10.78 million tonnes annually, accounting for more than 4% of the total municipal solid waste (MSW) stream. Waste arising from commercial sources contributes for 18% of total furniture waste generation. What is more, 80% to 90% of the EU furniture waste in MSW is incinerated or sent to landfill [16]. The high amount of waste production and the large employment of natural resources by furniture companies clearly highlight the importance of circular practices for reducing both the environmental damage and social impact of firms' production.

Nevertheless, to the best of our knowledge, there is a lack of contributions examining the relationship between CE and the furniture sector. Notably, very little is known about some practices, such as the recovery/reconversion of waste materials to create new products on which the CE lays its foundations [17].

Hence, the main objective of this study is to explore to what extent the furniture companies are aware about the CE principles, how they are implemented within them and which factors can influence their adoption. In this way, the research contributes to address a gap, still recognized in the literature, concerning the overall lack of knowledge on Circular Economy concept and characteristics [12].

Since the study takes into consideration manufacturing furniture companies, the main focus of the research is on the design and production steps of those companies. Notably, eco-design implies the continuous search for innovative solutions that limit industrial waste and improve the use of cleaner materials in all stages of the value creation process [18]. It enhances both product and process innovation, by integrating sustainability and environmental aspects from the earliest stages of the product development [19].

At an operational level, quality management practices including Quality, Environmental and Corporate Social Responsibility Management Systems (QMS – EMS – CSRMS) and Product Certifications (PC), are also investigated in this study, since they can be helpful for managers in implementing environmentally sustainable practices, which, in turn, are critical within a circular business context [20].

Two main research questions operationalize the above objectives:

RQ1) How much do furniture companies know about CE? What do companies do concretely? What factors motivate, support or hinder the adoption of CE practices?

RQ2) Do furniture companies adopt product and process certifications? For what reasons and purposes?

The study is exploratory in nature as the CE model is still recent and the process of transitioning from the linear economy to the circular one is in its initial phase, as well as the scientific research regarding the furniture industry is. Accordingly, the present work is based on a qualitative multiple case-study carried out on four Italian furniture companies. The findings add further knowledge to the scientific debate on CE, specifically concerning the furniture business. Moreover, practical implications for companies and public institutions can be drawn from the study, which are particularly useful for those who are moving towards circularity.

The rest of the paper is structured as follows. Section 2 provides a literature background. Section 3 describes the research method, while Section 4 illustrates the main research findings. The next Section discusses results and implications. Finally, the paper highlights the main limitations of the study and suggests future research directions.

2. Theoretical background

2.1 The concept of Circular Economy (CE)

The concept of CE has been firstly introduced by Pearce and Turner [21]. They argued that sufficient attention to environmental issues and, more specifically, to recycle of materials has not been paid within the traditional open-ended economic system, focused on the "*take, make and dispose*" paradigm [7]. Thus, they conceptualised a closed-loop of materials, primarily aimed at addressing the negative consequences coming from the uncontrolled exploitation of natural resources.

More recently, the Ellen MacArthur Foundation [11] defined CE as "*an industrial economy that is restorative or regenerative by intention and design*". This definition suggests that CE is a new business model, which replaces the "*end-of-life"* concept with that of reducing, alternative reuse, recycle and recover of materials in production and consumption processes. Such a business model can reduce the human dependence from natural resources, thus resulting in a lower exposure to negative effects of resource prices shocks with an increase in companies' competitiveness [11, 22] and society wellbeing [8, 9].

2.2 Factors affecting the implementation of a CE model

Zhu and Qiu [21] pointed out that implementing CE requires the compliance of three principles, namely *Reduce*, *Reuse* and *Recycle* (i.e.: 3R principles). *Reduce* is aimed at minimizing the input of raw materials, energy and wastes by increasing the efficiency in production and consumption processes [5, 24]. *Reuse* encompasses operations by which resources or components can be used again for the same purposes for which they were designed [25]. It implies that products are used to their maximum potential with recommended maintenance in order to extend their life [26]. Finally, *Recycle* relates to the possibility of reprocessing waste materials and components into the production processes [27].

The Ellen Macarthur Foundation [11] integrated the above 3R principles by four additional ones. The first one emphasizes the relevance of design stage to limit waste discharge in landfills. By introducing a new classification of materials into "*nutrients*" and "*technical*", the second principle states that nutrients materials can be safely reintroduced to the biosphere, while technical materials have to be designed in a way to be reused. The third additional principle recognizes the importance of renewable energy to reduce energy dependence and, more generally, to improve the overall adaptability of the economic system. Finally, the concept of eco-design becomes another fundamental principle of the CE paradigm, which can help companies in internalizing externalities related to design, by taking into account environmental impacts into all product development practices [26, 28].

Several conditions are required for implementing the above CE principles. Notably, a lot of economic and financial resources are needed [29] for allowing the use of advanced technology, sustaining the energy consumption required to carry out recycle activities [30] and for promoting an adequate waste disposal [31]. Geng and Doberstein [32] further stressed the role of an efficient information system for planning and managing all activities related to resources' reduction, reuse and recycle. Finally, given the critical role of consumers in the CE [32, 33], the overall circular supply chains should also consider consumption processes, in addition to production and distribution ones.

2.3 How to develop corporate sustainability and circularity: the role of quality certifications

Quality management (QM) tools such as Integrated Management Systems (IMS), which include the development of Quality, Environmental and Corporate Social Responsibility Management Systems (QMS – EMS – CSRMS) and Product Certifications (PC), are particularly useful to help companies in developing environmentally sustainable practices [34]. They are designed as a supplier-client-customer relationship regulation mechanism, which assure customers about the company's ability to control properly all quality factors, thus ensuring the conformity of certain quality measures to specified requirements [35].

Several International and European recognized standards can be adopted for developing IMS. The International Organization for Standardization (ISO) 9001 [36] standard provides guidelines for companies who want to adopt a quality system, to provide quality assurance to their business counterparts or final customers, and to achieve zero-defect products [37]. Environmental Management Systems, designed and certified according to the International ISO 14001 [38] standard and the European Eco-Management and Audit Scheme (EMAS), are usually used for integrating environmental protection programs into the company [39, 40]. As concerning the business safety requirements, the OHSAS 18001 [41] standard is aimed to control Organizational Health and Safety (OHS) risks in a proactive way. More recently, the ISO committee has published a new standard (ISO 45001) [42] applicable to any organization moving towards the establishment of an internationally recognized health and safety management system [43]. Finally, to translate the Corporate Social Responsibility (CSR) agenda into organizational settings, the main international standard is the Social Accountability 8000 (SA 8000) [44], which is considered a multi-stakeholder standard that helps organizations to develop, maintain, and apply socially acceptable practices in the workplace [45].

As for Product Certifications, Environmental Product Declarations (EDP) aim to promote pro-environmental products. However, several labels with significantly diverging requirements exist. The requirements may be based on a life-cycle-assessment of the product following the lines of the ISO 14040 standard or may focus on discrete issues such as the quality of raw material and recyclability [46]. Focusing on the wood-furniture sector, there is the European Ecolabel declaration that informs consumers about the intrinsic and extrinsic properties of a product and the Forest Stewardship Council certification (FSC) for sustainable wood, defined as the "*gold*" standard for wood sourced from well-managed forests [47]. It includes three types of on-product labels, namely "FSC 100%" (meaning that the wood within the product comes from FSC-certified well-managed forests), "FSC Recycled" (meaning that the wood or paper in the product comes from re-used material), and "FSC Mix" (meaning that the wood within the product is from FSC-certified forests, recycled material, or controlled wood). Notably, the FSC system also includes a process certification, namely "FSC Chain of Custody", which can be voluntary adopted by companies to demonstrate their commitment towards responsible forest management. Finally, for the wood-furniture sector, there is the Italian "Made in Italy" labelling that certifies, according to the UNI 11674:2017 [48] standard, the requirements for the determination of the Italian origin of furniture in a sustainability perspective.

3. Research method

The research is based on a qualitative multiple case study method. This approach is very useful to understand contemporary phenomena and practices and to provide background material to actual issues which are still unknown [49, 50] - as the topic of this study is. Moreover, the multiple case study allows a clearer comprehension of the phenomenon as it enhances comparisons between similarities and differences emerged from the analysis [51].

A total number of four Italian furniture companies were analysed, despite a greater number of companies were originally contacted. This agrees with Yin's guidelines [49] suggesting that the number of units to be investigated in a multiple case study is between four and twelve. The companies interviewed are all manufactures, producing design-based furniture and furnishing accessories (e.g. tables, chairs, shelves, display cases, magazine racks, umbrella holders and other accessories). Recent data depict the Italian design furnishing as a growing industry, with about 280 manufacturers [52]. The analysed companies come from northern and central Italy; they operate on a global scale and are small and medium-sized businesses with a turnover not exceeding €50 million and a number of employees less than 250.

Following the Eisenhardt's [53] guidelines, each company was deeply investigated to gain a rich understanding of the main practices developed to move towards CE. The case studies were then compared to analyse similarities and differences.

The study was structured in different phases.

Because the multiple case study method recommends the use of different detection tools for information reliability [54], in the first phase, a review of the companies' websites and their profiles on different social networks have been carried.

In the second phase of analysis, primary data were collected using a semi-structured questionnaire that was divided into three sections: the first part covered the background of the companies. The second part investigated the CE practices implemented and the related enabling/hindering factors. The third part explored the use of certifications and their role

within both the communication strategies of companies and their overall sustainable approach. The questionnaire was directly submitted to the companies. Each interview lasted for on average two hours. Some answers were evaluated using the five-point Likert scale [55].

Information collected through the questionnaires were interpreted and discussed together with a careful analysis of further information and documents (e.g.: conference proceedings, consultant's reports) provided by managers or sourced by the authors themselves.

To improve the overall quality of the research, some experts were involved for supporting the companies' selection. Moreover, interviews were conducted by the same researcher to reduce the role of bias [47] and respondents were given the opportunity to provide feedback on initial findings to reinforce the overall reliability of information.

Table I provides a general description of the companies' profile.

Table I*. Socio-demographic characteristics of the companies*

	C1	**C2**	**C3**	**C4**
Company age (years)	40	65	30	46
Type of products	Furniture and furnishing accessories (e.g.: tables, chairs, shelves, magazine racks, umbrella holders, ...)	Furniture and furnishing accessories (e.g.: tables, chairs, shelves, magazine racks, umbrella holders, ...)	Furniture and furnishing accessories (e.g.: tables, chairs, shelves, magazine racks, umbrella holders, ...)	Furniture and furnishing accessories (e.g.: tables, chairs, shelves, magazine racks, umbrella holders, ...)
Position held	Marketing and Communication Manager	Marketing and Communication Manager	Sales Manager	Chief Executive Officer
Headquarter	Northern Italy	Northern Italy	Central Italy	Central Italy
Reference Markets	Italy, Europe and Asia	Italy, Europe, USA, Asia	Italy, Europe, USA, Asia (Shanghai, Dubai, China)	Italy, Europe, USA (Canada), Asia (China, Japan)
Product Typology	Multiproduct	Multiproduct	Living	Multiproduct
Employees	90	78	25	50
Income:	€60 million	€16.5 million	€15 million	€8 million
Income (Italy) (%)	30.0	25.0	80.0	35.0
Income (Europe) (%)	40.0	50.0	10.0	35.0
Income (Extra-UE) (%)	30.0	25.0	10.0	30.0
Dimension (2003/361/CE)	Medium-Large Company	Medium Company	Small-Medium Company	Small-Medium Company
Process certifications	----	UNI EN ISO 9001 - OHSAS 18001	----	UNI EN ISO 9001
Product certifications	FSC	----	----	----

4. Results

4.1 The companies' approach towards CE

Companies interviewed are all aware about CE principles and related issues. Despite the high interest emerging towards circularity, only one company declared to be actually involved in CE projects promoted by national or international public institutions.

Practices related to the 3R principles are only partially implemented. Reduction activities have been implemented by three companies (C1, C3, C4), among which those concerning the reduction of raw materials per product and the overall reduction of raw materials and energy. Initiatives for enhancing energy efficiency and the use of renewable energies have

been highly implemented by company C1. Referring to the reuse activities, these are scarcely implemented by companies analyzed: C1 declared to make a moderate reuse of equipment cleaning materials, while C3 is moderately involved in reusing products' packaging materials. Recycling activities of waste produced in the manufacturing process have been employed very little by two companies, moderately in one company and highly in the last one. Only company C3 declared to recycle very highly waste products coming from consumers, while company C4 reprocess intensively waste and garbage to manufacture new products. Despite the high degree of commitment showed by C2, it emerges more attention and willingness to increase the commitment in the various circular practices for the future, including reusing and recycling activities.

As concerning the enabling factors, two companies recognized fiscal and economic incentives as crucial factors supporting the implementation of CE practices. An adequate level of consumers' awareness about environmental issues is also considered very relevant. Despite the emergence of different opinions, an efficient differentiated waste collection system and the use of artificial systems in production/distribution processes have been considered as important by two of four companies analyzed.

Different factors have been also considered to explain what hinders the adoption of CE practices among companies. Managers interviewed mainly underlined the difficulties in reusing some special materials used in manufacturing processes as well as the difficulties related to the reconversion of final products into new ones. The lack of financial resources to invest in R&D activities emerged as a critical barrier only for one company analysed.

4.2 The adoption of product and process certifications

Despite the interest towards a future adoption of product and process certifications, such standards are very little employed by companies interviewed. Surprisingly, nobody declared to adopt the Italian "Made in Italy" labelling, even though all companies produce high-quality products that are recognized worldwide for their design-content as well as for the exclusivity of materials and related production processes. As for other product standards, only company C1 declared to adopt the FSC label. A similar situation appeared for process certifications: only companies C2 and C4 have the UNI EN ISO 9001 standard, and C2 has also the health and safety standard (OHSAS 18001), but among those companies which do not have any certification there is the willingness to adopt them in the future.

Companies were asked to explain whether and why they could be interested in adopting voluntary certifications for the next future. The possibilities to assure compliance with environmental standards, to improve the workers' safety and to develop a socially sustainable strategy are recognized among the most important motivators, along with economic benefits linked to the overall improvement of processes' efficiency. The communicative advantages associated with such certifications appears interesting too. Companies C1 and C3, in particular, gave a lot of importance to the possibility of increasing customers' loyalty, improving corporate image and entering new market segments thanks to the use of international standards. This reveals the existence of a high degree of knowledge and awareness about product/process certifications which, actually, is still not reflected in an adequate implementation of related standards within companies analysed.

5. Discussion and implications

The above findings suggest useful implications for both private companies and public institutions.

Because circularity requires to be regenerative and restorative [11], companies will have to develop strategies that allow reducing, as well reusing and recycling of components and materials, since the design phase. Starting from raw materials, eco-design could encourage the saving of resources by creating, for example, furnishing objects whose components are readily separable at the time of their disposal or by using raw materials that are easier to recycle than wood (e.g.: aluminium and glass). In the production phases, eco-design also recommends the increasing use of water paints, in place of chemical ones, while during the assembly and finishing steps, eco-design invites to use machinery with high-energy efficiency as well as glues containing no-toxic elements. Finally, regarding distribution, eco-design suggests to optimize the storage of goods,

to assure a better use of spaces and to reduce the number of trips [56]. Internal training as well as informal and planned meeting for discussing the circularity issues could be useful for sharing the diffusion of a new business model that requires an overall cultural change and a general involvement of all skills within the company, including designers. Moreover, internal communication becomes critical to inform the personnel about the opportunities of circularity, above all at a social level (which emerged as less recognized by companies interviewed). Periodic reports, along with the use of indicators, can be helpfully for summarizing the CE benefits and operationalizing the CE results.

CE also enhances the introduction of a new consumption model where property is replaced by access [12]. This model should guide the transformation of consumers-owners into consumer-users, being aware that after the use of the product they must return it, to be reused or recycled. An adequate level of consumers' awareness of CE has been recognized as critical by the companies interviewed. To this end, it should be important to improve formative courses, which could be promoted by both schools and local institutions (e.g.: events, workshops, seminars to raise awareness on CE issues). However, companies should also promote this new model of consumption, for example by offering economic incentives stimulating consumers to give back the product at its end-of-life.

Another basic principle of CE concerns the reverse cycles. To create value from used materials and products it is necessary to collect them and take them back to their origins [12]. Therefore, companies should improve their ability to implement a reverse logistic and an efficient system of waste and product leftovers treatment that allow the return of such materials to the market. Furniture companies, as well as others operating in similar contexts, should move to implement such activities, as they can, by improving their ability to recover components into new products addressing the specific market needs. This requires financial and organizational resources, since important investments could be necessary for processing reused materials and waste disposal. The role of economic limitations and the lack of financial resources as potential obstacles to the CE implementation clearly emerged in this study. In this regard, Governments and public institutions' role is critical, as they should provide suitable economic and financial incentives and measures to support the companies' efforts [29]. Technology and investments in R&D, in fact, play a crucial role in the development of CE as they allow the implementation of new innovative and creative processes by companies, but their actual management requires financial investments which, sometimes, could discourage firms, especially those of small size that are usually facing resource scarcity issues.

Finally, a further suggestion can be drawn from the analysis of product and process certifications. Notwithstanding the recognition of their potential benefits, they are very little applied by companies interviewed. Literature shows that such standards may be particularly helpful to aid managers in implementing environmentally sustainable practices, thus moving towards a wider CE model [20]. This study didn't investigate the motivations underlying the limited adoption of certifications, revealing a potential gap that deserves certainly further analyses. It is likely to suppose that the adoption of product and process certifications is very difficult for companies mainly for high implementation and maintenance costs, but also for the high bureaucracy and organizational complexity that they brought with them [37]. To overcome such limits, companies shall see beyond the initial barriers, trying to think of certifications as a medium-long term investment that will lead to organizational and environmental improvements, as well as to brand image and competitiveness improvements [40].

Overall, a further suggestion could be derived from the literature, which highlights the importance of a favourable system condition. The collaboration between value chains and sectors could be very important for establishing a large-scale circular system [11, 12]. Relationships with other firms could provide some facilities and help companies for product development and information sharing, as well as sectoral standards adoption. This becomes particularly relevant if companies are based in specific areas, such as Italian furniture districts, as in the case of the companies investigated in this study.

6. Conclusions, limits and future research directions

This explorative study adds further evidence to the existing literature about the CE principles and characteristics in the furniture sector. With respect to the first research question of this study (i.e.: *How much do furniture companies know about CE? What do companies do concretely? What factors motivate, support or hinder the adoption of CE practices?*), the results show that CE applied to this sector is yet a new concept towards which companies are increasingly addressing their

attention. The case studies analysed, in fact, are very interested in CE, even if they need to develop further knowledge about it. Notwithstanding their interest, a potential gap seems to emerge between the positive attitude towards CE and their practical implementation since CE practices are still limited and mainly related only to reducing activities. Similar findings emerged with respect to the second research question of the study, concerning the adoption of product and process certifications (i.e.: *Do furniture companies adopt product and process certifications? For what reasons and purposes?*). Companies interviewed are highly aware of their potential advantages, both economic and environmental and communicative, but they declared to use them very slightly. Therefore, here lie some gaps that are worthy to be explored in future research. Further qualitative analysis can be drawn to proceed with explorative purposes, as the CE is still incipient and the transition to a more structured CE model is yet in its initial stage [12]. Further research could be conducted, in particular, involving CE applications on the end-of-life phase of the product, on which very scarce knowledge and practices emerged from this study.

Other research perspectives come from the limitations of this study, mainly due to the multiple case study adoption. The results of this research are not characterized by generalisability [57]. Therefore, a greater number of case studies, along with the development of a quantitative survey, could be recommended for the future, in order to provide a better understanding of the CE concept and practices within the furniture industry. A comparison with other industries could be also useful for revealing peculiarities and differences among various market contexts. Finally, as previously noted [58-60], future research should be deepened searching for criteria and indicators for assessing the level of circularity of both products and companies.

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Forensic phases in the Industrial Sector

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ABSTRACT

In the face of a cybersecurity incident in a productive industry, the phases to be carried out are explained to avoid information troubles using an adequate forensic approach. In this paper, several forensic methodologies are described including the different phases.

Keywords: Forensic, manufacturing industries, cybersecurity, standards

1. INTRODUCTION

The Information and Communication Technologies (ICT) are essential resources for our factories nowadays, including a vast amount of saved or sent data through the big data. That is why daily, protection becomes a priority. This issue concerns all kinds of organizations, including the home and the different industrial environments (mechanical, electromechanical, agriculture, etc.), where information is crucial to the proper business activities development.

Different information forensic methodologies have been developed. There is no methodology for Industry professionals to perform their tasks following a single regulatory framework. Without counting, there is no methodology in productive environments.

If we obtain an extensive methodology of generalized application throughout the industrial sector, it will lead to the expert opinion quality improvement and the forensic analysis. At the same time risk situations will be avoided (fundamental rights violation, violating criminal law, etc.) in the evidence acquisition, the investigation and reporting, between others.

2. RELATED WORKS

Over the years multiple studies about the information security forensic field, have been undertaken,including different approaches and objectives[1] [2] [3] [10] [11].In addition, due to its importance, forensic is supported by security-related international/national standards and national guides such as ISO[1]270037 [4], RFC[2] 3227 [5], UNE[3] 71505 [6], UNE 71506[7], UNE 197001[8], UNE 197010[9].

ISO 27037 belongs to the ISO 27000 security standards published by the International Organization for Standardization (ISO). ISO 27037,known as "*Guidelines for the identification, collection, acquisition and preservation of digital evidences*". This standard offers guidance to deal with frequent situations throughout the digital evidence process. It also defines two specialist roles: DEFR (*Digital Evidence First Responders*) and DES (*Digital Evidence Specialists*). In addition, ISO 27037 provides guidance for the following devices and circumstances:

- Digital storage media used in different equipments such as hard disks, floppy disks, magneto-optical and optical disks and the like.
- Mobile devices, PDAs, memory cards.
- Navigation systems (GPS).
- Video cameras and digital cameras.
- Standard computers, including networks connections
- Network protocols
- Other devices with similar functionalities to those described above

This standard ensures that the potential digital evidence is collected in a valid way for legal purposes facilitating their contribution in trials and legal proceedings. It should also be noted that it covers a wide range of different devices and situations, although not all an industry may have in a security incident.

RFC 3227 published by the *Internet Engineering Task Force* (IETF) gives guidelines to collect and store evidence without putting them at risk.

There are basically three principles to collect evidences: the order of volatility of the data, the actions to be avoided and privacy considerations.

Regarding the collection procedure, it should be detailed, taking care that it is not ambiguous and minimizing decision-making. Regarding the storage procedure, it is necessary to take into account the custody chain of the collected evidence and where and how they should be stored so that they are safe. In relation to the tools of expertise they should alter the least possible scenario.

[1]ISO: International Organization for Standardization
[2]RFC: Request for Comments
[3]UNE: Asociación Española de Normalización (Spanish Association for Standardization)

The UNE 71505 and 71506 published by AENOR (Spanish Association for Standardization and Certification) are intended to provide a methodology for the preservation, acquisition, documentation, analysis and presentation of digital evidences. These standards must respond to legal infractions and computer incidents in the different companies and entities. For this reason, this methodology is proposed in the next section.

3. PROPOSED FORENSIC METHODOLOGY FOR THE INDUSTRIAL SECTOR

The steps carrying out a forensic in the industrial sector are described below with the proposed methodology, the scenario of the case study description, the basis underpinning explanation and, finally, the conclusions.

3.1 Forensic Steps

Figure 1 shows the considered elements during a forensic analysis and how they relate to each other. To perform the expert's report, the following steps must be followed:

1. Previous analysis.
2. Secure the scene.
3. Identify and collect evidence.
4. Preserve the evidence.
5. Analyze and investigation.
6. The reportwriting.
7. Presentation of the report
8. In court ratification when required

Figure 1. *Example of forensic steps*

3.2 Case Description

The case study was conducted in a dairy production center in Spain. The factory to the complaint of a couple of workers knows that some colleagues are stealing high quality milk in large quantities. Faced with this complaint, she conducts an internal investigation and detects that something does not match and decides to hire professionals in the field.

3.3 Previous Analysis

To define the happening in place scenario we conducted personal interviews with system administrators and managers, CISO (*Chief Information Security O*fficer), and reviewed facilities and systems documentation.

This phase consists of analyzing and studying the case to be documented. Keep in mind that even if you are an expert in a subject and you have many years of material there are thousands of fields, devices, etc. and you have to analyze them for later applying your knowledge base that one has.

3.4 Secure the Scene

The environment equipment photographs, must be taken to show the original state of the scene, thus identifying the perimeter of the scene perimeter to be analyzed and protecting it from unauthorized personnel access whenever possible.

Keep in mind that in the industrial sector for example in this case we would leave the dairy production center for example without being able to make part of the production and billing of your product. Therefore, it does not make sense because it would have to close its factory and it would come out more expensive.

3.5 Evidence collection and identification.

The evidence identification is one of the most important and delicate tasks. Keep in mind that there are evidences that are volatile. Volatility of the data is understood as the period of time in which they will be accessible. Figure 2 shows the volatility ranking according to RFC 3227.

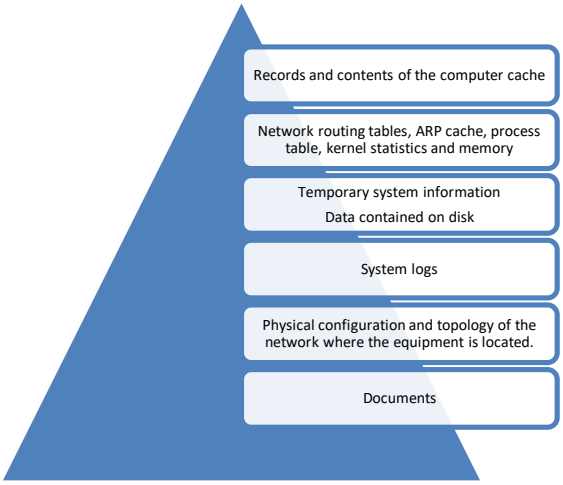

Figure 2. *Volatility of evidences ranking*

Once the necessary and cataloged evidences have been identified, their volatility should be collected.

In our case study, it was:

- a PLC (Programmable Logic Controller) that was manipulated so that the liters were not contracted.
- A computer where they manipulated.
- The central administration server where they save the heavy input and output and the liters that were sold to a client,
- Physical security data entry and exit where they cheated the jury guard.

Everything must be identified and carried out with the maximum technical and legal guarantees. In this case you have to start with the PLC (figure 3) because due to volatility issues it saves the information in a limited FIFO (First In First Out) memory, therefore, depending on the time you were doing the theft, we could be losing information.

Figure 3. *Volumetric PLC*

For the acquisition of PLC logs, the manufacturer's own software must be used. To guarantee the chain of custody and that these data cannot be maintained in the future we will use a notary (legislation based on Roman law; in Anglo-Saxon legislation the expert himself is equivalent to a “notary”). The downloaded files are hashed. If the PLC was destroyed there are other techniques that are not relevant here and it is not a case of study.

For the acquisition of the computer, as it has been in past days, we will clone the hard drive. To do this, we identify it and connect it to a cloner (figure 4) on its write-blocking side. On the other side we put the virgin hard drives where we want to be cloned. This process will also be done with a notary. The hard disk is hashed.

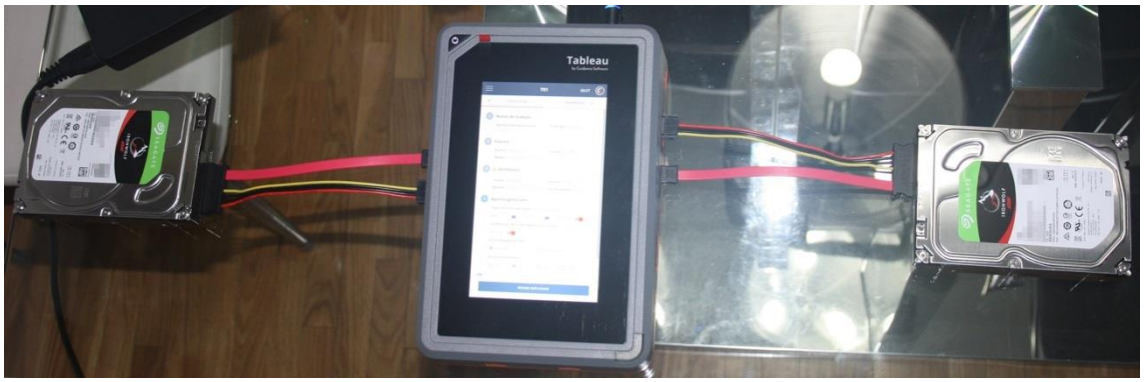

Figure 4. *Cloner*

For the acquisition of the management system that is on the server and in the cloud, it also keeps the notary and the database is copied and then examined. The downloaded files are hashed.

The entrances and exits of the trucks leave in paper and they are requested to the factory which delivers it to us.

Finally, we show that it has a presence control system. Therefore, we acquired these databases with the notary, and we made a hash of the obtained files.

In all the actions where the notary has been, a copy remains for his custody and he gives to us as forensic experts the other one to be able to carry out the study. Do not forget to take photos of the different processes to document it.

3.6 Evidence preservation

A bad preservation of the evidence, misuse or mishandling can invalidate all the investigation carried out in front of a court, this is a very important factor that is repeated throughout the methodology. For this reason, the chain of custody is very important.

The purpose of the chain of custody is to avoid any kind of manipulation having absolute control over all the items seized, who has manipulated them, how they have done it, why they have been manipulated, and when this manipulation has taken place.

While the evidences are in the laboratory and are not being used for the analysis, it is important to have them packed with information labels containing at least data such as:

- A unique identifier for each element,
- Name of the technician responsible for the evidence,
- The description of it,
- The owner of it,
- The place where it was acquired,
- Acquisition date and time.

Evidence should be protected again static electricity; blows or accidental falls, etc. The place of storage must also meet a minimum of security conditions, not only physical access but also environmentalto evidence. Digital evidence cannot be stored in humid places or with extreme temperatures or with dust and dirt excess, etc.

The documentation of the custody chain must also contain all the places where the evidence has passed and who has carried out its transport and its access

3.7 Analysis and investigation

Before starting the analysis and investigation, an environment must be prepared. In case of a hot analysis the investigation will be done on the original discs, entailing certain modification risks of the evidences. Therefore, the precaution will be

taken to put the disc into a read only mode. For this, there are two hardware and software methods. We always recommend the hardware with write blockers to avoid unnecessary scares and more easily demonstrate such blocking.

If you opt for a cold analysis[4], depending on what we analyze, one environment or another we will need. Each case will be different.

The analysis and investigation phase does not end until it cannot be determined who or what caused the incident, how it did it, what effect it has had on the system, when, etc.

As has already been explained, work with original data should never be done except for exceptions and each of the laws in force in the jurisdictions must be respected (there may be several countries) where the investigation is carried out.

The results obtained from the whole process must be verifiable and reproducible, so at any moment we must be able to set up an environment in which to reproduce the research and show it to whoever requires it.

This phase will have to be adapted in each case:

- Preparing a work environment adapted to the needs of the incident.
- Rebuilding a time line with the events that occurred.
- Determining what procedure was carried out by the attacker.
- Identifying the author or authors of the events that occurred.
- Assessing the impact caused and if possible, the recovery of the system.

After the analysis, the result was the attacker stole 58.000 liters of milk. Those liters of milk were sold.

3.8 Writing the report

The next phase of a forensic analysis is to write the reports. Although it does not seem important, this phase is as important as the rest because if it is not covered in a correct way what has been done, the observations, the problems that have occurred, the conclusions, etc. our expertise will have less strength.

Two reports will be written, namely the technical report and the executive report. In essence, both reports explain the same facts but vary their approach and the degree of detail with which the matter is exposed.

The technical report will have different sections:

1. Introduction where the background will be discussed, and the scope of the expertise and the work plan will be described.
2. General considerations where the used methodology and the work environment will be described.
3. Reference documents needed or used in the expertise.
4. Terminologies and abbreviations used in the expertise.
5. Actions. Acquisitions of evidence made in the courts, by notary or evidence provided by customers.
6. Analysis and research. This section describes all the analysis and research carried out in the expertise.
7. Conclusions. In this section the conclusions that have been reached after all the analyzes are developed.

The executive report will have different sections:

1. Tests carried out where the analyses carried out are described in a simple way and for non-technical people.
2. Relevant findings describe the most important facts found.

3.9 Report presentation

Once the report is finalized, it must be presented to the client and to the client lawyers to know what has happened and may have the legal basis to defend our client or to prepare the complaint if appropriate.

[4]Cold analysis is when the device is power off
Hot analysis is when the device is power on, for example the memory can be analysed

3.10 Ratification in court when required

If this report is taken to the court and the process continues, we will have to ratify it, that is to say, confirm that we have done this work and we have signed the report.

For the judiciary we also recommend reviewing

- All the expert notes
- The procedure performed
- The report
- The conclusions
- Weak and strong points (*SWOT – Strengths-Weaknesses-Opportunities-Threats*)

4. CONCLUSIONS

Actually manufacturing systems are not prepared to detect security incidents because until the end 20th century the machines were not connected to networks and due to that safety was only important. The situation changed dramatically at the beginning of 21th century with the biggest expansion of the ICTs. This expansion has taken much advantage but, at the same time fragility increased too much. Due to that when an incident occurs it is necessary that the ICT system collects the registers contains, to have evidences andbe able to demonstrate the facts of the responsibilities.

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Renewable Energy for Sustainable Mining

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ABSTRACT

Mining industry is known for requiring energy-intensive processes with significant impacts on the greenhouse gas emissions, which represents a major concern to both economic competitiveness of the sector and climate change. Low carbon sustainable technologies as renewable energy sources (RES) are emerging as key opportunities to sustainable mining in tandem with climate change challenges. However, the use of RES on this sector is still scarce even in countries well known for their mining potential and availability of renewable energy resources, as is the case of Brazil. This research investigates the economic viability of a proposed renewable-mining model for a mining company in the Northeast region of Brazil. The case of photovoltaic is analyzed considering the avoided electricity grid costs as potential benefits. The results showed that this renewable-mining strategy is promising for both PV and storage-PV systems.

Keywords: Renewable Energy Sources, Mining, Brazil

1. Introduction

The demand for raw materials has been increasing worldwide over the years, despite efforts in activities such as recycling [1]. This demand is still expected to increase significantly in the coming decades. The mining industry has been playing a fundamental role on supplying raw materials for the society and several industries worldwide, although in some cases at the expense of the ecosystems [2].

Mining activities are known for requiring energy-intensive processes which contributes to increase the greenhouse gas emissions [3]. The high energy demand represents a complex issue for the sector, however, the emerging debate on climate change has been placed on the agenda putting in evidence the need to reduce energy use, and also to promote clean energy options usage.

In this context, the use of renewable energy source (RES) has been considered as a key sustainable alternative for mining industries, with some international examples already demonstrating the suitability of this low carbon energy model at industrial level, as for the case of Chile [4] and Korea [5].

For the case of Brazil, the mining sector represents a valuable economic activity, which allied with the countries' privileged access to renewable resources such as solar and wind, turns this renewable-mining strategy particularly relevant to be considered. In fact, studies such as [1] already showed the importance of sustainable mining in the country and [6] clearly shows the high RES potential of the electricity sector. However, the mining-energy combination for sustainability is yet far from being adequately considered.

In this context, this research has two main objectives, firstly, to analyse the importance of energy for mining activities and the use of different energy sources in the processes; and secondly, to attempt for an economic evaluation of the possible use of renewable energy sources (RES) in the sector using the case of mining company to illustrate this approach.

In order to achieve the objective of this research, a review of the relevant existing literature was conducted. Then, the case of a mining company in the Northeast region of Brazil was analyzed. A case study method was chosen in order to assess the economic viability of the proposed renewable-mining strategy under the present market conditions.

2. RES and mining industries: an overview of the literature

Over the last decades, the population growth, associated with the increasing consumption of goods, services as well as trends in urbanization, have led to an increase in the global demand for raw materials worldwide [7]. As result, the mining industries are coming under increasing pressure with significant impacts on the energy consumption and on the greenhouse emission through its operations [3]. These activities are well known as an energy intensive industrial sector since extraction of ores from deeper levels requires intensive use of energy in several stages [8].

According to the International Organizing Committee for the World Mining Congress [9], excluding natural gas and petroleum, the countries which figure as the biggest players for mining industries in the world mineral production are China which produces 33.5% of this global production, USA 12.0 %, Australia 7.9%, Russia 7.1%, India 6.4%, South of Africa 4.7%, Indonesia 4.0%, Brazil 2.1%, and Canada (2.0%). These countries have been seen as key players on supplying raw materials for society worldwide.

Yet, the current literature related to the mining sector has been focusing on aspects such as relationships between extractive industry and development, community and its impacts and the social and environmental impacts of mining. The relationship between mining and climate change has received limited attention, which configures a gap in the literature[10].

In order to deal with the global challenge of mining and energy, initiatives towards a carbon neutral through implementation of RES by mining industries may become a strong priority for industries, scientific experts and decision-makers in the coming decades. This search for low carbon mining will lead companies operating in the sector to look forward for energy efficiency measures and alternatives for fossil fuels, such as renewable energy sources.

According to [11] the focus on the use of RES by mining companies can be seen as an alternative way of energy procurement aiming both a lower energy cost as well a clean energy source, enabling practices and progress for a sustainable mining.

According to the Word Energy Balances, mining industries account for about 4 - 7% of the total global energy use. This indicates that energy use for mining industries is between 16 and 27 EJ annually [12]. Excluding gas, oil, and rock excavation, the work developed by [13] shows a similar picture with an estimation of energy by these mining industries worldwide of about 12 EJ energy per annum.

Considering that mining activities are one of the worlds' largest industrial sector and these activities are expected to expand globally, these estimations show the importance of this industrial sector on regards to energy needs and as well the need for initiatives towards clean energy sources [14].

Despite of the feasible technologies used to generate electricity such as wind, solar and nuclear contributes with lower greenhouse when compared with diesel which the conventional source used in mining activities, initiatives and strategies towards implementation of these strategies are still insipient due to several aspects of mining operations.

The work developed by [7], highlights that the use of RES for mining industries depends on appropriate incentives such as regulatory schemes and policies, otherwise in the case of mining, the use of these technologies by industries will remain difficulty to be adopted. Also [15], claims that the implementation of RES for mining has several constraints such as technologic and economic aspects as the main challenges faced by the sector.

Therefore, RES can play a support role on mining companies allowing to lower costs and even to bring energy to remote regions where mines are located [4]. This RES-mining combination can be in the long term an economically attractive alternative, moving on the sector for a reorientation of the production system to a sustainable production system [10-16].

3. Materials and methods

This study addresses the case of medium size mining company located in the Northeast of Brazil, which works on the extraction of sheelite mineral and includes underground extraction activities and industrial surface related facilities. Most of the intensive electricity consumption activities are related to underground extraction, including the pumps of water exhaustion, winches for hoisting of cars, lighting, ventilation and the primary and secondary crushing. Underground extraction operates 24 hours a day from Monday to Saturday.

The information about the electricity consumption of the company is scarce and came mainly from monthly invoices sent by the electricity supply and can be summarized as follows in table 1. As shown, a dual-tariff scheme is in place with about four hours of the day charged as peak period.

Table 1- Summary of electricity use for year 2016

	Peak time	Off-peak time
Electricity consumption (kWh)	39208	485918
Tariff (USD/kWh)	0.397	0.081

This study addressed the case of the possible installation of a photovoltaic (PV) system to reduce the amount of electricity purchased from the grid. Information about the expected PV power production was computed from www.renewables.ninja platform ([17] and [18]) which provides monthly and hourly data based on the geographical coordinates of the location for the PV unit. Figure 1 describes the monthly electricity consumption of the plant and the expected load factor for the PV unit.

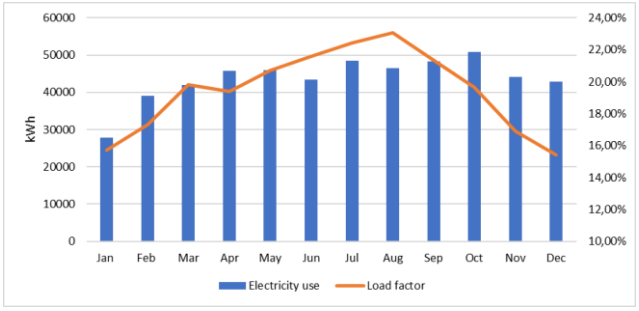

Figure 1- Electricity use on the plant and load factor for the PV unit

As it can be seen, the electricity use on the plant remains fairly stable during the year, but the PV plant output will reflect the seasonality of the local conditions. For the calculations it was assumed that the electricity consumption would also remain stable during peak and off-peak periods of the day.

For the economic evaluation study, 3 scenarios were considered:

- *Scenario 1* – A PV unit of 10 kW would be installed, which would allow to produce about 3.2% of the total needs of the plant or about 6.5% of the needs to the plant during day light.
- *Scenario 2* – A PV unit of 25 kW would be installed, which would allow to produce about 8.1% of the total needs of the plant or about 16.2% of the needs to the plant during day light.
- *Scenario 3* – A PV unit of 25 kW would be installed along with a lead-acid battery storage system with a storage capacity of 30 kWh. This would allow to storage electricity produced during the day to replace consumption from the grid during peak periods at the end of the day (no day light). As in scenario 2, about 8.1% of the total needs of the plant would be met but with higher avoided costs (benefits).

As such, both scenarios 1 and 2 represent a technical approach to the problem but scenario 3 can already be seen as first strategic study to analyze the benefits of the dual tariff scheme and its relevance for the economic viability of storage systems. The economic evaluation, included the assessment of the main costs of the PV system and storage and the benefits were computed as the avoided costs, meaning the electricity which would be produced and therefore would not be bought from the grid. Table 2 summarizes the main assumptions of the scenarios.

Table 2- Key parameters for the scenarios

	Scenario 1	**Scenario 2**	**Scenario 3**
Installed PV power (kW)	10	25	25
PV Investment cost (USD/kW)	1385	1247	1247
PV Life time (years)	25	25	25
Lead acid storage system (kWh)			30
Storage cost (USD/kWh)			Pessimistic – 600 Optimistic - 400
Storage life (cycles)			2000
Storage efficiency (%)			85
Discount rate (%)	5%/10%/15%	5%/10%/15%	5%/10%/15%

For the sake of simplicity O&M costs were not included in the model. Information on PV investment costs was obtained from the report of Instituto IDEAL [19] from a survey in Brazil for systems up to 5 kW. It was assumed that the value would be valid for the case of scenario 1 (10 kW) and that the investment cost could be reduced by 10% for the case of scenarios 2 and 3 (25 kW) due to some economies of scale. The information on the lead acid battery system was based on Geoffrey et al., [20] however the uncertainty of the information must be highlighted given the relative immaturity of the stationary storage market.

For each one of the scenarios, three possibilities were considered for the discount rate. The possibility of loans or access to public support scheme were not considered.

4. Results and Discussion

The results were analyzed considering a discount cash flow approach to compute the Net Present Value (NPV) and Internal Rate of Return (IRR). Table 4 presents the main results for the 3 scenarios.

Table 4- Economic evaluation

	Scenario 1	**Scenario 2**	**Scenario 3 (pessimistic)**	**Scenario 3 (optimistic)**
NPV at 5% (USD)	7557	22356	13755	30451
NPV at 10% (USD)	-63	3305	-7553	4973

NPV at 15% (USD)	-4032	-6616	-18363	-8105
IRR (%)	9.9	11.4	7.8	11.6

From the financial perspective, the results put in evidence the importance of the discount rate as a fundamental factor for the assessment of the economic viability of the system. In fact, if a 15% discount rate is assumed all options would be economically unfeasible. The intra-bank rate in Brazil (SELIC), which is used as a reference for loans and other economic operations, is presently around 6.5% but it has remained unstable during the past years (https://www.bcb.gov.br/controleinflacao/taxaselic). As such, the company must address this issue as a risk factor to be considered on a more detailed analysis. Nevertheless, results for 10%, which is already well above SELIC, are still positive for scenario 2.

As for scenario 3, it is evident that the cost of the storage system is a key aspect to be considered in the analysis. The results are highly dependent on these values as under a pessimistic approach scenario 3 would be the worst option for the case of both 10% and 15% discount rate. It can however become the best option, for lower prices of the storage system. Studies such as IRENA (2017) [21] already point to a promising decline of the costs for these lead acid systems and to the development of other storage options. This scenario underlines the future perspectives for the renewable producers which not only can benefit from a reduction of their costs but can also benefit from the strategic management of their PV and storage assets to better couple with the dual tariff schemes.

5. Conclusions

This study addresses the integration of renewable solutions into mining activities, which can be seen as an important route to increase the companies' competitiveness and contribute to meet sustainability objectives. However, costs and even the lack of awareness are still major barriers which have limited the renewables investments.

This study used a case study, to show how using PV system can contribute to reduce electricity costs on a mining company in Brazil. The economic viability of the system is demonstrated and the possibility of using renewable-storage-mining strategy is also highlighted. For this study only direct benefits (measured as avoided costs) were considered but aspects related to the contribution to the security of supply for the company can also be relevant. Moreover, the social contributions should not be overlooked such as the environmental benefits or even the potential impact on regional development and job creation that this local renewable-mining strategy implemented at large scale can have on the region.

However, some limitations of the study should be also pointed out namely the scarcity of detailed information that characterizes most of these companies. Moreover, the analysis is based on cost assumptions collected from the literature which must be validated by a local study of the plant and of the equipment suppliers. Additional costs, such as O&M and end of life expenses must be considered. The issue of storage cost assumptions is particularly important to be addressed as it is still a major source of uncertainty.

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Main Benefits of Integrated Management Systems through Literature review

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ABSTRACT

The main aim of this paper is to prepare a comprehensive list of benefits offered by integrated management system (IMS), namely quality, environment and safety, discussed in the previous literature. This paper had followed a methodology for literature review based on the keyword search in the electronic database of Web of science, Science direct, Scopus and Emerald. Findings of this literature review have unveiled several important and interesting benefits offered by the integrated management system and wider scope of integration.

Several studies have confirmed the listed benefits of integrated management system. Moreover, this study has highlighted some dimensions of future study in line with the analysis of benefits of integrated management system.

Keywords: Quality; Environment; Occupational Health and Safety; Integrated Management Systems

1. Introduction

Nowadays, business organizations are practicing several management systems such as quality management system (QMS) according ISO 9001, environment management system (EMS) according ISO 14001 and occupational health and safety management system (OHSMS) according ISO 45001/OSHAS 18001. Recently, business organizations are using corporate social responsibility management system (CSRMS). Each management system works in particular area and offers benefits in that area. For example, if a firm choose QMS, it can enjoy several benefits like continuous improvement of product and process quality, customer satisfaction on quality; improve product reliability, reduction of cost by improving process efficiency etc. Similarly, environment management system can offer saving in energy consumption, pollution prevention, customer satisfaction on environment protection etc. [1,2,3].

For this reason, many business organizations those who are not aware of management standard practice, are trying to adopt various management system standards. According to ISO:2015 data, number of certificates worldwide for ISO 9001 and ISO 14001 are 1.1 million and 3,24,148 respectively. Implementations of ISO standards are completely voluntary [1,4]. But, nowadays, it becomes obligatory measure to implement ISO 9001 and ISO 14001as instructed by the customers [3,5]. Researchers are trying to find out significant impact of these management system standards on firm's business performance. Some of them have found positive link [2,6,7,8,9], while other have not found any significant link [10,11,12,13,14]. Beside this, a large number of studies had been conducted to analyse the benefits offered by ISO 9001 and ISO 14001implemented sequentially or simultaneously [15,16,17].

Several authors have argued that, two above mentioned ISO standards has a lot of compatibilities from the angle of structure and management procedure [18,19,20]. Both of these standards follow continuous improvement practice (PDCA cycle). Many research scholars have argued that, companies those who have already implemented and are practicing ISO 9001 have enough knowledge to adopt ISO 14001 [21,22]. Because, both of the standards require similar practices to meet the regulations of quality and environment. Similarities between these standards in terms of structure, management philosophy can create an opportunity to integrate these two management systems.

In this context, synergies may be achieved by integrating these two standards based on their similarities. Greater benefits can be obtained through better synergies [6.23,24]. According to Rybski et al, 2017 [19] all individual management systems can be integrated into one management system. Important benefits obtained from the integrated systems are optimum use of resources, unification of audit, increase efficiency of the firm and so on [25,26,27,28,29].

Implementation of individual management system standards in a integrated way leads to achieve several benefits. So far our knowledge go, limited literature review has taken any attempt to prepare a comprehensive list of benefits offered by integrated management system. This is an important issue from both academic and managerial point of view. Therefore. contribution of this study covers both academic and managerial perspectives. First come to the point of academic perspectives, this study will increase the present knowledge regarding the benefits of integrated management system. Several benefits have been found from the previous literature and has prepared a comprehensive list of benefits obtained from integrated management systems. This could be a guideline of future studies. Second come to the point of managerial perspectives, the knowledge of benefits offered by integrated management system could help the manager to identify the level of integration of their firms.

The present study has the following structure. Background of the main benefits of integrated management system is highlighted in the first section. In the methodology section, strategy of research has been described. In the result section, main benefits of integration are presented. In conclusion section, direction of future research has been presented.

2. Literature Review

When an organization decide to integrate their management systems, they achieve a better efficiency related to more efficient management of multiple management systems as well as improving external image and relationship with stakeholders.

Bernardo et al., 2015 conducted a literature in the web of science, Scopus and Emerald database to identify the benefits arising from implementation and use of IMS. 18 empirical studies were analysed and result shows that, companies which integrate their management systems have obtained more benefits when compared to separate management system. Among the IMS benefits this study has highlighted the followings

The simplification achieve in the process leads to less confusion, redundancy, conflict in documentation and bureaucracy [6,7,30.31]. Better definition of management responsibility and authority also reduce less confusion [11,12,15,32].

Unification of audit both internal and external ensures better use of audit result and reduces cost through avoidance of duplication of effort [8,9,12,15, 33]. Organization began to conceive integrated procedures in order to make their process simple [2,8,16,17,34]. Integration of documents requires extra effort initially, but offer many benefits in long run.

IMS will give better risk management. In IMS risk are more likely to be identified and treated when process are reviewed from all angles. Elimination of these would have direct benefits [10,14,16,35]. Integrated approach of risk management and control will lead to optimum allocation of resources for it. IMS can provide a better opportunity for good communication [36]. Effective communication is a key element for efficient management. Holistic view of IMS is important to achieve objectives [1,6,8,12,17,39]. Improve management and process transparency leading to more efficient and effective management review.

When the management systems are united, increased profitability is attained through lowering cost, better risk control and creativity [5,7,9,15,16,40]. Greater computability and alignment of current standards facilities easier decision –making.

IMS promoting a sustainable success in business by efficient management and fulfil the requirements of all stakeholders [3,10,12,14,41].

3. Methodology

This study has performed a literature review to find out all possible benefits offered by integrated management system. This study has included the information regarding the benefits of integrated management system discussed in the previous research articles. This study has also reviewed several empirical studies of integrated management system.

3.1 Strategy of literature review

Four electronic databases (Web of science, Science direct, Scopus and Emerald) were utilized for searching the article related to benefits of integrated management system (quality, environment and safety). Strategy followed for searching articles is keyword searching Strategy. The key words used for searching the articles are “integrated management” or “IMS”, and “Benefits”, “implementation”. Electronic databases search result show the research articles containing text words present in the title or abstract in the article.

3.2 Selection of articles

Total 323 academic research articles were identified from the year 2008 to 2018. In order to identify relevant articles, title and abstract of identified articles were checked by both of the authors. Criteria that was set to include a paper in the review was; paper containing benefits of integrated management system. Excluding criteria was; benefit offered by individual management systems. Study regarding the firm performance analysis was also excluded from this study. Finally, 45 articles had successfully passed out from inclusion /exclusion criteria. These are part of the references. They helped us to find the main benefits of Management Systems Integration (Quality, Environment and Safety).

4. Results

Benefits of IMS are presented in the table 1. According to the study, two important benefits were obtained from integrated management system. They are improving company image [2,4,5,6,8], improvement of efficiency [1,9,11,13,18,22].

Table I. Main *benefits of integrated management system (IMS)*

Sl. No.	Benefits of IMS	References
1.	Enhance the reputation of the organization to its stakeholders	Bernardo, Gotzamani, Vouzas, & Casadesus , 2018
2.	Contribute integrated approach for risk management in business	Nunhes, Vilamitjana, & Oliveira, 2018
3.	Increase the capacity of the organization to attain objective	Nunhes, & Oliveira, 2018

Sl. No.	Benefits of IMS	References
4.	Provide better alignment of strategic, tactical, and operational policies and objectives	Nunhes, Barbosa, & de Oliveira, 2017 Bernardo, Gianni, Gotzamani, & Simon, 2017 Rybski, Jochem, & Homma, 2017
5.	Better decision -making	Gianni, Gotzamani, & Tsiotras,, 2017
6.	Ensure optimum use of various resources.	
7.	Provide competitive advantages from synergies of different management policies	Rebelo, Santos &Silva, 2014 Rebelo, Santos, & Silva, 2016
8.	Improve the compliance of legislation	Arimura, Darnall, Ganguli, & Katayama, 2016
9.	Enhance collaboration inside and outside the organization	**Mohammadfam et al**., 2016
10.	Develop inter-relationship among stakeholders	Manders, Vries, & Blind, 2016
11.	Reduce duplication of documents, records, and making them simple	Chen, Anchecta, Lee, & Dahlgaard, 2016
12.	Save resource and time lost in internal audit through unification of audit	Kafel & Casadesus, 2016
13.	Eliminate hostilities, doubt, and redundancy among the management standards	Barbosa, Oliveira & Santos, 2018 Luo, Li, and Li 2015
14.	Provide greater compatibility of several management systems	Mezinska, Lapin¸a, & Mazais, 2015
15.	Lowering the implementation and management cost of IMS	Bernardo, Simon, Tarí, & Molina-Azorín , 2015 Gianni & Gotzamani, 2015
16.	IMS is helpful to attain sustainability in business	Carvalho et al., 2015
17.	Improve process performance and simplify tasks	
18.	Provide wonderful and easier communication	Ribeiro, Santos, Rebelo & Silva, 2017
19.	Improvement of organizational culture	Rebelo, Santos, & Silva, 2014 Clougherty & Grajek, 2014
20.	Better imitative to arrange employee training	**Abad, Dalmau, & Vilajosana**, 2014
21.	Optimization of training activities through unification of training	
22.	Better employee motivation and greater participation in team work	Asif, Searcy, Zutshi, & Fisscher, 2013
23.	Ensure adequate number of competent workforce	Oliveira, 2013 Santos, Barros, Mendes, & Lopes, 2013
24.	Improve productivity and organization efficiency	Satolo, Calarge, & Miguel, 2013
25.	Yielding the ability to add a new management standards	Abad, Lafuente, & Vilajosana, 2013
26.	More precise clarification of authority and responsibility in new management system	Prajogo, Tang, & Lai, 2012
27.	Better utilization audit results in control procedures	Simon, Karapetrovic, & Casadesus, 2012
28.	Unification of external audit	Bernardo et al. 2012
29.	Greater robustness and agility	Hasle & Zwetsloot, 2011
30.	Better utilization of creativity and innovation	Zeng, Xie, Tam, & Shen, 2011

Sl. No.	Benefits of IMS	References
		Oliveira, Serra, & Salgado, 2010 Tari & Molina-Azorín ,2010 Santos, Mendes, Barbosa, 2011
		Asif, Bruijn, Olaf, & Steenhuis, 2009 Bernardo, Casadesús, & Heras, 2009 Vilamitjana, 2009
		Salomone, 2008
		Santos, Mendes, Barbosa, 2011

Some other studies have highlighted the following benefits. They are optimum use of resources [6,8,12,17,18,23,24], better communication [12,18,21,23,27,29], reduction of cost [1,8,12,18,24,28,30].

Some research scholars have argued that, shearing of resources reduce the effort of duplication [10,12,16]. Many authors like Bernardo et al., 2018, Nunhes et al., 2018, have argued that, in integrated management system implementation, common elements are implemented in shared way.

Most important benefits close to human resource management, are employee training [2,7,9,10,12,15], employee involvement [8,13,14.18.21.23,25], team work [1,5,9,12,18].

Some other researchers have argued that, integrated management system provides simplification of process which leads to reduction of confusion [8,9,12,15,17,25,26], redundancy [2,5,8,9,14], bureaucracy [12,18,19,22,23,25].

Other studies have highlighted the benefits related to audit. They are unification of audit [23,24,25,28,30,32], better utilization of audit result [22.25,28], reduction of resource and time [2,6,9,10,12].

According to some research scholars, such as Nunhes et al., 2018 [42] and Arimura et al., 2016 [8] claim that, integrated management system can bring sustainability in business. Improvement of stakeholder's relationship with firm and their satisfaction are the two important benefits highlighted by several authors [30,32,35,36,42, 44, 45].

4. Conclusions

Several relevant conclusions can be drawn from this literature revision about IMS. In first place, it confirms that many companies around the world follow the integration rules. integration of the referred Management Systems of companies bring advantages in terms of: Enhance the reputation of the organization to its stakeholders; Contribute for integrated approach for risk management in business; Increase the capacity of the organization to attain objective; Provide better alignment of strategic, tactical and operational policies and objectives; Provide competitive advantages from synergies of different management policies; Eliminate hostilities, doubt and redundancy among the management standards; IMS is helpful to attain sustainability in business; to Improve of organizational culture; to improve productivity and organization efficiency. And more: multiple systems with the same goals; reduction of management costs; better definition of management responsibilities and authority; improved external image of the company.

Regarding direction of future research, it can be done a study/review with more articles. But the result should not be very different from that presented in this paper. Can only be optimized, because it is always possible to improve.

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Application of FMEA for improvement in the manufacturing process of mobile phones in a factory of the industrial pole of Manaus

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ABSTRACT

The objective of this paper is to analyze the excess of failures in a mobile phone line production in order to make process improvements in a factory of the industrial pole of Manaus (PIM) by using FMEA methodology (Failure Mode, effect analysis). The excess of failures was an extremely influential aggravating factor by its customer, since the increase of the productive capacity in the company would be determined by the reduction of the percentage of failures or increase of YIELD from the conception of the product until the final phase of its life. Tracing the root causes is an important step in improving manufacturing processes for reducing failures. The impact of this is the reduction in industrial costs and an increase in the quality index of the product, ensuring customer satisfaction in having to produce its product in a factory that operates under condition the EMS (Electronic Manufacturing Services).

Keywords: FMEA, Process, Quality

1. Introduction

In the first two months of 2017, the Industrial Pole of Manaus (PIM) earned R $ 11.82 billion, representing a growth of 12.19% over the same period last year (R $ 10.54 billion). In dollar terms, revenues for the two months were US $ 3.81 billion, a significant increase of 45.01% compared to January and February latest year (US $ 2.62 billion), according to [1].

A significant increase in production in the first two months of 2017, in comparison to the same period of the previous year, the LCD monitor for computer use (1285.75%) stands out. Home theater (328.80%), electronic concierge (447.31%), air conditioners split system (94.74%), microwave oven (88.35%), television with LCD screen (30.77%), tablet PC (25.79%), Blu-ray DVD (24.21%), portable microcomputer (21.43%), television signal receiver (17.21%) and cell phone (13.26%).

The companies that are responsible for the production of the 13.26% of cellular telephones and the other items that compose the slice of the electronics sector in the industrial hub of Manaus (PIM) suffer from high rates of process and product failures caused by the inefficiency of manufacturing processes and insufficient training to employees working on the production lines. Thus, the index of discarded products, or that have failures awaiting analysis and repair by the technical team, grows according to the increase of production, generating high costs with areas for repairs and highly qualified workforce to carry out diagnostic services, repairs and maintenance of assets in stock awaiting technical analysis.

The approach using the FMEA methodology in these industries, and in particular in the studied company, to determine the failure modes and their effects, is of paramount importance for tracking the possible root causes of the problems generated in the production environment. Knowing how they behave is crucial to determine the prevention and elaboration of the best proposals for improvement, adopting predictive maintenance and subsequently productivity improvement determined by the YIELD (index that determines the total produced according to the number of failures generated).

The production or manufacture of consumer goods is based on how companies organize the items that make up the assembly processes in the production lines and how the defects that occur will be solved. The speed in solving the problems and the improvements generated in the processes to mitigate the emergence of the same, will determine in short, if a company is able to produce a certain product efficiently or not. Producing a product efficiently means that the quality criteria demanded by customers are put first, and the reduction of industry costs are the result of well-defined process designs aligned with the quality policies of the corporation. These have been the premises discussed by different researchers in the last decades, from competitive advantages and costs [2], quality and performance [3] and reliability [4-5].

The general objective of this article is the application of the FMEA tool to identify the causes of failures in testers in production lines with the purpose of proposing actions for their reduction and/or elimination. These modes may arise in the process of producing new products of the company under study, particularly in NPI (New Product Introduction) projects, as well as in current products, affecting the quality, cost and reliability of the process. In particular, the work tries to answer to the following question:

RQ1. Given the various manufacturing problems, what methods or tools would the engineering team have to adopt to eliminate or reduce failures, so that the company would not fail to deliver the orders to their respective customers in a timely manner?

2. Theoretical Background

In 1949, the military procedure US MIL-P 1629 entitled Procedures for Performing a Failure Mode Effects and Criticality Analysis was created by the US Army to identify the effects of failures in systems and equipment, and classification according to their impact on the success of the mission, and the safety conditions relating to personnel and equipment [2].

The FMEA was first developed as a formal design methodology in 1960 by the aerospace industry, seeking to excel in its reliability and safety requirements [4].

This section intends to present, in a summarized way, the concept of the FMEA tool, its derivations and applications.

2.1 FMEA conceptualization

FMEA is an approach that helps identify and prioritize potential failures in equipment, systems or processes, becoming a logical system that prioritizes potential failures and provides recommendations for preventive actions [6]. [7] corroborates defining the FMEA as the most established tool for risk analysis and prevention of various engineering failures.

In addition, the FMEA allows identifying and prioritizing potential failures in equipment, systems or processes, aiming to anticipate known or potential failure modes and recommend corrective actions to eliminate or compensate for the effects of failures [8].

Failures in the manufacturing process occur when the process does not meet the specifications established for the manufacture of the product. This may be due to: (1) defects in the raw material or components used in the manufacture of the product; (2) failures in the manufacturing process; (3) Mounting errors [9]. The FMEA tool is also used in products that are already in operation. In this case, it is sought to find the root cause of system failures to propose improvement solutions. Thus, unlike the FMEA carried out in the project phase, it is not necessary to predict possible failures, since it works with failures that are already occurring in the system [10].

According to [11], a team person (the engineer) usually has the most knowledge about the subject matter; however, as an individual, that person cannot clearly see and understand all aspects of the project, process, or service. Still according to the author, the process FMEA (PFMEA) should start as soon as possible (after the concept of the project and the concept of the process).

FMEA is a tool that is widely adopted in several companies and processes around the world, that has transposed the limits of the industrial barrier, with applications in service environments in general, offices, among others, as attested to the wide bibliographic production available [12-24].

2.2 Types of FMEA

The FMEA can be applied in the development of a new product / process or also in existing products and processes. The steps and the way of accomplishment are the same; however, the difference lies in your goal [2].

In relation to the type of FMEA, there is no unanimous number, where some authors defend the existence of four types (system, product, process and service) and others advocate the existence of three (product, process and service).

The types of FMEA can be classified, according to their application [9]:

a. Systems FMEA: used to analyze systems at the beginning of design and project stage;
b. Project FMEA: used to analyze projects before they are products. The focus is on failure modes caused by design deficiencies;
c. Process FMEA: used to analyze the production processes;
d. Service FMEA: used to analyze services before reaching the consumer.

In this sense, FMEA is a reliability analysis method intended to identify failures that alter the functioning of systems and enable priorities for actions to be defined [25].

3. Methodology

The research is exploratory, since the design of the study is related to the application of the FMEA tool. Thus, it is intended to gradually introduce theoretical concepts that lead to practical results. The approach is of the qualitative type, since it aims at the practical application of the FMEA tool in the manufacturing processes of cellular phones in a PIM company. In this context, it has a quantitative approach because the research is based on data processed statistically from the events collected from the company's production lines. The research procedure consists of a case study.

Regarding the production process, the stages consisted of data collection of failures, analysis and grouping of failures in spreadsheet, identification of major failures, selection of the most critical processes and failures associated with them, root cause study, proposed action plan, implementation of the action plan and evaluation of results.

4. Case study

In the following study, the excess of failures in the production process resulted in measures that caused the company to take action so that the reduction and / or elimination of these did not result in quality problems in the process. Furthermore, these measures reached the prevention of failures in the field or for the consumer, influencing cost and production, as well as to delineate the process with a view to preventing functional failures in new projects.

The manufacturing process of cellular phones in the studied company takes place in five productive stages, according to Figure 1 below.

Figure 1. *Line Production Structure*

- Board Assembly (BA): stage for the automated assembly of the boards with the electronic components listed in the BOM (Bill of materials) of the project;
- In Line (IFLASH): stage where the already assembled boards go through the first programming stage, known as Factory Mode (Factory Mode);
- PHASING: stage where some basic tests are performed (Self-test) and calibration of RF (Radio Frequency) in the electronic board;
- Radio Test: stage designed to completely assemble the product and perform all functional tests (display tests, proximity sensor, gyroscope, digital sensor, microphones, speakers, etc.);
- CFC: the final part of the phone's assembly, and where the Customer mode software will be inserted and tested.

For each production step, manufacturing failures, occurring in the process is recorded in an automated system hosted on the company's intranet called Governance for future or real-time evaluation of productivity and quality indexes of production lines. This web page application is accessible to all company sites in Brazil and worldwide to track production. These records can be downloaded according to the date, as well as the start and end times of occurrences.

The period for data collection included May (01/05/2018) until the end of July (07/31/2018). The data collected were given in the production environment and correspond to all the manufacturing processes, as shown in Figure 1.

The compilation of the information was based on the defect codes entered into the system by process technicians, the description of the failures in the automated testers, the codes related to each failure, the type of product, the sector where the failures occurred and the type of process of test.

In order to determine the type of process where the failures occurred, the respective faults codes registered in the company's governance systems were separated and grouped by each type: *board assembly (SMD), material, machine and assembly*. Thus, all data related to the number of failures by sectors in the periods from May to July 2018 is shown in Figure 2 below.

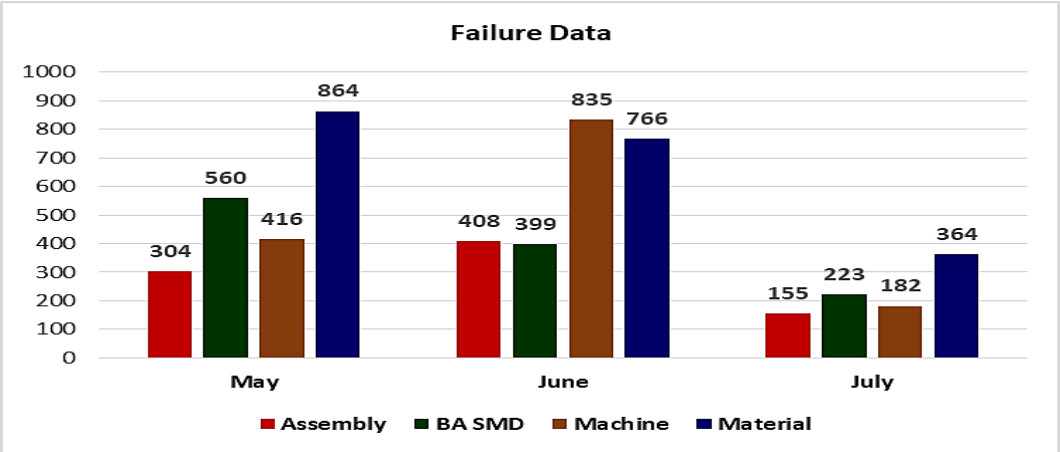

Figure 2. *Total number of failures by type of process (May to July 2018)*

For a more accurate stratification of total failures by production lines of the company, analyzes were performed using the Pareto chart for the period under study. Production lines are identified as Middle End, Front End (FE01, FE02, FE03), Back End (BE01, BE02, BE03), CFC1, CFC2, CFC3. The values collected during the period of May and July are shown in Figure 3 and Figure 4 below.

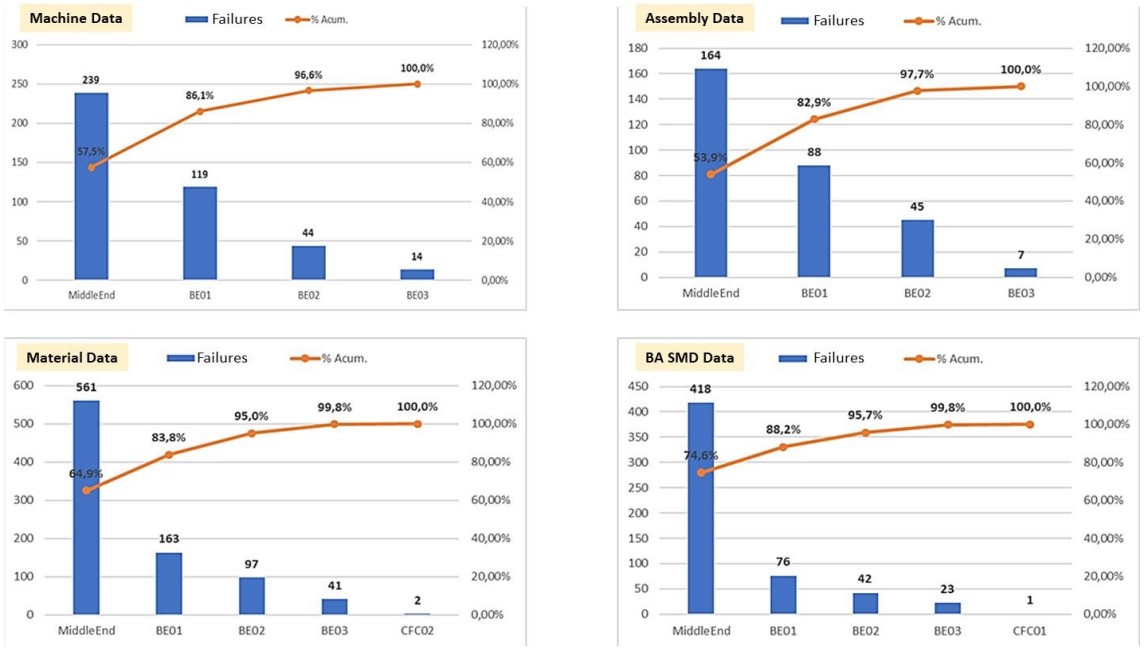

Figure 3. *Total number of failures by type line production (May 2018)*

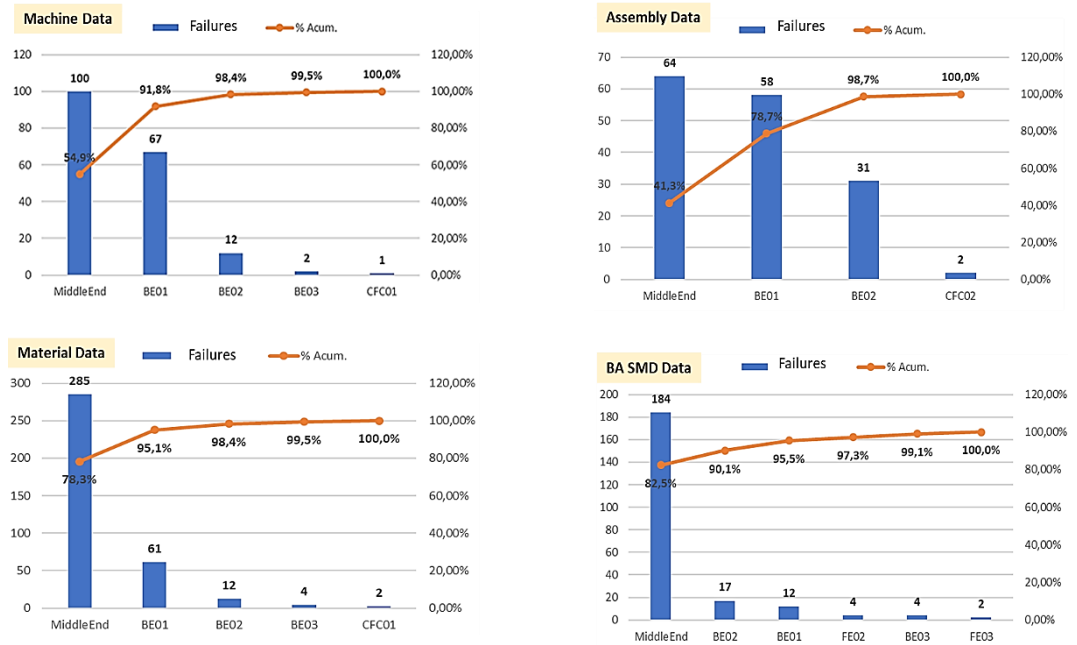

Figure 4. *Total number of failures by type line production (July 2018)*

According to the data shown in the figures, it can be seen that the most impacted production line for all types of processes where failures occur is MIDDLE END. Based on the analyzed data, the FMEA of processes was mapped, to document and to point out the failure modes, as well as the root causes related to BA (SMD), machine, assembly and material.

Using, as reference, the failure data from May and those related to machines, we verified that the MIDDLE END line was the one that got most impact. The stratification of machine failures allowed an association with the possible causes: NT (false fault), S2 (erase), RA (recalibrated), ENG (engineering), RC (recalibration), FTDS (FTDS). In this way, the data were stratified, compiled and shown in Figure 5 below.

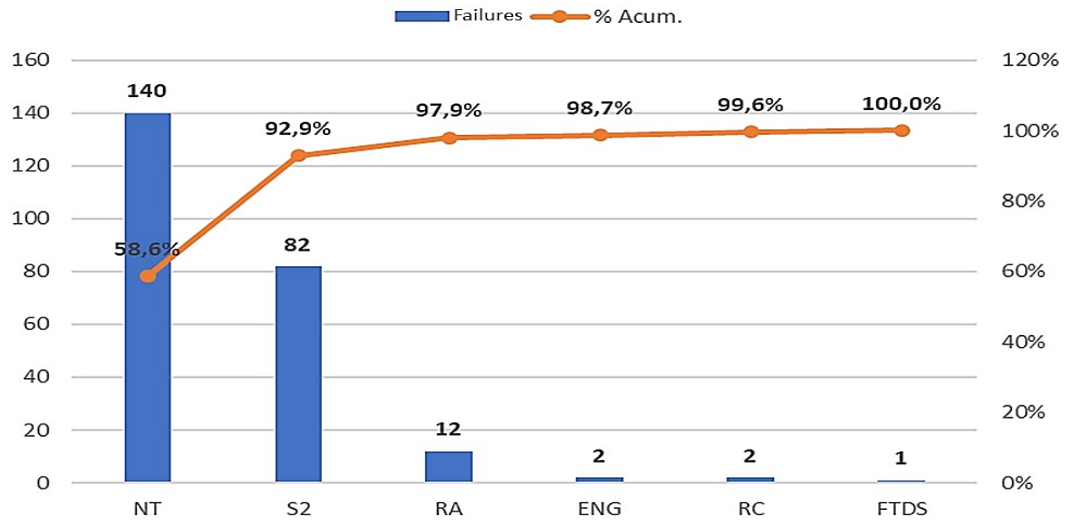

Figure 5. *MIDDLE END Total failure mapping (machines)*

Figure 5 shows that the main offenders that influenced YIELD in the studied period in the productive process were NT and S2, respectively. For the NT fault, a process FMEA was performed, to map the possible causes and effects in the automatic functional test step.

The result of FMEA is shown in the Table 1 below.

Table I. *FMEA: Number of Priority Risk (NPR) Result.*

Cause	NPR	Accumulated (%)
10 MHz cable damaged	420	8%
RF coaxial cable damage	360	15%
RF relay broken	360	22%
Test SW updating	336	29%
CMW out of calibration	324	36%
AC/DC supply out of calibration	324	42%
Meter out of calibration	324	48%
Setup poorly done	240	53%
Light sensors unbalanced	210	57%
SIM DOOR worn out	192	61%
10 MHz generator turned off	180	65%
Operational error	144	68%
Test nails dirty	144	71%
Key test out of position	144	73%
Warm environment	126	76%
Shield box cover in loop	126	78%

RF connectors with impurities	126	81%
Client server and machine out of sync	126	83%
Coupling sensor unbalanced	126	86%
RF connector broken	120	88%
Lack of energy	120	91%
Connection error with network	108	93%
Test nails broken	108	95%
Shield box open	84	97%
Guide pin worn out or broken	60	98%
Board mismatch in the tester	48	99%
USB connections worn out	36	100%

The failure modes that appear with greater quantity in the Pareto diagrams should be carefully considered, as the effects of these modes may result in significant impacts on future NPIs (New Product Introduction), and the proposals will be based on modes that occur in assembly, material and BA (board assembly).

The various failures in the testers were foreseen in the brainstorming meetings of the FMEA, but were not taken into account by the test engineering team. As a result, the first glitches that occurred were analyzed and apparently, technicians and product engineers did not find any problems with the phone mounted. However, due analyze performed by process technicians, it was noticed that there were no problems identified and the phones were approved after second pass in the tester, called false failure.

The elaboration of the FMEA of processes resulted in the treatment of data to reduce one of the main offenders that occurred in the assembly process of cellular phones, which were false failures.

This analysis resulted in the company's need to upgrade the test software version used in MIDDLE END, BACK END and CFC line machines.

So, upgrading the test software version in the automatic testers of the production. This change was basically made by changing the upper and lower limits of each step throughout the programming, that is, the test rangers were increased so that the devices that failed with marginal faults could approve. The engineering team adjusted the upper and lower limits of the steps, thus enabling the most effective approval of the failures that were related to the NT failure mode and no longer requiring them to be dismantled.

After updating the version of the test software, it was waited one month to verify the performance of the tester's equipment's and it was verified the substantial reduction of the false faults (NT). The quality results in the process is collected in the BEO1 machines are shown in Figure 6 below.

Before

BE01			RADIOTST (JOT)						RADIOTST			ASHLEY_LATAM_BE01			CAR_IN
Time			P. YIELD		P. NTF		P. DPHU		YIELD	NTF	DPHU		Failure	Action	3%
15:00:00	-	15:59:59	77,78%	116	8,64%	8	15,38%	18	77,78%	8,64%	15,38%	TOP #1	SUSPEND_1	Maintenance of Dummy USB.	WMS_BE
16:00:00	-	16:59:59	83,73%	151	1,81%	3	14,46%	24	83,73%	1,81%	14,46%				
17:00:00	-	17:59:59	78,26%	157	6,21%	10	15,53%	25	78,26%	6,21%	15,53%				
18:00:00	-	18:59:59	81,88%	161	2,50%	4	15,63%	25	81,88%	2,50%	15,63%	TOP #2	GET_SIM2_Card_PRESENT_STATE	DUMMY SIMCARD short-circuit alignment and removal.	SMT
19:00:00	-	19:59:59	78,29%	124	3,88%	5	17,83%	23	78,29%	3,88%	17,83%				
20:00:00	-	20:59:59	71,21%	125	9,85%	13	18,94%	25	71,21%	9,85%	18,94%				
21:00:00	-	21:59:59	75,89%	100	5,36%	6	18,75%	21	75,89%	5,36%	18,75%	TOP #3	MIC_A_LEVEL_SPEC_01750	Audio Calibration with Golden Phone	TEST
22:00:00	-	22:59:59	72,91%	76	4,05%	3	22,97%	17	72,91%	4,05%	22,97%				
	-			0		0		0	0,00%	0,00%	0,00%				
TOTAL			78,02%	1010	4,71%	52	16,73%	178	78,02%	4,71%	16,73%		GOAL YELD: 93%	GOAL NTF: 3% GOAL DPHU: 4%	GOAL CAR IN: 2%

After

BE01			RADIOTST (JOT)						RADIOTST			ASHLEY_LATAM_BE01			CAR_IN
Time			P. YIELD		P. NTF		P. DPHU		YIELD	NTF	DPHU		Failure	Action	3%
07:00:00	-	08:00:00	86,09%	148	1,74%	2	12,17%	14	86,09%	1,74%	12,17%	TOP #1	AUDIO_OUTPUT_ALERT_THD_02800 - 18 falhas de DPHU	03 cell phones failed. They have been retested and approved. Cause under review.	WMS_BE
08:00:00	-	09:00:00	91,86%	185	1,16%	2	6,98%	12	91,86%	1,16%	6,98%				
09:00:00	-	10:00:00	89,68%	149	0,65%	1	9,68%	15	89,68%	0,65%	9,68%				
10:00:00	-	11:00:00	89,13%	177	2,17%	4	8,70%	16	89,13%	2,17%	8,70%	TOP #2	GPS_CARRIER_TO_NOISE - 10 Falhas de DPHU	Component without weld. (U3705 and U3706) Reoccurring failure. .	SMT
11:00:00	-	12:00:00	84,11%	106	4,67%	5	11,21%	12	84,11%	4,67%	11,21%				
12:00:00	-	13:00:00	77,88%	87	0,96%	1	21,15%	22	77,88%	0,96%	21,15%				
13:00:00	-	14:00:00	86,71%	168	2,31%	4	10,98%	19	86,71%	2,31%	10,98%	TOP #3	SUSPEND_1 - 6 Falhas (5 de DPHU e 1 de NTF)	02 cell phones failed. They have been retested and approved. Cause under review.	TEST
14:00:00	-	14:50:00	72,83%	84	4,35%	4	22,83%	21	72,83%	4,35%	22,83%				
	-			0		0		0	0,00%	0,00%	0,00%				
TOTAL			86,40%	1104	1,96%	23	11,10%	131	86,40%	1,96%	11,10%		GOAL YELD: 93%	GOAL NTF: 3% GOAL DPHU: 4%	GOAL CAR IN: 2%

Figure 6. *Process failure matrix for line BE01 (before and after implemented actions)*

4. Conclusions

The mapping of processes by some kind of qualitative and / or quantitative tool is of fundamental importance for the manufacturing process, since they are the ones that show the indicators of the line and show the possible defects that occur in the day to day of the factory. FMEA is a tool that, if used correctly, aims to prevent failure modes in processes, products, projects and services.

The various failure modes that appeared during the NPI period of the company studied were predicted in previous FMEAS. However, the engineering team did not give due importance to the failures that could occur. Thus, great efforts were required to construct the FMEA of processes only to determine and organize the problems that occurred in the production lines. Experts do not advise this type of palliative process, since the methodology is always used in a way to treat preventively the ways that will happen.

Reduction of the failure rate in the process steps, component losses, machine downtime and corrective actions in the process, increase of process reliability and reduction of rework with defective boards were objectives achieved with this project, from the application of this tool, confirming its potential.

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Mapping, identification and improvement of the productive capacity of the printed circuit board cutting sector: Case study in a board assembly company of the industrial pole of Manaus

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ABSTRACT

The goal of this paper is to demonstrate a process mapping and chronoanalysis study to improve the workflow process on printed circuit boards in a manufacturing plant, by identifying production bottlenecks and productive capacity improvements. The methodology used was a case study and included the following steps: bibliographic survey, data collection, data processing, evaluation of productive capacity, suggestion of improvements, application and analysis of results. The result was 20% increase in the productive capacity of CNC 1 Station and 177% in Station 1, through the operational balance, resulting in a reduction in operating costs. The present article was able to demonstrate the gain obtained in the process with the achievement of the productive capacity of the Router sector. In conclusion, it was possible to highlight the importance of engineering of methods and the time and motion studies to obtain an optimized scenario at the electronics factory, which allowed making better decisions and plan for future demands.

Keywords: Process mapping, Chronoanalysis, Bottleneck, Productive capacity

1. Introduction

This article presents a case study developed in a company of the Industrial Pole of Manaus (PIM) in the electronics segment that offers solutions in Manufacturing Contract (CM) in several technological segments such as audio and video products, IT and telecommunications, with clients that are also members of the PIM.

The company under study received a service request of over one hundred thousand units and, in order to meet this demand, a mapping of the general productive capacity of the sectors was carried out in order to check the plant's actual capacity and what would be required to meet the client's request.

However, at the start of the production plan, it was found that the Router sector, which is responsible for the separation of plates using CNC milling machines, which is frequently used in industry for precision cutting, was not meeting the planned goal, becoming a bottleneck and leading to delays that could affect delivery scheduling, generating customer dissatisfaction. Companies become more competitive when they had better manage their processes, so knowing their constraints and improving them is crucial to good performance.

According to [1], *"bottleneck is any resource whose capacity is equal to or less than the market demand imposed on it."*

[2] support this assertion, who sustain that *"bottleneck being the slowest component of the process, set the rhythm of the system, so that when the drum is lowered it sets the tempo of the march for the band."*

Thus, if the company does not mind getting out of the rhythm of its bottleneck, its performance will be affected. Meeting the demand is the main center of every company that seeks to maintain and increase the quantity of customers. To meet quality and punctuality, the organization needs a constant improvement in the operational performance of its processes. Showing the value of the definition and control of capacity in the productive process awakens in the institution attention to possible unexpected increases in demand, thus requiring speed and flexibility of response.

Bringing the analysis of productive capacity to the center of business discussions allows the company to understand its impact on the management of plants by companies and aims to increase market focus. After all, manufacturing companies seek to add value to their processes at a given time, meeting all demand without loss of revenue.

Thus, for this study, it was necessary to carry out an analysis in the Router sector, in order to determine the causes for which the sector was not flowing the demanded production per hour and varying the rhythm of the productive system.

In this context, increasing the production of studies and content on Process Mapping and Productive Capacity can be the beginning of an improvement process that begins in the academy and expands its reflexes to the social and business reality.

2. Theoretical Background

All existing systems, whether corporate or even organic, follow an order of magnitude or importance where each scale has its degree of complexity that, to be better understood must be divided into parts.

Knowing that each part of a system assumes an important role for its own existence, it is relevant to understand how each receives information, processes and releases to the next process. In this sense, the perception of how each division interacts and adds value to the customer becomes a competitive differential.

This section intends to present, in a summarized way, the concept of the process control management, its derivations and applications.

2.1 Process

According to [3], processes selection decisions determine the type of productive process to be used and the high management must decide how the process flow would be organized, if as a high-volume or a low-volume. Extending this idea, [4] explains that when a process is very complex, it is recommended that it be divided into sub processes.

According to [5] the process is a logical sequence of organized activities that transform inputs from suppliers into outputs for customers, with value added generated by the unit.

[6] also explore this idea, which maintains that the process is the set of activities that aim to transform inputs (inputs), adding value through procedures, in goods or services (outputs) that should satisfy the customers. Aligning with other researchers, [7] define processes as a set of specific activities that interact and undergo changes in a logical sequence, adding value to inputs by pre-established processes, in order to produce products or services that meet the needs specific customers. In the case of processes and their hierarchies, we can observe the following formation, according to Figure 1 below, defined by [8].

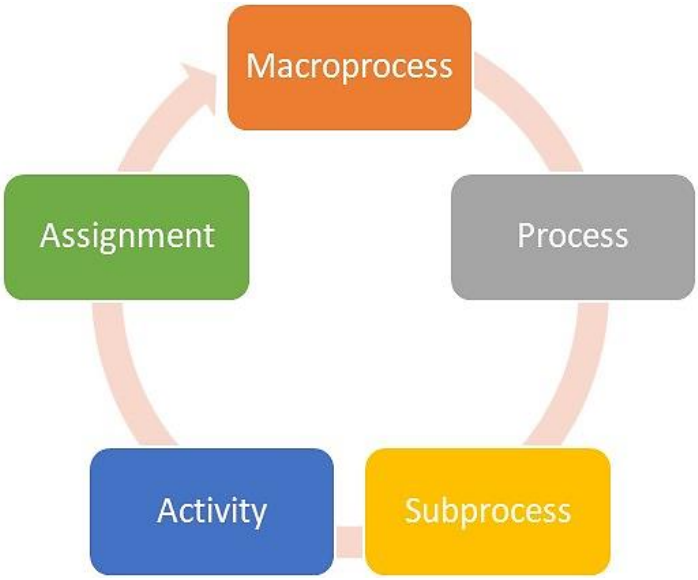

Figure 1. Processes and their hierarchies

2.2 Process Mapping

Among several tools used for process correction, there is the mapping, which consists of representing each step of the operation including inputs, actions and outputs. Their concepts and techniques, when used, allow the decomposition of a complex process and simpler parts, aiding in the detection of activities that do not add value and are inefficient. As defined by [9], mapping is a tool that provides us with a picture of the entire production process, including value activities and non-value aggregates.

The process mapping can bring benefits to the measure that it offers a set of techniques that can represent in a simplified way the relations among the several processes of a Company. It explains how relationship maps, cross-functional process maps (swim lane diagrams), and flowcharts can be used as a set to provide different views of work [10].

[11] defend the extension of this concept, where the mapping of processes is done through techniques that register the processes in a broad and specific way, where it will have to inform the bottlenecks that impair the good progress of the system, which correspond from its product or service.

2.3 Flowchart, Chronoanalysis and Productive capacity

The flow process chart is a chart of all activities involved in a process [12]. The author indicates that it is similar to an operation process chart and have more detail related to transportations and delays, in order to list every detail and to examine each one.

The Gilbreth couple proposed the pattern of the flow chart in 1921. Initially 40 symbols were proposed. In 1947, the American Society of Mechanical Engineers (ASME) defined five symbols for the process flow diagram [13]. So, flowcharts are used to describe and improve the transformation process in business [14]. Different researchers in the literature approach flowchart's openings and their applications [15-17].

The chronoanalysis analyzes the methods, tools, materials and facilities used to carry out a work in order to find a more economical way to do a job. It also aims accurately and reliably determine the time required for a worker to perform a task at a normal pace, taking into account tolerances (fatigue, physiological needs, among others) for determining the standard time [18-20].

In order to remain competitive in the market and meet its demand adequately, keeping customers satisfied, it is necessary to obtain the productive capacity of all sectors of the company. Since there is a link between sectors, there is no point in the company having a sector working successfully if the next job there is one that cannot be produced in time, generating delays in all subsequent processes.

Each sector must control its activities in order to be satisfactory to all at the end of the process in order to meet the demand and contribute to the reduction of costs in the processes [21]. Several authors classify the concept of productive capacity containing some small variations in the context, but all are related to the capacity of operation and realization of the different sectors of production and services [22-27].

3. Methodology

This research is classified as quantitative in relation to the approach of the problem. In relation to its objectives, it is exploratory, and with respect to technical procedures, it is a case study.

The stages of the study consisted of: *(a) Bibliographic Survey; (b) Data Collection; (c) Data Processing; d) Evaluation of Productive Capacity; e) Proposals for improvements*.

In practical terms, the methodological procedures consist of: a) Map the production process of the Router sector b) Analyze each part of the process, identifying opportunities for improvement c) Collect data such as: times and methods d) Analyze the data; e) To suggest improvements, to test and to compare the obtained results.

4. Case study

In the following study, the excess of failures in the production process resulted in measures that caused the company to take action so that the reduction and / or elimination of these did not result in quality problems in the process.

Furthermore, these measures reached the prevention of failures in the field or for the consumer, influencing cost and production, as well as to delineate the process with a view to preventing functional failures in new projects.

The section studied in the project is the Router sector, responsible for the separation of the PCBs coming from the SMD section.

The operational structure of the sector consists of two operators, who have the function of receiving the CNC station cards and registering them in the system, printing the QR Code tags, attaching them to the cards and, using a reader, registering in the system database the records of the boards.

Also part of the sector are two CNC operators, who are responsible for the operations of receiving the SMD sector, cutting and storing the boards in the transport box for the registration station.

Figure 2 below shows the layout of the CNC Router sector, illustrating the location of the operators and machines, two in the CNCs and two in the registration benches (C1 and C2).

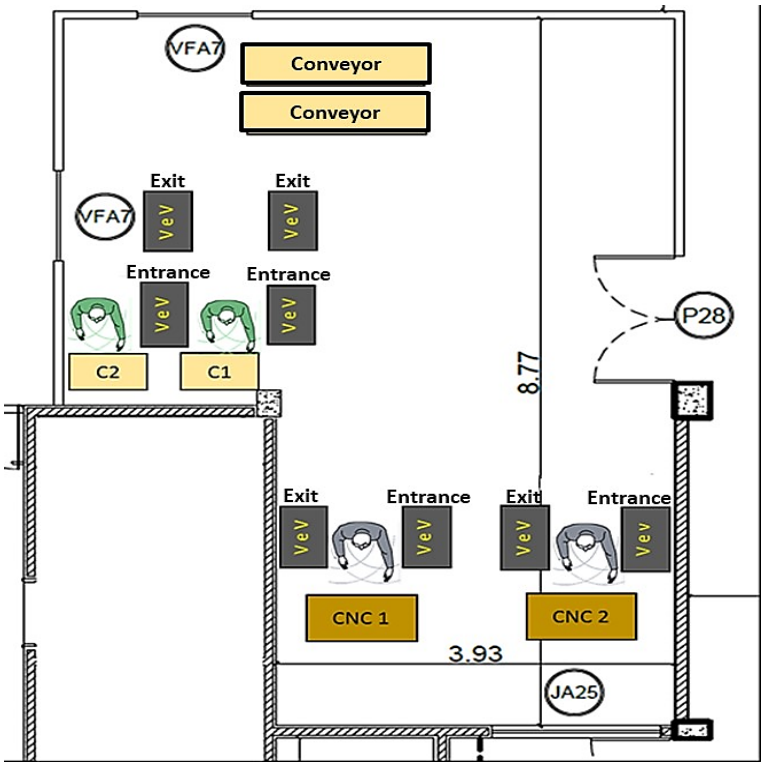

Figure 2. *Physical arrangement of the Router sector*

In order to understand how each sub process interacted with the others in the Router sector, a mapping and collection of task times were performed in CNC 1 and register 1 with the objective of finding the sector restriction. As the sector was

not able to supply 395 boards/hour, it was also necessary to calculate the actual capacity of station CNC1 and Registration 1. Figure 3 below shows the flow diagram of the Router sector, with its production steps and activities that are developed.

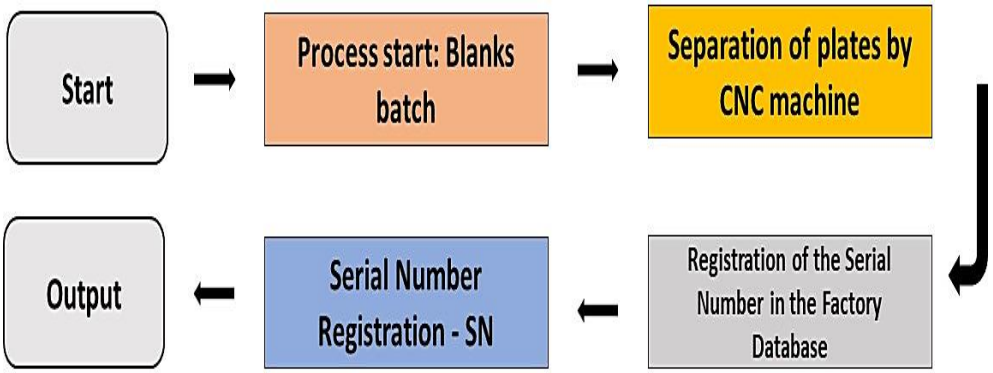

Figure 3. *Router Process Flowchart*

Next, a study of the capabilities of the stages that constitute the process of the routing sector was carried out. The results are shown in Table 1.

Table I. *Productive Capacity CNC 1 and Register 1.*

Parameters	CNC1	Registration 1
Machine time	24,34 seg/blank	-
Man + Machine time	32,67 seg/blank	-
Average time per board	-	5,41 s/board
Maximum working time	24 h	24 h
Working day without loss	10 h/shift	10 h/shift
Working day with loss	8,5 h/shift	8,5 h/shift
Installed Capacity	10.649 boards/day	15.972 boards/day
Available capacity	4.437 boards/shift	6.655 boards/shift
Effective capacity	3.772 boards/shift	5.657 boards/shift
Capacity performed	2.810 boards/shift	2.814 boards/shift
Efficiency index	74,50%	50%
Index of use	85%	85%
Availability Index	41,67%	41,67%

After the collection of the previously mapped operational times and the calculation of the productive capacity of the CNC1 station, it was identified that the station produced an average of 331 Plates / hour, not meeting the demand of 395 boards/hour. When calculating the effective capacity of station Registration 1, it was verified that it produced an average of 665 boards/hour, that is, 101% more than the CNC1 station. It is notable that the station Registration 1 supplies the realized capacity of CNC1 production per hour, even if it adds unplanned losses.

After an evaluation of all the steps of the CNC1 station, it was verified that during the machine time of 24,34s the operator used on average 10,26s for the step of fixing the QRCode labels in the shielding of the PCBs. In this position, the operator is on average 14s waiting for the operation to finish.

Analysis of the labeling step and the time required to perform this activity, compared to the idle station level (operator), allowed this phase to be performed in advance. In other words, the labels would be previously inserted in the blanks, since the operator of the Registration 1 stage would be responsible for the activity, delivering the labels to the CNC1 phase operator. After the change in the steps performed at the stations, there was a significant improvement in the Registration 1 station, as shown in Table 2 below. The CNC1 phase indicators remained unchanged.

Table2. *Productive Capacity CNC 1 and Register 1 reviewed.*

Parameters	CNC1	Registration 1
Machine time	24,34 seg/blank	-
Man + Machine time	32,67 seg/blank	-
Average time per board	-	1,95 s/board
Maximum working time	24 h	24 h
Working day without loss	10 h/shift	10 h/shift
Working day with loss	8,5 h/shift	8,5 h/shift
Installed Capacity	10.649 boards/day	44.275 boards/day
Available capacity	4.437 boards/shift	18.448 boards/shift
Effective capacity	3.772 boards/shift	15.681 boards/shift
Capacity performed	2.810 boards/shift	2.814 boards/shift
Efficiency index	74,50%	17,95%
Index of use	85%	85%
Availability Index	41,67%	41,67%

The output of the CNC1 station remained the same, changing only the addition of one more operational step, which will be performed during machine time, making the operator less idle.

The effective capacity of Registration 1, dedicated to CNC1, was 665 plates per hour on average. It was observed that it would be possible to supply the production of the two CNCs.

However, with the goal of increasing CNC1's capacity to 395 plates per hour, only one registry operator would not support the production of the two machines, since CNC2 produced 350 plates per hour of another model, totaling 745 plates per hour.

After the labeling step from Registration 1 step to CNC1, new time collections were made, and the effective flow capacity of the Registration 1 station averaged 1845 plates per hour, generating an increase of about 177% of the initial capacity.

Consequently, only one collaborator could process the production of the two CNCs. Even with increased capacity of the CNCs, it would have resources to process all the products. This led to changes in the organizational structure of the sector.

Because of the reorganization of the sector, the operator of the Registration 2 phase was relocated to the test room sector, and the other equipment remained as a reserve to be used in some eventuality, both in the Router process and in the sectors that also made use of this type of equipment.

The actions developed and implemented so far were enough to improve the performance of the Registration 1 sector.

However, the capacity of the CNC1 phase does not meet the planned demand that the production system requires (395 boards/hour). In fact, improvement actions are also needed at this stage.

After extensive study, actions to improve performance of the CNC1 sector were implemented. which consisted in changing the cutting tool (milling cutter from 1mm to 1.2mm). At the end of the test period, to validate the effectiveness of the action, there was a significant change in the Capacity at CNC1.

The production of the equipment, which before the implementation of the action was 2810 PCBs, increased to an average of 3381 PCBs, corresponding to a 20% increase, reaching the planned target. Table 3 below stratifies the results.

Table3. *Productive Capacity CNC 1 reviewed.*

Parameters	CNC1 (milling tool 1 mm)	CNC1 (milling tool 1.2 mm)
Machine time	24,34 seg/blank	19 seg/blank
Man + Machine time	32,67 seg/blank	27,15 seg/blank
Maximum working time	24 h	24 h
Working day without loss	10 h/shift	10 h/shift
Working day with loss	8,5 h/shift	8,5 h/shift
Installed Capacity	10.649 boards/day	13.642 boards/day
Available capacity	4.437 boards/shift	5.684 boards/shift
Effective capacity	3.772 boards/shift	4.832 boards/shift
Capacity performed	2.810 boards/shift	3.381 boards/shift
Efficiency index	74,50%	69,98%
Index of use	85%	85%
Availability Index	41,67%	41,67%

Table 4 below shows the comparative results regarding the adoption of different types of milling cutters.

Table4. *Viability projection between 1mm and 1.2mm milling cutters.*

Parameters	Results 1	Results 2
Milling tool (cutter)	1 mm	1,2 mm
Average consumption of cutter	2 unit/shift	2 unit/shift
Capacity performed	2810 boards/shift	3381 boards/shift
Quantity of Shifts	2 shifts	2 shifts
Total	4 units/shift	4 units/shift
Time available in Month	22 days	22 days
Average monthly cutter consumption	88 units	88 units
Milling unit cost	R$ 18,00	R$ 20,00
Monthly cost	R$ 1.584,00	R$ 1.760,00
Total produced	123.640 boards/month	148.764 boards/month

4. Conclusions

The development of the present case study has proved important to better understand the need for process mapping and knowledge of the productive capacity of the manufacturing sectors, improving decision-making. In this sense, it should be noted that the company studied faced difficulties in delivering the first lots in the given time due to the lack of the correct capacity information.

The methodology suggested was effective because the systematization of actions made it possible to identify more quickly the problems that generated productive incapacity and also other opportunities that were hidden in the sector, such as the lack of balancing of workstations. Given this, it was possible to achieve the objective of the work that was to reach the productive capacity demanded by the client. The capacity identified at CNC1 Station was around 331 plates per hour and achieved a gain of around 20%. For this gain to be possible there was an 11% increase in investment, as it became necessary to change the type of mill used. In addition, there was also an improvement in the manual operations of the Registration 1 station, raising its capacity from 665 boards/hour to 1845 boards/hour, resulting in an increase of 177%. With this, there was the relocation of an operator to the Test Room sector, which was demanding labor, besides the reduction of the use of equipment and gain of physical space in the sector.

The study focused only on identifying the root cause of the capacity problem, but ended up identifying other opportunities and optimizing the operating results of the sector. In this way, it is suggested to carry out more detailed studies in the CNCs, elaborating investigations of the types of cutters for each model of plate that is cut, seeking more efficiency in the cut and possible reduction of costs. Studies of this nature can be made in other sectors of the company, aiming to map the capacity and optimize the operations to the maximum, since the market demands more and more that the processes are controlled, since there is oscillation in the demand, that makes the companies have to adapt quickly and with quality and meeting deadlines.

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Quality Management Systems: Motivations Benefits and Barriers to the Implementation of the ISO 9001:2015 Standard in Italian Companies

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ABSTRACT

Currently, the growing globalization has changed the way of doing business leading companies to operate in a supply chain that is more complex than it was in the past. In order to operate in a more standardized and recognized way companies voluntarily adopt certified Quality Management Systems, following the lines of the ISO 9001 standard. This standard, in order to keep up with market changes was reviewed in 2015, in order to make it compatible with the ongoing evolution of the market and with the standards related to other management systems, such as those which consider health and safety, environmental and ethical issues. Therefore, the aim of the study is to evaluate companies' perception of the latest version (2015) of ISO 9001 in terms of motivations that pushed companies to the implementation of a Quality Management System, and the subsequent benefits and barriers obtained from the adoption of the standard. The research was conducted through a questionnaire proposed to 3,975 ISO 9001 certified companies, making a simple random sampling among the 150,143 Italian companies certified in 2018. Among the companies contacted, 493 participated in the survey and gave shape to the reference sample. The results of the study show that the "culture of quality" is rooted in Italy and mainly in the North, which represents the most economically advanced area. With regard to the evolution of the standard from ISO 9001:2008 to 2015, companies seem to have perceived the main changes introduced with the latest revision, that helps to easily adopt its principles in companies.

Keywords: Quality Management System; ISO 9001; Total Quality Management

1. Introduction

The implementation of a Quality Management System (QMS), and its subsequent certification, is a voluntary process, supported by the motivations, objectives and policies of the organization. Jones et al., [1] identified two types of organizations, based on the main purpose for which they decide to certify themselves, that is, the "non-developmental companies", which tend to implement a quality system only to obtain a certificate and the "developmental companies", which adopt the standard, because they believe in the internal benefits that can derive from it.

Based on a survey conducted in 2016 by the International Organization for Standardization (ISO) it emerges that, with 150,143 certified companies, Italy is at the top of the European classification of Quality Management System (QMS) certifications according to the ISO 9001 standard, and it is second in the world after China, which, for the year under review, presents 350,631 certified companies (www.accredia.it).

This research reported a total of 1,105,356 certificates valid for the ISO 9001 standard worldwide (including 80,596 issued for the 2015 version), with an increase of 7% compared to the previous year (2015). The first four industrial sectors by number of ISO 9001 certifications in 2016, based on the data, are the metal and metal products sector, with 116,457 valid certificates, followed by Electrical and optical equipment (88.482), construction (87.605) and wholesale & retail trade, repairs of motor vehicles (79,492) (www.iso.org).

Currently, the growing globalization has changed the way of doing business; customer's expectations have increased and are more articulated and the ease of access to information by all stakeholders has lead companies to operate in a supply chain that is more complex than it was in the past. Therefore the ISO 9001 standard, in order to keep up with market changes began a review process in 2012 to make it compatible with the ongoing evolution of the market and with the standards related to other management systems. In fact, all the ISO standards are periodically reviewed, undergoing a review process every 5 years, to establish whether it is necessary to make any changes that keep them updated and relevant to the current economic, social and technological context [2].

The path that led to the publication of the UNI EN ISO 9001:2015 standard began with a preliminary phase through the creation of a web survey aimed at identifying the weak points of the standard and then improving them within the process of reviewing. The fundamental stages of this journey, which lasted three years, were: the creation of the Committee Draft (CD), in May 2013, which is the draft of the standard prepared by the Technical Committee circulating among the ISO members to decide how to continue to develop the revision of the standard; the creation of the Draft International Standard, in May 2014, a document to which only formal and non-substantial changes were made; the creation of the Final Draft International Standard, that is the final stage of the draft.

In September 2015, the standard was published and it has become the global reference point to guarantee the ability to meet quality requirements and improve customer satisfaction in supplier-customer relationships.

The revision of the ISO 9001:2015 standard has introduced significant differences compared to the 2008 edition which can be summarized in 9 points [3]:

- the adoption of the High Level Structure (HLS), a structure that is common to the ISO standards related to management systems and defined in Annex SL of the ISO Directives - Part I.
- An explicit requirement that requires the adoption of Risk Based Thinking to support and improve the understanding and application of the process approach.
- Less prescriptive requirements.
- Greater flexibility in relation to documentation.
- Better applicability to services.
- The requirement to define the boundaries of the QMS.
- Increased emphasis on the organizational context.
- Increased leadership requirements.
- Increased emphasis on achieving process results to increase customer satisfaction.

Considered the above, the aim of the study is to evaluate companies' perception of the latest version (2015) of ISO 9001 in terms of motivations that pushed companies to the implementation of a Quality Management System, and the subsequent benefits and barriers obtained from the adoption of the standard.

2. Literature Review

Making an historical overview of the reasons cited in literature, regarding the implementation of ISO 9001, the motivations can be classified according to two main categories: internal and external [4]. With regard to internal motivations, these are linked to the objective of achieving an internal organizational improvement; while external motivations are mainly related to promotional and marketing issues, customer pressures and the improvement of market share [5, 6, 7, 8].

Regarding the factors that influence the decision to adopt ISO 9001, various studies have shown the importance of the size of the company [9, 10] Larger companies are associated with more market shares, and are more likely to operate in different markets or across different segments of the same market. For large companies, the possibility of tackling ISO 9001 is higher, leads to greater customer satisfaction, reduces personal information between customers and other interested parties, is a penetrating legacy of the market and increases barriers for competitors of smaller size [11, 12].

As for the benefits that a company can receive developing a QMS, according to Douglas [9] and Van der Wiele [8] these can also be classified into two categories: internal and external. As stated by Sampaio et al. [7] there is a consensual opinion that the benefits of ISO 9001 are linked to the reasons why the organization achieves the certification; when companies are certified on the basis of internal motivations (productivity improvements, improvements in quality awareness, and internal organization improvements), the resulting benefits have a more global dimension [8, 13, 14, 15]. On the contrary when companies are certified on the basis of external motivations (access to new markets, customer satisfaction, and improvement of market share), the improvements obtained are mainly of an external nature [5, 16, 17]. With regard to the main barriers associated with the implementation of ISO 9001, these may be linked with various aspects such as lack of resources, or specifically technical resources and capabilities, changes in corporate culture, organizational idiosyncrasies, etc. [18]. Other important barriers identified by organizations are: high implementation and maintenance costs, and excessive support for auditors on the bureaucratic management of the standard [5, 8, 11, 12].

3. Methodology

The research was conducted through a questionnaire proposed to 3,975 ISO 9001 certified companies, making a simple random sampling among the 150,143 Italian companies certified in 2018. All the information necessary to contact the companies was obtained from the Italian Accreditation Body (ACCREDIA) database through its website (www.accredia.it). Among the companies contacted, 493 participated in the survey and gave shape to the reference sample. The questionnaire, sent using Computer Assisted Web Interviewing (CAWI), began on September, 5th 2018 and the replies were accepted until October, 27th 2018. The questionnaire was administered via e-mail and exactly 3,834 e-mails were sent, as 141 e-mail addresses were not valid. A second submission was made 15 days after the first submission, as a reminder for those companies that had not previously considered the e-mail. The questionnaire was administered anonymously to encourage the sincerity of the answers.

The questionnaire was divided into two sections: in the first section, general questions were asked to the interviewees, in order to obtain basic information necessary to define companies profile, while the second section considered the perception of companies about the ISO 9001 standard, investigating the evolution over time, the reasons that lead companies to certify themselves, the advantages and the barriers to its implementation.

Descriptive analysis was performed to describe the sample profile of respondent ISO 9001 certified companies. A five-point Likert scale was used to evaluate companies' motivations that pushed them to the certification and the main advantages and barriers to its implementation perceived. The coefficient of variation, that allows to evaluate the dispersion of values around the average regardless of the measurement unit, calculated as the ratio between mean and standard deviation has been performed. It represents a good value when it is equal or minor to 0.5. Non-response bias was assessed by verifying that early and late respondents were not significantly different [19]. A set of tests compared respondents who answered to the questionnaire during the first administration and those who answered when the survey was submitted for the second time. All possible t-test comparisons between the means of the two groups showed insignificant differences ($p<0.1$ level).

4. Results

4.1 Profile of respondent companies

Among the 493 companies that participated in the survey, 55.2% are service companies, while 44.8% are manufacturing companies. Based on the size of the company, 29.2% of the sample is made up of Micro companies (<10 employees) (144), 48.1% by Small companies (10-49 employees) (237), 18.3% by Medium-sized companies (50-249 employees) (90) and 4.5% by Large companies (> 250 employees) (22). Considering the level of internationalization of the respondent companies and also the internal division in Italy, in total, 51.3% of the companies interviewed work only in the Italian market, while 16.2% in Italy and Europe, and 32.5% operates in international markets. Considering the size of the companies in relation to the markets in which they operate, it can be noted that no large enterprises of the sample operate simultaneously both in Italy and in Europe, most operate only in Italy (15), even if a good number goes also abroad; the Medium-sized companies operate mostly in international markets (43); instead the Small and the Micro enterprises work mainly in the Italian market only (200), even if, few are those that operate in international markets (110).

With regard to the specific location of companies in Italy, most of them, that is 44.6% are located in the northern regions (220). Furthermore, from a further analysis of the data it emerged, that the Large companies are located mostly in the North, and so are the Medium-sized companies, while as regards the Small ones and the Micro enterprises these are located almost equally between North and Center, although a good number is also concentrated in the south.

4.2 Evolution over time of the ISO 9001 standard

After outlining a general picture of the companies that make up the reference sample, the moment in which companies adopted ISO 9001 certification was considered, in order to have an opinion, from companies certified for many years, on the evolution of the standard from ISO 9001:2008 to the latest version ISO 9001:2015, to which companies, by September 15, 2018, have had to adapt.

It was found that most companies (355, or 72%) have been certified for over 7 years, (having been certified both with the version of the ISO 9001 standard of 2000 and 2008), thus showing the presence of a good quality culture, especially among Medium-sized companies (87.7%), but also in Large companies (77.2%) and Small ones (74.6%). Finally, even more than 1 Micro enterprise out of two (56.9%) has been certified according to the ISO 9001 Standard for a long time. The 23.32% (or 115 companies) has been certified for a period ranging from 2 to 7 years; these companies have therefore been certified only with the ISO 9001:2008 revision of the standard, while 4.66% (23 companies) have been certified for a year or less and therefore, they have not made any change from previous revisions of the standard, having certified directly according to the latest version of 2015.

Furthermore, it has been established that the companies certified for more than seven years are located mainly between North (144) and Center (126) of Italy.

Later, companies that had experimented or were experimenting with the transition from ISO 9001:2008 to ISO 9001:2015 were asked, what was their opinion on the evolution of the Standard.

Most respondents noted that the new revision of the standard gives greater importance to the concept of "Risk management" (67.1%; mean value: 3.85), makes it easier to integrate with standards related to other issues (environment , health and safety, ethics ...) (60.9%; mean value: 3.63), presents a greater propensity to the aspect of "continuous improvement" (57.4%; mean value: 3.54), allows the implementation of a more quality-oriented system (49.6%; mean value: 3.38) and it adapts more easily to the organizational structure (47.4%; mean value: 3.32). This is in line with what has been defined in literature [3].

According to the interviewees the transition to the new version of the Standard does not allow the achievement of an higher profit (56.4%), especially for Medium (53.3%) Small (49%) and Micro enterprises (45.8%), and at the same time the 42.1% says they are indifferent to the increase in the financial cost of implementing the standard (Table 1).

Table 1. *Changes perceived by companies in the transition between ISO 9001:2008 and ISO 9001:2015*

	N	***Mean (μ)***	***St. Deviation (σ)***
It requires less bureaucratization	470	3.13	1.11
It has become easier to understand	470	3.05	1.03
It adapts more easily to the organizational structure	470	3.32	1.06
It allows to implement a more quality-oriented system	470	3.38	0.99
It makes it easier to integrate with standards related to other issues	470	3.63	1.02
It has made conformation to the standard of easier implementation	470	3.22	1.01
The financial cost of implementing the standard has increased	470	2.75	1.03
It allowed the achievement of a greater profit	470	2.25	0.99
It provides guidance to project the company into the future	470	3.12	1.13
It presents a greater propensity to the aspect of "continuous improvement"	470	3.54	1.02
It leads to greater centrality of the leadership	470	3.26	1.11
It gives greater importance to the concept of "Risk management"	470	3.85	1.11

4.3 Motivations, benefits and barriers to the new standard

Initially, the survey focused on the reasons that led Italian companies to obtain ISO 9001 certification. Based on what can be observed in Table 2, the reasons that led companies to certify themselves are mainly: the possibility of improving their own corporate image (89%; mean value: 4.36), obtaining internal organizational improvements (75.2%; mean value: 4.04) and the opportunity to use the standard as a marketing tool (51.3%; mean value: 3.30). The first two reasons are the most important for all companies in the sample, in fact for these items there is an average value higher than 4, and the Coefficient of Variation (σ / μ) is lower than 0.5. Two out of three of the main reasons are linked to external factors and are in line with what stated in previous research [5-8].

Overall, the less important reasons seem to be: the reduction of costs (18.2%; mean value: 2.23), the benefits experienced by other companies (19.5%; mean value: 2.47), the improvement of relations with the communities (26.1%; mean value: 2.82) and, as previously stated, the possibility of avoiding potential obstacles to exports (23%; mean value: 2.23).

Table 2. *Motivations that pushed companies to ISO 9001 standard*

	N	***Mean (μ)***	***St. Deviation (σ)***	***Coefficient of variation (σ/μ)***
Reduction of costs	493	2.23	1.24	0.5
Pressures from customers	493	3.03	1.44	0.4
Use of the Standard as a marketing tool	493	3.30	1.19	0.4
Get internal organizational improvements	493	4.04	1.09	0.3
Keep up with its own certified competitors	493	3.17	1.32	0.4
By word of mouth from benefits experienced by other companies	493	2.47	1.17	0.5
Avoid potential export barriers	493	2.23	1.39	0.6
Improve relations with communities	493	2.51	1.33	0.5
Improve relations with government authorities	493	2.82	1.45	0.5
Improve the corporate image	493	4.36	0.86	0.2

Subsequently, the main advantages of implementing an ISO 9001 QMS were considered (Table 3). The main benefits perceived include an improvement in corporate image and reputation (77.7%; mean value: 3.98), a greater awareness of corporate opportunities (in terms of continuous improvement) (71.6%; mean value: 3.91) and the reduction of non-conformities (62.5%; mean value: 3.55).

Further perceived benefits are the greater customer satisfaction (58.6%; mean value: 3.52), an increase in corporate efficiency (56.4%; mean value: 3.43), followed by an improvement in customer relations (55.6%; mean value: 3.49), an improvement in internal communication (55.4%; mean value: 3.43), and a reduction in complaints (53.3%; mean value: 3.40).

However, there are also benefits that are not perceived by the companies in the sample, i.e. the 71% do not believe that certification leads to an improvement in delivery times (mean value: 2.78), and 72.6% believe that there is an increase in sales (mean value: 32.79).

Only a small percentage (27.3%) believes that the certification has contributed to the increase in sales, and these are mostly medium and small companies. Therefore this confirm various studies [9, 10] highlighting that for large companies, the possibility of tackling ISO 9001 is higher, thank to their dimension.

Table 3. *Benefits perceived from the implementation of ISO 9001 standard*

	N	***Mean (μ)***	***St. Deviation (σ)***	***Coefficient of variation (σ/μ)***
Greater customer satisfaction	493	3.52	1.12	0.3
Improved image and reputation	493	3.98	0.89	0.2
Greater awareness of company possibilities	493	3.91	0.97	0.2
Improved relationship with customers	493	3.49	1.08	0.3
Improved delivery times	493	2.78	1.16	0.4
Increase of corporate efficiency	493	3.43	1.08	0.3
Reduction of non-conformities	493	3.55	1.09	0.3
Reduction of complaints	493	3.40	1.17	0.3
Improvement of internal communication	493	3.43	1.09	0.3
Increase in sales	493	2.79	1.12	0.4
Improvement of competitive advantage	493	3.17	1.15	0.4
Greater staff motivation	493	3.03	1.18	0.4

After analyzing the positive aspects related to the certification, the research focused on the analysis of the perceived barriers. The survey highlighted three main disadvantages (Table 4): the increase in the bureaucratization of company activities (48.3%); an increase in the complexity of procedures in the company (40%), and an increase in business costs (34.5%). These results are in line with extant literature underling an increase in maintenance costs, and on the bureaucratic management of the standard [5, 8, 11, 12].

Only a small number of Small and Micro companies have found, after the certification process, a reduction in profits.

Table 4. *Barriers perceived from the implementation of ISO 9001 standard*

	N	***Mean (μ)***	***St. Deviation (σ)***	***Coefficient of variation (σ/μ)***
Increase in business costs	493	2.92	1.13	0.4
Increase in the complexity of procedures	493	3.04	1.12	0.4
Increase in bureaucratization	493	3.29	1.14	0.3
Reduction in profits	493	1.87	0.97	0.5
Reduction in customer satisfaction	493	1.47	0.78	0.5

Subsequently, considering the perception of the cost of the certification (Table 5) in relation to the financial indicators of the company, such as the Return on Investment (ROI), return on Net Capital (CN) and turnover, a good number of respondents (161, or 32.7%) considered the costs for the implementation of a Quality Management System acceptable, only a small percentage considered them to be high (15.8%), and unacceptable (5.7%). Investigating the size of companies, it emerged that among those companies that believe that the cost for the certification is high there is the 18% of Large companies, 14.4% of Medium-sized companies, 15.2% of Small businesses and 17.4% of Micro companies. On the contrary no company considers the costs unacceptable, in fact the value found for this item, on average, is below 2.

Table 5. *Perceived costs from the implementation of ISO 9001 standard*

	N	***Mean (μ)***	***St. Deviation (σ)***	***Coefficient of variation (σ/μ)***
Irrelevant	493	2.46	1.26	0.5
Moderate	493	2.58	1.10	0.4
Acceptable	493	3.00	1.18	0.4
High	493	2.33	1.11	0.5
Unacceptable	493	1.77	1.05	0.6

4.4 Evaluation of the integration of ISO 9001 with other standards

Later, companies were asked whether they had other certifications, in addition to the ISO 9001, and 45.8% answered positively. Considering the size of the companies, it is mainly the Large (81.8%) and Medium-sized ones (63.3%) that adopt further standards. Among the other certifications held, it appears that 52.2% has also the ISO 14001 (Environmental Management System) standard, 35.3% has also the OHSAS 18001 (Management Systems for Safety and Health of workers) standard, 7.1% has the SA 8000 (Management Systems for Social Responsibility) standard and finally only 3.1% has also EMAS III (European Environmental Management System) standard. Furthermore, it appears that 16% of companies is certified to both ISO 14001 and OHSAS 18001 and they manage these standard in an integrated manner, just like in other countries [30, 33, 34]. This can promote the appearance of new businesses [29, 31,32] even when consumers are more demanding [35].

In continuing the investigation, it has been verified how many companies were aware of the ISO 9004:2009 standard, that is the ISO 9001 guidelines which help companies to implement a QMS oriented to excellence. Only 11.2% said they knew the ISO 9004:2009 standard, while 17.2% said they knew it only partially and 71.6% did not know it at all.

5. Conclusions

The respondent companies that participated in this study are mostly Small and Micro-sized ones, and this reflects the Italian entrepreneurial reality. The majority of them work in the service sector, and mainly in Italy, although a good percentage also operates in European markets, and it is the Medium-sized companies, more than the Large ones, that operate internationally.

In Italy, most companies are concentrated in the northern regions and these seem to be also the most economically developed, and among them it seems that the Large and Medium-sized ones are mainly located in the North.

A large number of companies, located between North and Center, have been certified for over 7 years, overcoming the various revisions of ISO 9001 that have occurred over time. Among these there are mostly Medium-sized companies.

Considering these first results it is possible to affirm that the "culture of quality" is by now rooted in Italy for years and mainly in the North, which represents the most economically advanced area.

With regard to the evolution of the standard from ISO 9001:2008 to 2015, companies seem to have perceived the main changes introduced with the latest revision, in fact they believe that ISO 9001:2015 gives greater importance to the concept of Risk management; favours integration with standards related to other issues such as environmental, ethical and health and safety issues [30, 33, 34].; presents a greater propensity to the aspect of "continuous improvement"; enables the implementation of a more quality-oriented system; and it adapts more easily to the organizational structure[27, 28]. This is in line with what is highlighted in the literature [2, 3].

As far as the motivations that drove Italian companies to certify themselves are concerned, these follow what was mentioned in the literature [5, 6, 13, 15, 20, 21, 22, 23], in fact among the internal motivations it has been found the possibility of achieving an internal organizational improvement, and to improve its corporate image, while among the external ones there is, mainly, the opportunity to use the standard as a marketing tool, but unlike the opinion of some

authors, pressures from customers, the possibility of improving relations with the communities and the possibility of avoiding obstacles to export do not seem to be such important reasons as to encourage companies to adopt certification.
Paying attention to the benefits obtained by the companies after having gained the certification, a correspondence can be noticed between the perceived motivations and benefits.
Therefore what Santos & Milan [7] stated can be confirmed, that is, there is a link between the benefits of ISO 9001 and the reasons why the organization achieves the standard.
Finally, it was noted that, for the companies in the sample, the improvement in delivery times and the increase in sales and profits are not among the major benefits. This may be due to the fact that, as stated by Psomas et al., [24], the impact of the efficiency and quality of the product / service on financial performance is indirect.
Certification, however, also involves disadvantages, including: greater bureaucratisation of company activities, an increase in the complexity of procedures in the company and an increase in costs, perceived above all by Small and Micro businesses. These are easily conceivable disadvantages, given the Small and Micro dimensions of Italian companies, and in line with the literature considered [7, 21, 25, 26].
A positive aspect to highlight, is that only a little number of Small and Micro enterprises have found, following the certification, a reduction in profits and customer satisfaction, something which, on the contrary, has not been manifested at all in larger companies.

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The Main Benefits of the Implementation of the Quality Management System (QMS) in Higher Education Institutions in Angola

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ABSTRACT

In last years, higher education in Angola has had an evolution in terms of demand and access, diversification of training and institutions, as well as, new expectations of society on higher education. Due to the quantitative evolution of higher education in Angola, it is necessary to be accompanied by qualitative growth, which implies the reinforcement of the need for quality management. Therefore, higher education in Angola is confronted with new challenges related to quality assurance in education, particularly the evaluation processes that allow the monitoring and continuous improvement of teaching, research and community support services.

The characterization and analysis of higher education in Angola was made and a survey of 50 institutions was carried out to obtain a diagnosis regarding the implementation of QMS (Quality Management System) in Higher Education Institutions (HEIs) of Angola. Of the 50 Angolan HEIs referred to, only 20% of them have the Quality Management System implemented, which shows that there is still much work to be done in this area. It was concluded that the Angolan HEIs recognize the advantages and are interested in the implementation of a QMS but have as main limitation the financial reasons, because the implementation of a QMS have high costs.

Keywords: Organization Context, Higher Education, ISO 9001, Quality Planning and Organizational Processes

1. Introduction

In recent years, quality management in Higher Education Institutions (HEIs) in Angola has been the subject of increasing interest motivated by the impact on their performance. The implementation and certification of the Quality Management System (QMS) is nowadays indispensable to any institution, because it is seen as a differentiating flag for the institutions of the sector. However, quality is still questioned, and inefficiency of management is identified as a result of bottlenecks in funding, curricula, faculty and student bodies

The adoption of a QMS in organizations represents, even in the case of public organizations, a strategic decision that can help improve their overall performance and provide a solid foundation for sustainable development initiatives. On the other hand, risk-based thinking enables organizations to determine the factors likely to cause deviations in their processes and QMS from planned results, implement preventive controls to minimize negative effects, and maximize the opportunities that emerge [7].
In this sense, the implementation of a QMS should seek to instill the principles of quality in the organizational processes according to ISO 9001: 2015, of which we highlight: Customer focus; Leadership; Commitment of people; Process approach; Improvement; Evidence-based decision making and Relationship management.

The implementation of the QMS in the functional structure of public organizations is now supported by specific initiatives and models such as the Common Assessment Framework (CAF), European Foundation for Quality Management (EFQM) and International Organization for Standardization (ISO) standards, which represent an important methodological support. These benchmarks for the implementation of QMS tend to emphasize the importance of the role of the clients in the definition of strategic objectives, the minimization of errors and bet on the continuous improvement of the processes of supply of products and services. On the other hand, its current relevance also stems from the fact that efficiency in resource management (including human resources) and customer capture have become central factors in the survival of public organizations, especially in a context of greater competitiveness between educational institutions and simultaneously, the successive budget cuts that Angola is experiencing [16]. In the last decades of the twentieth century, the Angolan government, regardless of its ideological tendency, encountered structural problems stemming from ineffective Higher Education.

The transformations that occurred in Higher Education in Angola during the last decade had as a consequence the modernization and administrative reform that the government started to take in order to improve the subsystem, conducted for the effectiveness, efficiency and quality of the services they provided. In view of this situation, we note the concern of the Angolan State regarding the need to improve the quality of higher education. For this reason, the use of the QMS as a possible way to find the desired quality is invoked.

Higher Education should develop the potential of each individual and provide graduates with the necessary knowledge and skills that promote individual development to be successful in their professions. According to the President of the Republic of Angola, José Eduardo dos Santos (2008: p 35) [1], [2].

> "We must make an evaluation of the implementation of the programs for the reform of the education system and the subsystem of Higher Education to detect the shortcomings and correct them and define the instruments for the materialization of the guidelines emanating from the Government program approved by the voters with a view to improve the quality of teaching, the working conditions of teachers and the management of educational establishments at all levels. "

According to Adão do Nascimento, "despite the successes achieved over the years, since the proclamation of national independence, improving quality and expanding the network of institutions of the subsystem of Higher Education is an imperative that is put to the Angolan State"[14]. Thus, education is the most determining sector for the future of a society. This importance increases with the level of development of the Country or the region, in particular because competitiveness requires higher levels of qualification, which are not possible to achieve without the teaching-learning systems being able to meet the needs of the community in quantity and quality [9].

The reform and modernization of Higher Education in Angola also depends on the competence and motivation of teachers and researchers. However, the number of teaching and research professionals has often not accompanied the increase in the number of students, which exacerbates the already felt capacity pressure [15].

The main objective of this work is to improve the quality of education in HEIs in Angola, namely, better working conditions, including transparent and fair recruitment procedures, better initial and continuing professional development, and better recognition and reward of excellence in teaching and research are essential if Angola is to produce, attract and academic staff you need.

2.Literature Revision

Although quality management has become a notorious issue since the early 1980s, it is not a modern invention. You can tell the story of quality in many ways. A large number of scholars agree that the concept or philosophy of quality has long existed, disagreeing only with some that the concept of quality has existed for hundreds of years and others speak for thousands of years [3], [10].

The benefits of implementing the QMS were analyzed by several authors, of which Santos et al. [11], Santos & Milan [12]. Among the major benefits to institutions, we highlight the improvement of the institution's image, the introduction of clear procedures for quality, awareness of quality, clarification of responsibilities, reorganization and improvement of efficiency [11]. On the other hand, it also occurs according to Santos et al. [5], return on investment made.

According to the French association for standardization, quoted by Fey & Gogue [4] "the quality of a product or a service is its ability to meet the needs of users". The American Society for Quality (ASQ), quoted by Kotler & Keller [8] says that "quality is the totality of attributes and characteristics of a product or service that affect its ability to meet stated or implied needs." ISO 9000: 2015 defines quality as the degree of satisfaction of requirements given by a set of intrinsic characteristics. In the twentieth century, the greatest importance attributed to quality led to the investigation, formulation and publication of various definitions for the concept, highlighting such illustrious authors as Joseph Juran, Philip Crosby, Walter Shewhart, Edwards Deming and Kaoru Ishikawa.

2.1 The concept of Quality in Higher Education.

The term "quality" has been used in the most diverse fields of knowledge, including the educational one, although there are substantial differences in its conceptualization, that is, there is no universal definition. The universal is the recognition of quality, both in products and services, as a decisive factor for the development of organizations, in an increasingly competitive world. In the educational context, definitions of the term "quality" focus on various aspects such as customer satisfaction, management and administration of educational institutions, availability of human, financial and infrastructural resources, since they contribute to the successful accomplishment of the functions of IESs [9].

For António & Teixeira [3], in the case of higher education, an integrative approach to the term quality, expressed in its trans versatility with respect to the provision of institutions, is recurrent. To gauge the quality of the university presupposes a global approach to the functions of the university, which results, on the one hand, from the interconnections between them and, on the other, from the articulations of these functions with the other dimensions that make up the organization.

The objective of this work is to present the Advantages of the Implementation and Certification of the Quality Management System in higher education in Angola, its performance and the efficient use of resources for the training of students and the provision of services to the community. With the implementation of a QMS in HEIs in Angola, based on ISO 9001: 2015, it is intended to make management more efficient, with impact on academic training, financial resources management and human resources. With this implementation we intend to continuously improve the quality of both the training offer and the services provided to the academic community. It can also be an important support for Institutional Marketing, for the external recognition that certification can bring, besides being a differentiating factor and influencing the attractiveness and notoriety of HEI for a teaching of recognized quality.

3. Methodology

55 Angolan HEIs were selected from the 73 existing ones, which are part of the Statistical Yearbook of the Ministry of Higher Education, corresponding to 75% of the total (guaranteeing coverage of public and private HEIs), to which the questionnaire was sent by email. Fifty completed questionnaires were received, representing the sample of this work. From this sample, the AMOSTRAL data base was built to support our work.

Table 1 - *Main questions of the questionnaire*

Group of questions	
Iº Group	What is your role in the Institution?
	What is the educational system in which the institution is inserted?
	Does the Institution have the QMS * implemented?
IIº Group	Do you know the advantages of implementing QMS in HEIs *?
	What is the benchmark you used as a basis for implementing the QMS in your HEI?
	Is the System implemented in every Institution or only part of it?
	Which sectors of the institution where the QMS is implemented?

*Quality management system

*Higher education institutions

For the treatment of the data we used statistical analysis SPSS (Statistical Package for the Social Sciences) version 22.0 for Windows. As mentioned earlier, 50 institutions participated in the survey of the 55 respondents, representing a percentage of questionnaires answered and received in the order of 91%.

4.Results

A total of 50 Angolan HEI leaders participated also in this study. The majority were male (70%), n = 35) whereas the female gender was represented by only 30% (n = 15). Of the 50 Angolan HEIs surveyed, only 20% of them have the Quality Management System implemented, as can be seen in figure 1.

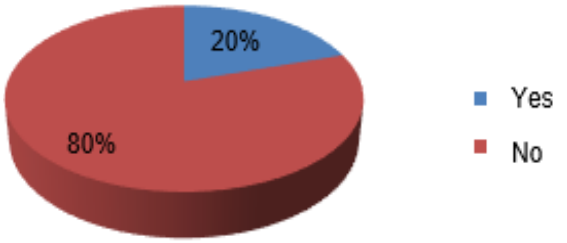

Fig. 1. *Participants in the survey with QMS implemented*

According fig.2, the main reason for non-implementation of the QMS is financial incapacity.

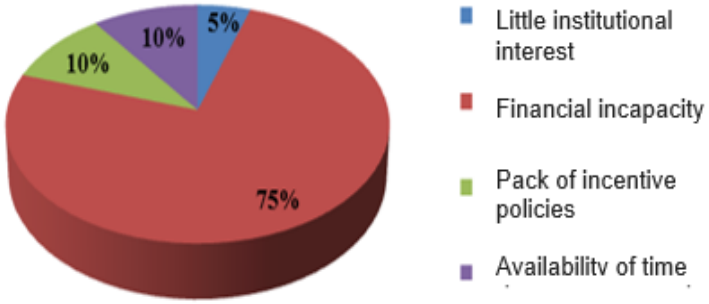

Fig. 2. Reason for non-implementation of the QMS

According to the respondents' responses, the most used benchmark for the implementation of the QMS was ISO 9001, as we can see in Figure 3.

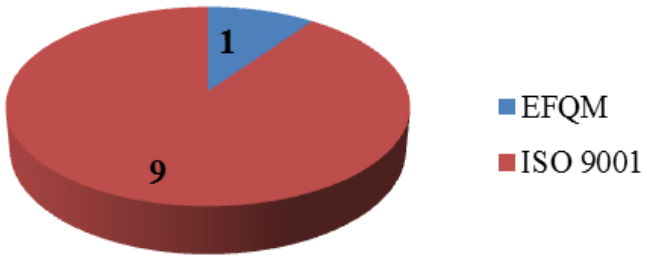

Fig. 3. *What is the benchmark that you used for the implementation of the QMS.*

The differences of opinion between the respondents with Dean and their vice, those with the functions of Director are all statistically significant, and those with a Director role are more in agreement with the statements related to the implementation of the quality management system (see table 2 and figure 4).

Regarding the representativeness of the Deans 'and Directors' opinions, according to table 2, we emphasize that it is important for Directors and Deans to implement the QMS. The Directors and Deans agree that "it is important that higher education institutions in Angola implement the quality management system".

Table 2. Representativeness of opinions regarding the implementation of the QMS between Deans and Directors

	Deans		Directors		
	M[1]	DP[2]	M	DP	Z[3]
1. It is important that higher education institutions in Angola implement the quality management system.	**5.21**	1.48	**6.97**	.17	-6,298***
2. All Angolan higher education institutions must have a certified quality management system in place.	4.50	1.40	6.75	.44	-5,770***
3. The Ministry of Higher Education of Angola must create a legislative decree that obliges higher education institutions to implement the quality management system.	4.50	1.34	6.67	.48	-5,448***
4. Quality management enables higher education institutions to improve the quality of teaching.	4.50	1.45	6.86	.35	-6,016***
5. One of the main objectives of the implementation of quality management in higher education institutions has to do with student satisfaction.	4.79	1.48	6.81	.40	-5,626***
6. The confidence of students and other stakeholders in higher education is established and maintained through effective quality assurance activities.	3.36	1.01	6.11	.82	-5,584***
7. Institutional self-knowledge is the starting point for effective quality assurance.	**4.79**	1.93	**6.94**	.23	-6,051***
8. Students' evaluation is one of the most important elements of their training course in higher education.	3.93	1.38	6.42	.69	-5,410***
9. It is important that teachers of higher education institutions in Angola have the complete knowledge and understanding of the area they teach.	4.21	1.25	6.08	.81	-4,781***
10. Teachers represent the most important learning resource for most students in higher education institutions in Angola.	4.57	1.50	6.89	.32	-6,112***

M[1] - Average

DP[2] - Standard Deviation

Z[3] - Statistically significant difference

According table 2, the results of the survey, it is possible to improve education in Higher Education Institutions of Angola. As main benefits of the implementation of the QMS in HEIs of Angola, we can highlight: Improvement the quality of teaching; Improvement of student satisfaction; Improvement of confidence of students and other stakeholders; Promotion of institutional self-knowledge for quality assurance; Improvement in student assessment; Improvement of teacher competences; Teachers as the most important resource of learning.

Fig. 4 shows the representativeness of opinions between Directors and Deans. Directors deal more closely with the problems of teaching quality and organization. Thus, they have a more open opinion than that of the Deans. These have to deal with other types of major problems.

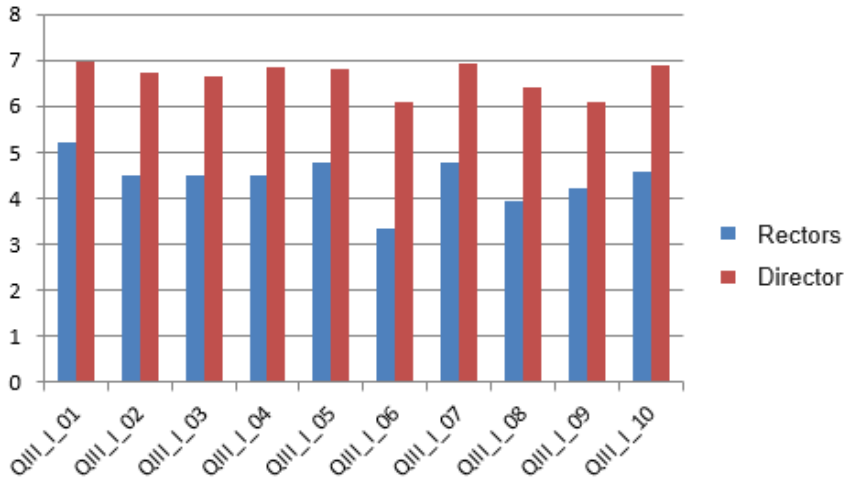

Fig. 4. *Representativeness of the views of the implementation of the QMS between Deans and Directors*

Conclusion

The key to quality begins with changing the mindset of managers, through knowledge, commitment, communication and involvement. Nevertheless, it is necessary, in addition to changing the management mindset, a radical change in the mentality of all who are involved with the organization. The need arises for all members of the organization to work towards the same goal, towards the satisfaction of their clients, which in the specific case of Angolan HEIs are their students.

Higher education in Angola has grown quantitatively over the last four years, but now there is a need to start looking for qualitative growth, which will imply the introduction of practices related to quality.

The results of the survey of Angolan HEIs show that most respondents are aware of the advantages of implementing the QMS, which is a significant step towards implementing it. It was found that the majority of the respondents who answered the questionnaire were the Directors to the detriment of the Deans, on the other hand it was concluded that one of the main reasons for not implementing the QMS is limited in the scarce financial resources that institutions have.

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Six Sigma: Main Metrics and R Based Software for Industrial Quality Control and Teaching Purposes

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ABSTRACT

A very short reference to statistical process control is presented, followed by an introduction to the works developed by Motorola and General Electrics that led to the development and general use of the six sigma methodology. A discussion of the continuous, attribute and counting data worlds is carried out, together with their main applications in process analysis. Because many professionals working in management areas may have difficulties dealing with engineering perspectives, a review of main classic and six sigma process metrics is done with examples. Complementing discussions, four functions written in the R language are presented, which can deal with real organizational data and provide useful graphical displays and all necessary metrics, but that also have the ability to let the user provide theoretical values for teaching and learning activities. Real and simulated examples are discussed, showing that six sigma metrics and informative graphical data displays can be made easily accessible to all interested professionals.

Keywords: Six sigma, Process Metrics, Quality Control, R

1. Introduction

Six Sigma is essentially a methodology developed by Motorola, to address manufacturing or business problems. It is related to improvement projects following DMAIC, a well-defined project approach, utilization of selected quality tools, and, in many circumstances, applying lean methodologies and other quality tools available [1-6]. However, it started to be a well-defined methodology to reduce variability, whose origins can be traced back to the beginning of the twentieth century after the works of Walter Shewhart [7] dealing with the control of the variability of high yield machines. He proposed the use of statistics to control high throughput processes, and the quality control charts devised by Shewhart, which can be faced as the beginning of SPC (statistical process control) were the main tool to follow and control processes' performances and are still referred to as one of the seven basic quality tools [7,8].

The works of Shewhart are still valid, but the advent of computers and efficient software enabled the production of high yield machines and high throughput processes, forcing professionals to be increasingly concerned with precision and control, maintaining process parameters within very narrow specification limits, to avoid production of defectives (waste) and re-work [2,3,8].

The six sigma methodology tries to address all these problems, but uses procedures and metrics that are sometimes difficult to understand. Also, possibly because too many people with very different backgrounds are working in the field, a lot of confusion in critical aspects of this methodology is evident. For example, there is unanimity in the definition and calculation of "Cp" (the traditional process capability metric), but in what concerns metrics defined within six sigma, definitions are not unanimous. "Pp" is referred as overall capability (e.g. [10]) or as process performance (e.g. [11]), and some authors do not provide clear definitions (e.g., [2]). The same happens with "DPMO" and "PPM", crucial six sigma metrics, that can represent "defects per million opportunities", "parts per million", or both [9].

The purposes of this paper are three: (i) to try to clarify some crucial aspects of the six sigma methodology in what concerns important metrics, following the terminology used by the American Society for Quality [11]; (ii) to address three types of data worlds (continuous, attribute and counting data worlds) following the Minitab terminoly [10]; (iii) to present a set of useful functions, written by the authors using the R language [12,13] to assist lecturers in six sigma and young six sigma practitioners, enabling the user to analyze several types of process data, producing useful graphs and automatically calculating the most important metrics.

It is important to highlight that some comprehensive functions were written in R [14,15] to deal with six sigma. However, these functions require a very good knowledge of the R language. Consequently, there is still an opportunity to produce simple, easy to handle functions, helpful for young practitioners and for people from backgrounds other than engineering.

2. Methods

Four functions were written by the authors using the freely available R project software [12]. The first purpose of these functions is to provide two main possibilities: (i) "simulate" and analyse data using argument "simulate=TRUE": the user supplies specification and process parameters and the functions simulate data and analyse it, so that they become quite friendly for teaching/learning purposes; (ii) "read" and analyse real examples supplied in ASCII files, using argument "read=TRUE": the user supplies specification parameters and a file name with real data, which is then automatically analysed.

In both "simulating" and "reading" modes, these functions produce two frames: (i) a frame with information on data, six sigma metrics and statistical tests; (ii) a frame with graphical aspects, including histograms or barplots and time plots.

All functions were designed in order to be confined to specific data worlds, requiring minimum knowledge of computation and of six sigma. These functions are available to all interested readers on request.

3. Results and discussion

In this section definition of data worlds follows that used in Minitab [10] and metrics follow the definitions of the ASQ [11].

3.1 The Continuous Data World

Many processes can be described by KPIs (key process indicators) that are continuous variables following normal distributions, or that can be transformed in variables following that important probability distribution. This implies that a KPI can be characterized by a mean value (μ) and an uncertainty (3σ), i.e., in the form $\mu \pm 3\sigma$, where σ is the process standard

deviation and the value ±3, which multiplies σ, is a *z* value from the standard normal distribution inducing a 99.74% confidence interval. Then, the lower process limit (*LPL*) is given by *LPL*=μ–3σ and the upper process limit (*UPL*) is *UPL*=μ+3σ, with the process range (*PR*), also called precision, given by *PR=UPL–LPL*=6σ.

To analyze these processes they must be compared with specifications. Any specification (required by customers, laws or imposed internally) can be written in a way similar to a process, i.e., considering a target value (*TV*) and an allowable error (*AE*), and be written in the form *TV*±*AE*. Than the lower specification limit (*LSL*) is *LSL=TV–AE* and the upper specification limit (*USL*) is *USL=TV+AE*, and the specification range (*SR*), also called tolerance, is *SR=USL–LSL*.

3.1.1 Capability metrics

Taking these definitions into consideration, the main metrics for process evaluation are the "capability metrics", *Cp* (process capability) and Cp_K (process capability index) [10,11] given by the following equations where σ_w represents an estimate of the process σ based on several samples collected from production along time:

$$Cp = \frac{SR}{PR} = \frac{tolerance}{precision} = \frac{specification\ range}{process\ range} = \frac{USL - LSL}{6 \times \sigma_w}$$

$$Cp_L = \frac{LSL - \mu}{3 \times \sigma_w} \qquad Cp_U = \frac{\mu - USL}{3 \times \sigma_w} \qquad Cp_K = \begin{cases} Cp_L & if\ |Cp_L| < |Cp_U| \\ Cp_U & if\ |Cp_L| \geq |Cp_U| \end{cases}$$

It is also important to evaluate the number of items falling out of the specification limits, expressed in parts per million (*PPM*): the PPM_L or *PPM*<*LSL*, PPM_U or *PPM* > *USL* and $PPM_T = PPM_L + PPM_U$. These *PPM* metrics are referred as the process "defective yield". The "sigma level" (Z_σ or Z_{BENCH}) is the value of the standard normal variable corresponding to PPM_T, imagining all defective items as exceeding the *UPL*. *PPM* are calculated as areas under the normal curve exceeding the specification limits, and are therefore the "expected" or "probable" fraction of defective units that will be produced, multiplied by 10^6.

Dispersion (*D*) is a new metric, herein introduced, calculated as *D=AE*/σ=3×*Cp*, and is used to make a distinction between the sigma level and the common sense of 3σ. If a process mean is centered in the specification target value, *D* is the number of standard deviations between the process mean and the specification limits.

For the estimation of the process σ, referred to as σ_{within} or just σ_w, units can be collected in three different ways: (i) samples collected one at-a-time, therefore collecting *N* samples of size *n*=1 and estimating σ_w based on moving ranges; (ii) groups of units always with the same number of units, i.e., *N* samples of size *n*, with *n*>1, and estimating σ_w based on samples' variances; (iii) groups of units with different numbers of units per group, i.e., *N* samples of different sizes, and estimating σ_w based on samples' sums of squares. These estimates of the process σ based on σ_w reflect the common causes of variation, inherent to the process, and therefore represent the best that the process can do, and are used for the calculation of capability metrics.

3.1.2 Function *SS.Cp*

In order to understand these definitions, function *SS.Cp* was built (mainly for teachers and students). The user supplies the values for a specification (*TV* and *AE*) and the process parameters (μ and σ). The function draws the specification and the normal curve corresponding to the process parameters and calculates all metrics referred above.

Figure 1 was produced with function *SS.Cp* with arguments *TV*=μ=500, *AE*=15 and σ=*AE*/3=5. In this situation, the process is fully adjusted to the specification. In Figure 1, the specification values, process characteristics and the yield metrics just discussed are calculated and shown on the left-hand side, and on the right-hand side, the specification is plotted together with the normal curve corresponding to the process. Because the process is centered in the specification, *Cp* and Cp_K are equal, and because the process limits and specification limits are also equal, *Cp*=1 and *D*=3. Nevertheless, some defective units are produced and Z_{BENCH}≈2.8: hence the difference between "dispersion" and "sigma level".

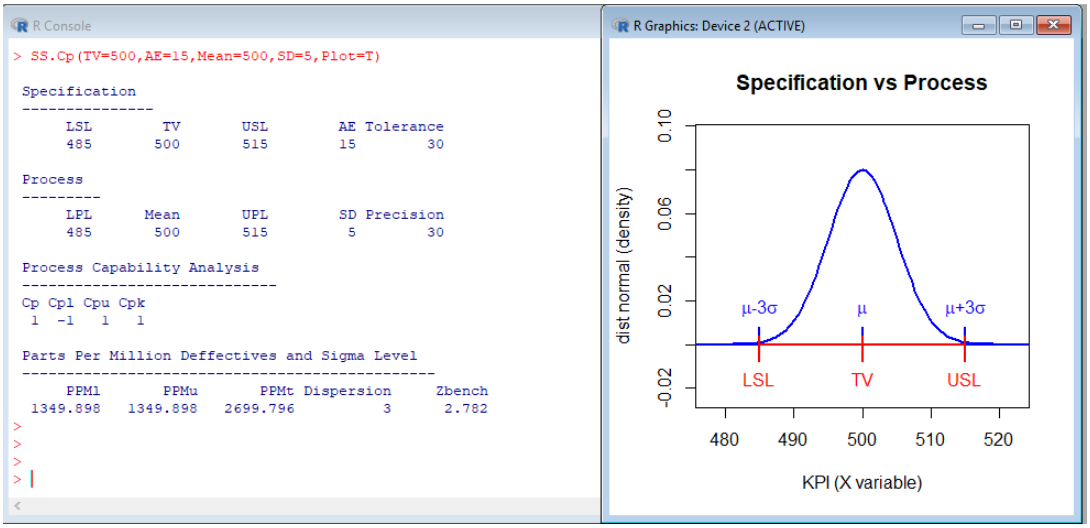

Figure 1. *Output of function SS.Cp, comparing a process with μ adjusted to TV, and with σ = AE/3. The dispersion is 3, Cp = Cp_K = 1 and 2700 PPM are produced, corresponding to a Z_{BENCH} = 2.78. The process parameters μ and σ are not calculated, but stipulated by the user.*

Figure 2 was produced with the same function *SS.Cp* with the same arguments for the specification, *TV*=500 and *AE*=15, but with σ=*AE*/4=3.75 and μ=500–1.5×σ=494.375, reflecting a 1.5 sigma-shift. In this situation, although the process is capable, as seen by *Cp*=1.33 and *D*=4, the sigma-shift displaced the processes to the left, resulting in a Cp_K which is negative and smaller than *Cp* in absolute value. Consequently, more defectives are produced exceeding the *LSL*. The sigma level is now only Z_{BENCH}=2.5.

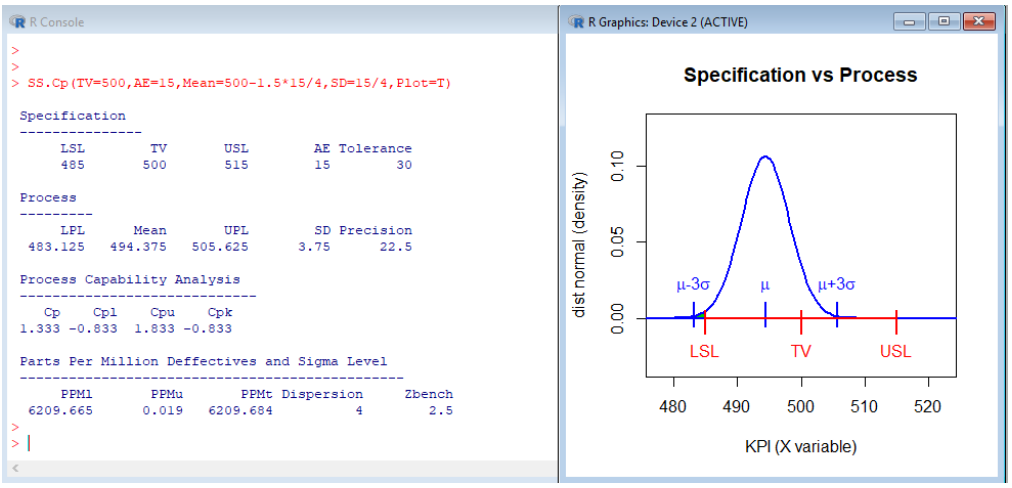

Figure 2. *Output of function SS.Cp, showing a process with a 1.5σ shift to the left of the TV, with σ=AE/4. The dispersion is 4, Cp=1.33, Cp_K=−0.833 and 6200 PPM are produced, leading to a Z_{BENCH}=2.5.*

3.1.3 Performance metrics

In six sigma projects, besides capability metrics, performance metrics are also important: these are *Pp* (process performance), Pp_L, Pp_U and Pp_K (process performance index) [11], the difference between both types of metrics residing in the estimate of the process standard deviation:

$$Pp = \frac{SR}{PR} = \frac{tolerance}{precision} = \frac{specification\ range}{process\ range} = \frac{USL - LSL}{6 \times \sigma_o}$$

$$Pp_L = \frac{LSL - \mu}{3 \times \sigma_o} \qquad Pp_U = \frac{\mu - USL}{3 \times \sigma_o} \qquad Pp_K = \begin{cases} Pp_L & if\ |Pp_L| < |Pp_U| \\ Pp_U & if\ |Pp_L| \geq |Pp_U| \end{cases}$$

It can be seen that the performance metrics are equal to capability metrics, but use a different estimate of the process σ, referred as $\sigma_{overall}$ or just σ_o. The calculation of σ_o uses all units collected, irrespectively of time or samples, i.e., as if it was just one big sample. Such an estimate is called the "overall sigma" and incorporates all common causes of variation, and also the special causes of variation arising along time.

Following the definitions for capability and performance metrics, it can be concluded that these metrics will be different if: (i) the process is affected by special causes of variation; (ii) if the process variability increases with time; (iii) if there is a sigma shift, a term that is used in six sigma [8] to refer to a displacement of the project mean in relation to the specification target value, measured in standard deviation units. In all these three cases, σ_o will be higher than σ_w and all performance metrics will be significantly higher than the corresponding capability metrics.

3.1.4 Function *SS.Norm*

Once capability, performance and defective yield metrics are understood, processes can be analyzed in business practice with function *SS.Norm*. This function needs to be supplied with the specification values (*TV* and *AE*), the name of an ASCII file with practical data, and argument "samples". The latter argument is just the number of samples actually analyzed, as described in section 3.1.1. Based on these arguments, function *SS.Norm* will automatically calculate estimates for σ_o and σ_w and all metrics just discussed.

Figure 3 presents a real industrial example: the analysis of daily losses, expressed as the fraction of wasted fruit mass per day in a fruit juice processing plant. On the left-hand side of the function output, all metrics are presented: observed data and the estimates of capability, performance and yield, together with some statistical tests. On the right-hand side, the specification, a histogram of observed data and the estimates of process behavior as two normal curves (the narrower, blue curve representing the process with only common causes of variation, and the wider, yellow curve representing the process in the long term including the observed special causes of variation), and shaded areas under the normal curves showing the fraction of defective units . Also, on the same side, a plot of data values over time enables the visual observation of the special causes of variation.

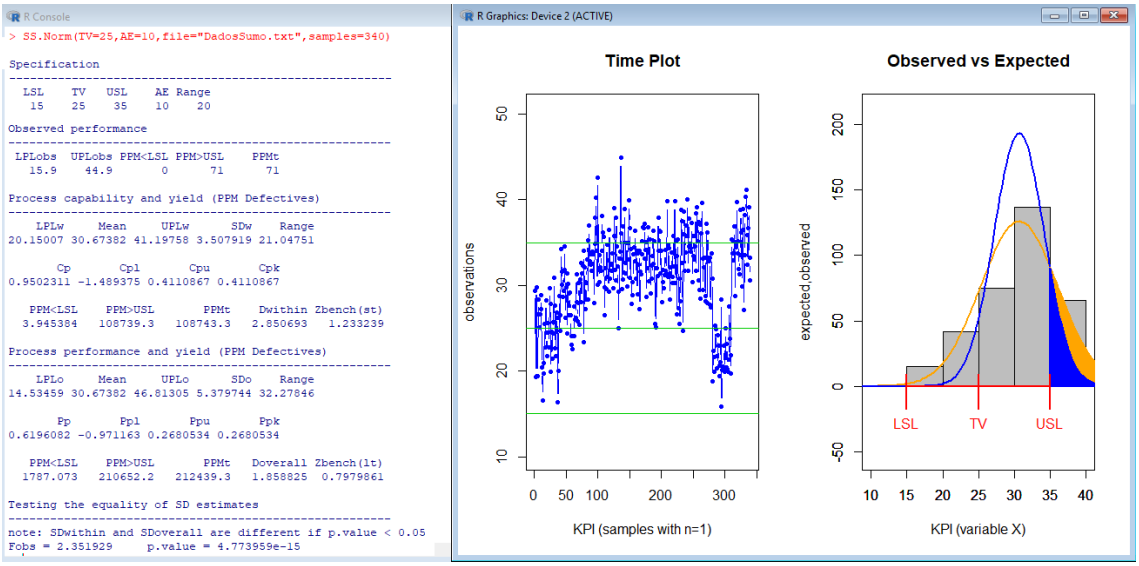

Figure 3. *Output of function SS.Norm, showing a real industrial process dealing with daily losses in juice production. The process has very low performance (Pp=0.62) and is displaced towards the right (Pp_K=0.268), producing 108743 PPM corresponding to a long term sigma level of 0.798. There are evident special causes of variation ($p = 4.773959 \times 10^{-15}$), and a Cp=0.95 shows a need for improvement*

Figure 3 is an example of a very bad process: *Cp* is lower than 1, meaning that the process range is higher than the specification range; the positive and small values of Cp_K and Pp_K demonstrate that the process mean is displaced towards the right, producing higher daily losses; the sigma level is very low and even if all special causes of variation were removed, Z_{BENCH} would only be slightly higher than 1.2, which is a very low value.

Figure 4 shows the analysis of a real industrial example relative to coffee packaging. The specification limits were derived from legal aspects (Portaria 1198/91) and internal specifications. The short-term sigma level is extremely high

($Z_{BENCH(LT)}$=8.5), reflecting a process with very high precision. The long-term sigma level is also high, and curiously reflects a sigma-shift of 1.5 ($Z_{BENCH(ST)}$=7.0), as predicted in the six sigma theory [8]. This shift shows that the process is very accurate, but there is a margin for improvement just by removal of the special causes of variation. It is worth noting a *Cp*≈3 and a dispersion *D*≈9.

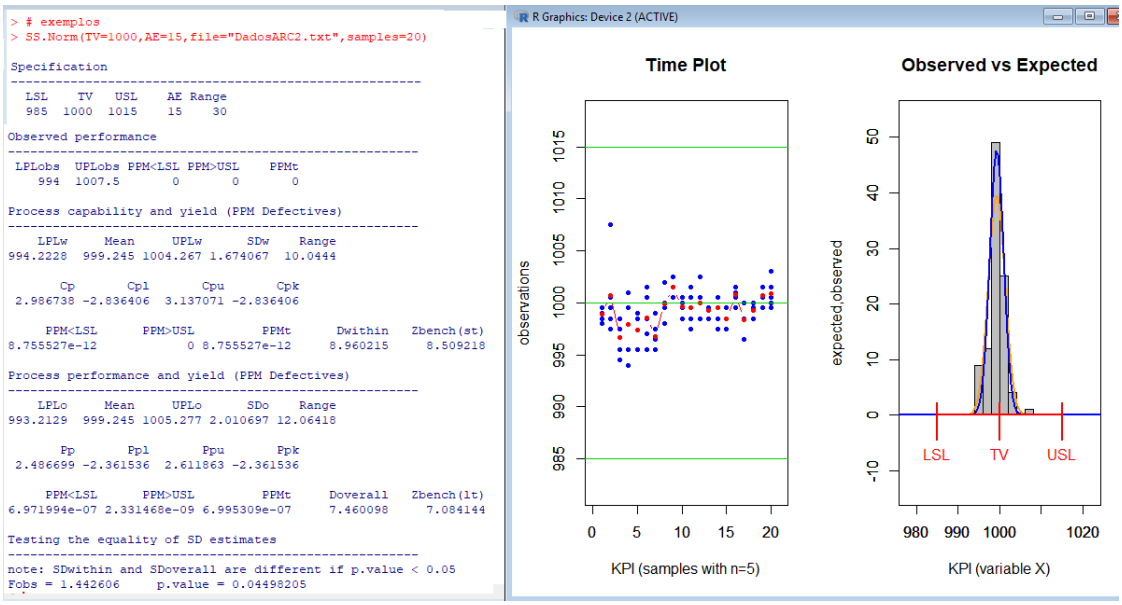

Figure 4. *Output of function SS.Norm, showing a real industrial process of coffee encapsulation. The process has a very high capability expressed as a short-term sigma level equal to 8.5. Metrics show that with time this level will be reduced to 7, reflecting a true 1.5σ shift.*

3.2 The Attribute Data World

Some processes can be described by KPIs that classify units as "defective" or "non-defective", i.e., as "1" or "0". In this situation, data follows a binomial distribution and the important process parameter is the fraction of defective items produced, denoted by π. These KPIs that are expressed as only two possible quality outcomes are referred as "attributes".

3.2.1 Main Metrics for Attributes

In the case of attributes, one has to collect and inspect *N* production units, classifying each unit as a "1" (defective) or a "0" (non-defective). Units can be collected and inspected in different ways, leading to different aspects.

One can collect and inspect *N* units, one at-a-time, leading to a series of *N* "zeros" and "ones". In this case,

two data displays are useful: (i) a barplot with two bars, one for the amount of defective, the other for the amount of non-defective units; (ii) a plot of results (of "zeros" and "ones") over time, to try to investigate possible special causes of variation.

If one collects *N* samples of equal size *n*, this leads to a series of natural values ranging between "0" and "*n*" representing the number of defective units observed in each sample. Therefore, a barplot with *n* columns, with the height of each column representing the number of samples with 0, 1, …, *n* defectives will be informative. Also, a plot of the evolution of the number of defective units per sample along time will be important.

Finally, one may have a series of *N* samples of different sizes. In this situation it is important to convert number of defective units per sample in fraction of defective units per sample, producing a plot of the fraction of defective units observed along time and a histogram showing the distribution of the fraction of defectives per sample.

Whatever the procedure used, all data is used to estimate the production defective fraction, π. Such an estimate is calculated as the sum of all values (the sum of all defective units) divided by the total number of inspected units (*M*), which is referred by *P*. In mathematical notation, one collects a series of *M* values x_1, x_2, x_3, …, x_i, …, x_M, and *P*, the estimate of π, is:

$$\pi \sim P = \frac{1}{M}\sum_{i=1}^{M} x_i \qquad PPM_T = P \times 10^6$$

It is worth noting that it is irrelevant if one is talking about samples of size 1, or of equal or unequal sizes, since the average of sample's defective fractions is equal to the overall defective fraction.

An estimate of the long-term defective production is just the part per million defectives, calculated as $PPM_T = P \times 10^6$. Consequently, a sigma level, $Z_{BENCH(LT)}$, can be calculated using P as the extreme right-hand side area under the standard normal distribution and determining the corresponding variable z.

However, with this type of data, unless one is talking about huge numbers of inspected units, it is virtually impossible to distinguish between short- and long-term defective fractions, as well as special causes of variation. Hence, all data is faced as long-term and if a short-term sigma-level, $Z_{BENCH(ST)}$, is desired, it can be approximated by:

$$Z_{BENCH(ST)} = Z_{BENCH(LT)} + 1.5$$

3.2.2 Function *SS.Defectives*

In order to deal with attribute data, function *SS.Defectives* was built. This function has two possibilities: (i) using argument "Simulate=TRUE", intended for teaching and studying purposes, leading to the simulation of production outputs based on values supplied by the user for π (the production defective fraction), *N* (number of samples) and *n* (sample size); (ii) indicating an ASCII file, which overrides all other arguments, leading to the automatic analysis of real data.

Figure 5 shows an example of the use of function *SS.Defectives* applied to real data consisting of *N*=120 samples of different sizes. All raw values in the file are converted to sample defective fractions, which are shown on the left-hand figure frame, together with a division in classes for analysis of dispersion and as the basis for the histogram. Several metrics are also presented, mainly the estimate of the production defective fraction, total *PPM*, and the sigma-levels $Z_{BENCH(LT)}$ and $Z_{BENCH(ST)}$. In this example, 4.45% defective units are estimated to be produced along time, which corresponds to a long-term sigma-level of 1.7.

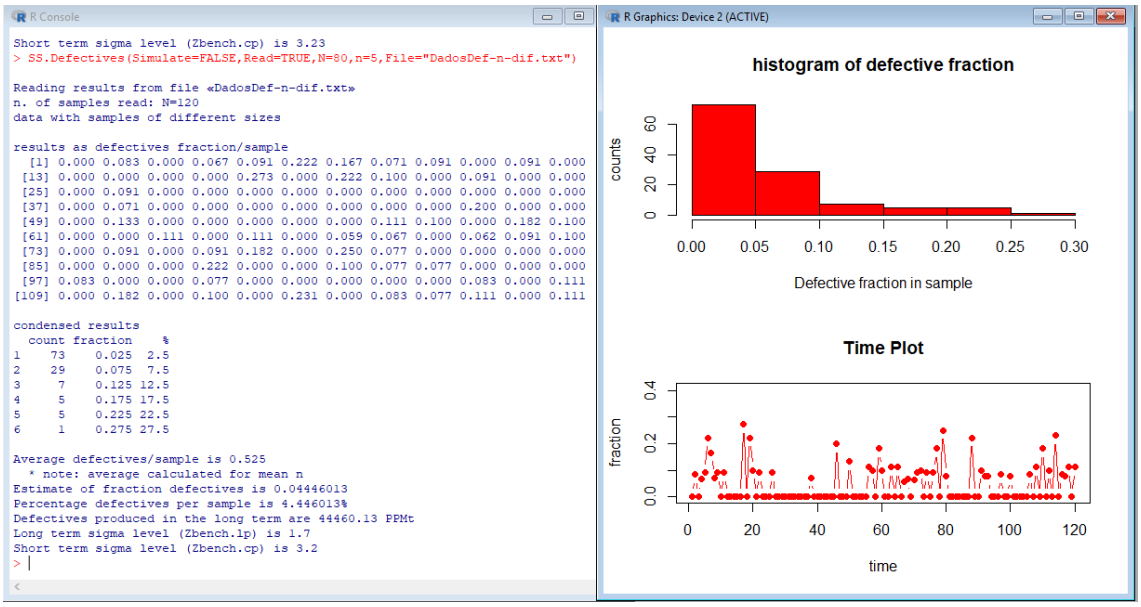

Figure 5. *Output of function SS.Defectives, showing a real industrial process, analyzing samples of different sizes of pre-packaged coffee beans. Units with contents lower than the legal AE or higher than the internal AE, are defective.* $Z_{BENCH(LT)}$ *shows possibities for improvement.*

3.3 Counting Data World

The last type of KPIs of interest belongs to the "counting data world". To work with this type of data, each production unit is faced as an "area", or "quantity", where some "types of defects" are possible. Each type of defect is called an "opportunity", and the total number of opportunities is referred as "NO". The number of units inspected is *N* [10,11].

The purpose of this quality control practice is to count the number of defects observed for each opportunity and for each unit, for all units, and calculate an estimate of the population parameter of interest: the average number of defects per opportunity in the long-term, λ, expressed in parts per million, usually referred as *DMPO* [8,9].

3.3.1 Main Metrics for Counts

In what concerns the actual work that has to be carried out to calculate main metrics, the following aspects are important: (i) a template is prepared with a matrix-like structure, with columns representing opportunities (types of defects) and rows representing sample units; (ii) a unit is collected and inspected, counting the number of defects of each type, filling a matrix row; (iii) this practice is repeated for all *N* units, filling all *N* matrix rows; (iv) the last matrix column is the automatic row sum, i.e., the total number of defects per unit (*NDU*); (v) the last matrix row is the automatic column sum, i.e., the total number of defects per opportunity (*NDO*).

Based on these initial metrics (*NDU* and *NDO*), two important intermediate metrics are derived: (i) the average number of defects per unit, *DPU*; (ii) the average number of defects per opportunity, DPO:

$$DPU = \frac{1}{N}\sum_{i=1}^{N} NDU_i \qquad DPO = \frac{1}{N \times NO}\sum_{i=1}^{N}\sum_{j=i}^{NO} NDO_{ij} = \frac{DPU}{NO}$$

Because any unit with one or more defects is faced as a defective unit, *DPU* is an estimate of the process parameter λ, the long-term number of defects per unit. Because this parameter follows a Poisson distribution, the probability of "0" defects per unit, i.e., the probability of *NDU*=0, can be calculated and the process yield, in terms of fraction defective units, in the long-term, is expected to be $1–e^{–DPU}$ [10]:

$$P(NDU = 0) = \frac{DPU^0 \times e^{-DPU}}{0!} = e^{-DPU} \qquad P = fraction_{(defectives)} = 1 - e^{-DPU} \qquad PPM_t = 10^6 \times P$$

The long-term sigma-level, $Z_{BENCH(LT)}$, is the *z* value corresponding to the extreme right-hand side area under the standard normal curve equivalent to *P* (fraction defective), and the short-term sigma-level, $Z_{BENCH(ST)}$, is:

$$Z_{BENCH(ST)} = Z_{BENCH(LT)} + 1.5$$

Finally, if instead of PPM_T the interest is in the study of "defects per million opportunities", referred as *DPMO*, instead of defective units per million (PPM_T), then metric *DPMO* is the important metric calculated as:

$$DPMO = 10^6 \times \frac{DPU}{NO}$$

This metric, although famous in the area of six sigma projects, should always be avoided, unless one can be sure that all opportunities for defects are unambiguously defined and that no new opportunities will arise in the course of an industrial practical work [8,10].

3.3.2 Function *SS.Defects*

Function *SS.defects* was built to address counting data problems as described in section 3.3.1, and is similar to function *SS.Defectives*, enabling simulations for teaching/studying purposes, but also the treatment of practical organizational problems.

Figure 6 provides an example of the use of this function in the simulation mode. The user supplies the function with a list of opportunities (a list of names of defects that can occur in bottles of mineral water) and a list of defective fractions for each opportunity (a list of π values). In this simulation, the opportunities were "Con" (content), "Nec" (bottleneck), "Lab" (label), "Cap" (capsule) and "Cla" (clamping), with π values 0.01, 0.05, 0.2, 0.01, 0.5, respectively. The user also tells the function how many units are to be generated (*N*). Then, using the binomial distribution, the *SS.Defects* function, generates random data for each opportunity and, afterwards, provides two frames: a frame with reports and metrics (left-hand side), and a frame with graphical aspects (right-hand side).

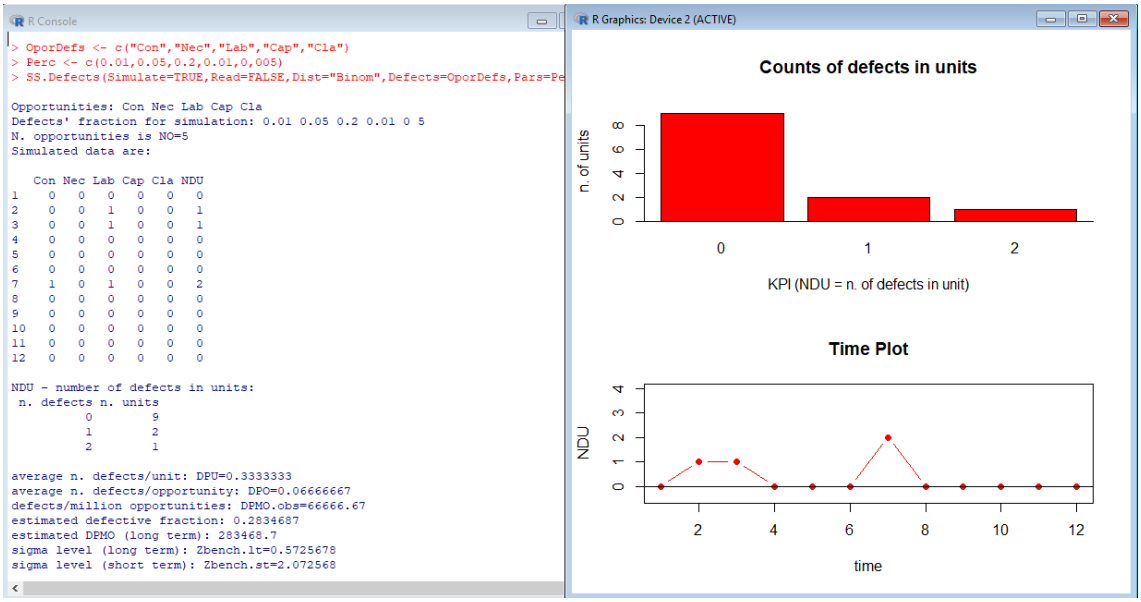

Figure 6. *Output of function SS.Defects, in the simulation mode. Simulated data is presented on the left-hand side, together with the main metrics: DPU, DPO, DPMO and sigma-levels. On the right-hand side, barplot with main observed counts of samples per number of defects, and evolution with time.* $Z_{BENCH(LT)}$ *is very small and* $Z_{BENCH(ST)}$ *must be seen with caution since its meaning is doubtful.*

4. Conclusions

Although six sigma is a very comprehensive methodology, involving a lot of quality tools and ways to address projects, six sigma metrics may be a key question in the methodology.

In this paper the main metrics and the main graphical displays were presented and discussions were followed with practical cases treated with functions *SS.Cp*, *SS.Norm*, *SS.Defectives* and *SS.Defects*, which were designed using the R language, to work within the continuous, attribute and counting data worlds. These functions are very versatile because they can be used in the "simulation mode" for teaching/learning purposes, and on the "reading mode" for the analysis of real data, enabling users to quickly carry out any process analysis with the correct six sigma metrics.

The examples show that with a very little knowledge of computing or statistics, any interested professional can analyse real cases, producing illustrative graphs and all relevant six sigma metrics. Furthermore, these functions can be used to simulate data, treating simulated data as real and produce the same graphs and metrics, being very useful for teaching six sigma metrics and for students to compare specifications with process parameters and understand the meaning of six sigma metrics. These functions are available for any interested reader.

All functions presented in this paper work with one KPI and single stage processes. In order to make them more versatile, work is being carried out in order to treat data arising from multistage processes and is is envisaged to extend them to deal with more than one KPI.

5. Acknowledgements

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Lean Philosophy and Management Assets applied to Industrial Valve Production Company

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ABSTRACT

Actually, due to more competitive business world, the maintenance activities and their management are extremely important for the good performance in the industrial companies. through analysis of the existent practices and procedures was performed in the company in relation to the overall management and maintenance activities. Due to the use of Ipinza method, it was possible to identify which equipment needed to implement certain preventive maintenance routines, and for those, maintenance plans were developed. A number of issues as well as improvement points were identified. The establishment of foundations to implement the Lean's methodology 5S technique as well as to manage the company's assets. Following the implementation of the proposed improvements, it is expected more efficiency and a greater performance of the maintenance services in addition of significant improvements in decision execution discipline as well as employees' motivation.

Keywords: Lean Philosophy, Management Assets, Ipinza method; 5 S; cost analyse

1. Introduction

Given the current economic crisis that companies live, regardless of the sector in which they operate, it is essential to ensure efficient and effective performance of their operations. In the industrial sector, in particular, maintenance of the equipment and its management are fundamental areas in the companies, not only to ensure the uninterrupted operation of the equipment and to ensure the continuous flow of materials, but also to guarantee the quality of the product, so that they remain in a competitive market.

Industrial maintenance is usually seen by companies as a cost-generating activity. However, all equipment, regardless of the environment in which they are inserted, their age and their functions are subject to deterioration. In this way, it is essential to develop methodologies that allow an efficient management of maintenance activities, so as not to ignore the good practices of the same, making them crucial for the companies, as well as resource optimizers.

It is necessary to go back in time to see the most important phases of the maintenance history, since this is an activity that has undergone changes throughout the time (see Figure 1). There are four important dates in maintenance evolution. Before First World War which happened in 1914, maintenance was of no importance and the breakdowns were repaired by workers in the production area, as there was no one specialized in maintenance. Between 1914 and 1930, after the first World War appeared the corrective maintenance, that is, the equipments were repaired after the breakdown to reestablish the production. As a consequence of the Second World War, in 1940 the concept of preventive maintenance appeared and the companies began to have a responsible for the supervision of their assets conservation, even because at that time there was an expansion of commercial aviation. In 1970 the maintenance engineering body assumed the role of manager, starting with a view to economic optimization. After the Second World War and in recent years there has been a positive evolution of maintenance, because nowadays, awareness of environmental safety, quality of products and services, makes maintenance one of the most important functions for the industries success.

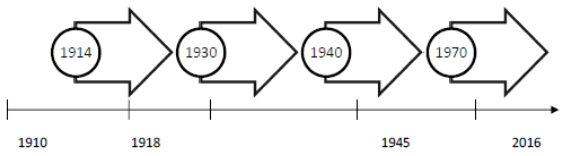

***Figure 1**. Historical evolution of maintenance [1]*

The main objective of maintenance management is to act at the following levels:

- Human: provide working conditions, provide safe conditions and protect the environment.
- Technical: act on the availability and durability of the equipment, as well as on the facilities conditions and functioning
- Economic: to provide lower operating costs, lower failure costs, practice of energy saving and company enrichment.

The concept of maintenance management, according to the norm NP EN 13306 2007 [2], is all the activities developed within the scope of the management that define the strategies, the objectives and the responsibilities regarding the maintenance.

This work consisted in promoting possible improvements in maintenance and management in a company that manufactures industrial valves. This company produces two types of valves *stop valves* and *check valves*. Since the former are used to control the flow of the fluid and the latter are valves used to control the flow direction. Within the **stop valves** there are the **gate valves** and the **globe valves**. The most significant uses of these two types of valves are in the *downstream* of refineries or in power plants, essentially in the control of steam. The valves produced can be of various sizes. At the level of size, the largest and smallest industrial valve produced in the company to this day were five tons and eighteen kilograms (see Figure 2), respectively [1].

***Figure 2**. Biggest and smallest valve produced in the company.*

Using tools from the Lean philosophy [3-8], this work involved the development of maintenance plans for certain equipment in the factory, creation of discipline in relation to them and implementation of all activities in maintenance management software.

2. Methodology

The methodology used in this work was based in Lean Philosophy. Firstly, a detailed analysis of the existent practices and procedures was performed in the company in relation to the overall management and maintenance activities. Processes and proceedings of lines production were study and consequently the production equipment's were analysed. Due to the use of Ipinza method [1, 9, 10, 11], it was possible to identify which equipment needed to implement certain preventive maintenance [2] routines, and for those, maintenance plans were developed. Maintenance proceedings and maintenance work orders were proposed and implemented based in Lean philosophy and in equipment age. It was implemented the management maintenance software that allows, among other things, to generate working tasks and equipment failure historical reports which, for future record, enable to analyze the equipment's availability and other efficiency parameters, as maintainability and availability [2]. In addition of the initially proposed targets, other key aspects were also accomplished including namely the completion of the equipment's codification system, the improvement of the machine's master file, the introduction of paper failure registries to the machine operators and the establishment of foundations to implement the Lean's methodology 5S technique as well as to manage the company's assets. Costs of management assets were study and improvement proposals were made.

2.1 Study of the principals' equipment

The company's equipment is inserted in three production processes: i) machining ii) assembly iii) tests and finishes. In the machining zone are all the equipment dedicated to the transformation of the molds of the bodies of the valves. In the assembly zone are all the equipment dedicated to the assembly of the valve bodies. And in the test zone, there are the test and painting equipment of valves. Table 1 shows the number of critical equipment identified in these 3 production zones.

Table I. *Critical Equipment identified by production zones*

Production Sector:	Machining	Assembly	Tests and finishes
Number of Critical Equipment	30	14	7

As a rule, the equipment during the operations they perform became very dirty, since most of them have hydraulic systems, lubrication and cooling systems and pneumatic systems In the case of the first two systems, the lubricants used (oils or grease) made equipment became soiled.

Pneumatic systems, although not working with lubricants, accumulate a lot of dust. The accumulated filings after the operations leave the equipment with a lot of dirt. In this first survey it was also verified that many equipment would fail because of poorly performed cleanings. When service technicians move to the equipment, it is a habit to clean them before carrying out any maintenance activities. The fillings are usually removed from the equipment after the operations (this process is often automatic and carried out by the equipment itself) and discarded at the end of the day.

2.2 Ipinza Method

The Ipinza method [1, 9, 10, 11] was used in this work as a method to evaluate the criticality of the equipment through the evaluation by scores. This score determines the application of preventive maintenance (critical, important, convenient or optional) as well as the type of maintenance to be applied to each equipment, (see table 2).

Table 2. *Classification by Ipinza Method*

Nº of points	The application of Preventive Maintenance is:	Type of Maintenance to be applied
19-22	Critical	Preventive maintenance
13-19	Important	Preventive maintenance
6-13	Convenient	Corrective maintenance
0-6	Optional	Corrective maintenance

Table 3 presents each condition defined as a function of the level of failure and production quality, to which is assigned a number of points, which, added, result in the total score acquired by the Ipinza Method.

Table 3 *Ipinza Method*

Features	Condition	Punctuation
Effect on production	Stops	4 points
	Reduce	2 points
	Do not stop	0 points
Economic value of equipment	High	4 points

	Medium	2 points
	Low	1 point
Damage - consequence of failure	a) The machine itself	
	Yes	2 points
	Not	0 points
	b) To the Process	
	Yes	3 points
	Not	0 points
	c) To staff	
	Risk	1 point
	Without risk	0 points
Logistics dependency	Foreign	2 points
	Local	0 points
Labor dependency	Others	2 points
	Own	0 points
Probability of failure	High	1 point
	Low	0 points
Ease of repair	High	1 point
	Low	0 points
Flexibility and redundancy	Simple	2 points
	By-Pass	1 point
	Double	0 points
Total		

3. Results and Discussion

A careful survey and analysis of the fabric equipment was carried out, the manuals of the plants were consulted, and maintenance plans were created. Before these were done, a symbology was implemented to facilitate reading by the machine operators and the maintenance technicians, so as to save time after consulting these plans.

Given that the factory has a lot of equipment and that the master file is very extensive, colors have been defined to simplify their consultation and, consequently, the collection of information:

i) Red: corresponds to deactivated equipment;

ii) Yellow: corresponds to damaged equipment;

iii) Lilac: corresponds to equipment that is not represented in the layout of the factory;

iv) White: corresponds to equipment that is in normal operation.

The fact that there is a document that collects the information of the equipment, ensures that the information gathering process requires less time, that is, it becomes more efficient, so that any employee of the company that searches for the information he wants will be faster and will have more time to devote to value added activities for the company.

In the maintenance plans created, three columns were defined: (i) the column corresponding to the equipment system (hydraulic, pneumatic, electrical and power system, lubrication and cooling system), ii) the column corresponding to the maintenance operation together with their symbols and iii) the column corresponding to the frequency with which the operations must be repeated (hours). At the end of the plans were added other operations that are not associated with any particular system, only concern the cleaning of the equipment.

In order to create discipline and rigor in the face of maintenance plans, log sheets for operator maintenance activities were developed. These were only developed for the operators, since the maintenance technicians register their activities in the **software.** ***Figure 3 shows the sequence of work developed by maintenance management software.***

Figure 3. *Software Operating Scheme.*

It is very important to comply with maintenance plans as well as fill in the worksheets, not only to create maintenance routines, but also to create a history of faults in the company. The fact that the operator records observations after each operation, allows the maintenance team to continually analyze the development of the equipment parameters and allows the reworking of the defined hours for the maintenance frequencies in order to create plans that meet their actual needs and more appropriate maintenance intervals.

3.1 Software of Maintenance management

First of all ***assets*** were created. The more specific information about each equipment such as its designation, its physical location at the factory, serial number and the date of installation are inserted in this section and the equipment in question is registered in the ***software***.

Secondly, ***job plans*** are created from the preventive maintenance plans developed. In this section the maintenance operations for maintenance technicians are inserted and their duration is estimated. There is the possibility of attaching images or technical drawings of the specific places to carry out the operations, as well as pertinent recommendations to make. It is also defined the priority of carrying out the work orders associated with these work plans, with level 1 being the most urgent and level 4 being the least urgent.

Third, preventive maintenance plans were created in connection with work plans. Once these have been developed, the maintenance frequency for these plans has been stipulated, so that the program informs in advance that it is necessary to re-conduct the maintenance operations.

It is the maintenance team that definitively stipulates when and what to do the maintenance as well as the deadline for its realization. In this work, it was stipulated that the software launches a warning of maintenance operations, in advance of 7 days. Finally, as soon as preventive maintenance is scheduled, the status is changed to active.

After all these procedures have been performed, the ***software*** generates ***work orders*** (OT). Work orders are associated with developed work plans. These contain the degree of urgency (1 most urgent, 4 less urgent) for its realization as well as

the expected dates for it. After the creation of the OT the state is changed to approved and after its execution and changed to completed. It is possible in this software to define the duration of each operation and also leave comments regarding the operations performed as well as the state of the equipment and / or parameters of the same.

If an equipment requires a new component or body, or if it requires an early maintenance, or if there is an unexpected breakdown of any equipment in the factory, the software has another section called service request. This section allows you to fill in detail the purpose of the ***requested service***, as well as its degree of urgency. When the service requirement is created it generates a work order which, if carried out, changes the state to complete. If only it is approved, but not done, the state is only approved.

3.2 Assets management

According to Regulatory Decree 25/2009 of September 14, Diário da República, 1st Series, number 178, not all equipment has the same depreciation. Depreciation varies, as might be expected, from equipment to equipment and depending on the industry in which they are located.

As an example, an example of cost analysis carried out in the scope of asset management is presented. The company has equipment of specific use that has as function the certification of the composition of the valves that will be sold. This equipment needed to be calibrated outside the company and other problems that needed to be solved were detected. In this way it has been questioned whether it would be better to buy new equipment in view of its devaluation over the years.

Therefore, the information required for this decision is summarized in table 4.

Table 4. *Decision Data*

Equipment Acquisition Cost	Arrangement budget	Depreciation of equipment per year	Existence of equipment in years	Cost of new equipment in exchange for existing one
17000€	3500€	14.28%	6	17000
Current value of the equipment requiring arrangement: 2434€				

Considering that the equipment is currently worth € 2434 and that its arrangement was € 3500 in a first analysis would compensate to buy a new equipment. However, since the new equipment is not valued in the face of the damaged one, and taking into account that buying a new one is expensive for the company, it was only It was decided its arrangement.

4. Conclusions

Using the Lean philosophy, a number of issues as well as improvement points were identified. Due to the use of Ipinza method, it was possible to identify which equipment needs to implement certain preventive maintenance routines, and for those, maintenance plans were developed. In addition, other keys aspects were also accomplished including the completion of the equipment´s codification system, the improvement of the machine's master file, the introduction of document failure registries and the establishment of foundations to implement the Lean's methodology 5S tool as well to manage the company' assets.

Following the implementation of the proposed improvements, more efficiency and a greater performance of maintenance services have been achieved. In addition, significant improvements in decision execution discipline as well as employees' motivation were obtained. The equipment's maintenance management was improved. Assets management was successfully implemented.

As final conclusion, the authors recommend the use of Ipinza method as a decision tool to implement the maintenance plans.

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Running Small Lean Projects in Transport and Logistic Services

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ABSTRACT

Running small Lean projects in transport and logistic services can induce major improvements in quality, reducing cost of operations and reducing lead time. To face the dilemma of improve quality and reducing cost, lead time and meeting the customer demands, providing high quality services.

Lean method is a systematic effort to reduce waste and cost, while simultaneously improve and standardize procedures in order to achieve high quality levels and financial incomes. To achieve the goals, this powerful method takes us on an internal journey in the company and the different logistic departments, looking their inside and tries to improve procedures to use their resources efficiently.

The example of a Portuguese Company that deployed Lean tools on their services will show that the tools and Lean principles can be used to improve efficiency by using the company resources, reducing causalities in production line and during all logistic process.

Keywords: Lean, 5S, Kanban, Poka-Yoke, Jidoka, Kaizen.

1. Introduction

Lean is a theme that has not been sufficiently explored in Portugal and even less known in logistic and transport services, therefore is the object of the present paper. So, this project is a result of a systematic data gathering about Lean theme and the way that he can be implemented in service companies, mainly connected to logistic and transports. Lean is considered a method that can "produce fast quality", but it can induce in false interpretations such as the faster we go, more mistakes can be made. Lean doesn´t focus only after the labour or the machines but reducing times and reducing the waiting time between activities and eliminating non-valued-added processes. Lean tools can also be used in services since the focus of his tools is to improve the speed and the quality in a process and can be deployed in any kind of companies including finance, Marketing, Sales, Human Resources.

2. Lean

Lean principles had their origin in Toyota and they were initially implemented by Taiichi Ohno on the fifties, just after the Second World War, where the natural resources were limited and Toyota was near bankruptcy due to the lack of investment and raw materials. Lean as we know, has derived of many evolution steps within Toyota Production System (TPS) and as a result focus all efforts in adding value to the customer and reducing waste. Lean has his origins in TPS [1], therefore follows four basic rules that provide all the strength:

1. All activities are focused on their content and at the final goal, with a timing and logic sequence:
2. All connections/relations between supplier and consumer must be direct:
3. The flux of the products and services involved must be simple and direct:
4. All improvement occurs according to scientific methods and under the supervision of a Sensei.

Lean adapted TPS basic rules and consider that all activities are properly defined and sustained, otherwise they can create factors of variation, or factors that consume time, efforts, money, raw materials and ultimately produce waste in the company. Such variations can hide or can be the cause of risk factors that can compromise the relationship between the work and the cost involved. These factors of variation induce negatives impacts in an organization, such as, low productivity of human resources, low quality of the final product or the service provided and, as final result, high costs[1].
Following the origins on TPS and keeping the focus on building the structure for the creation of a Lean concept, Fugio Cho during his presidency as Chairman of Toyota Motor Corporation, has created a metaphoric model that describes the concept and was baptized as The House of Lean:

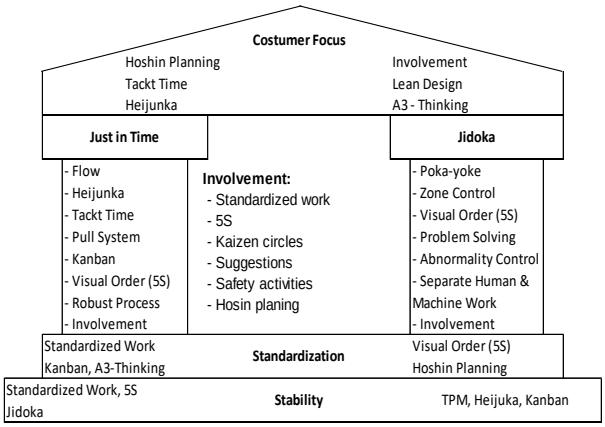

Figure 2 - *The House of Lean* [2]

2.1 Lean Tools

There are several tools associated with Lean, namely, Jidoka, Poka-Yoke, 5S, Just in Time, Kaizen, amongst others.

2.1.1 Jidoka

Jidoka, which in English means automation, was created in Toyota and, is a way to provide one operator or a machine the ability to stop the production process every time that any defect or something abnormal appears while the product or service is processed. This concept was introduced by [3], facilitating the work of one person to operate more than one machine simultaneously, increasing the efficiency of the production. Jidoka term used to describe this process is pre-automation [4], that consists on the ability of a machine to automatically stop the production or a process when the quantity that was programmed is reached or when any activity or defect appears during the process.

Costs that don't add value must be eradicated, so Lean has a crucial part in the elimination of this costs.

2.1.2 Poka-Yoke

According to the same pillar, the equipment's or the systems should have mechanisms to detect defects and that lead to the detection and eradication of errors. These mechanisms are known as Poka Yoke and one worker must be responsible for multiple equipment's and operations, therefore he must process the ability to stop the process once that something not normal appears in the process, or when a problem emerges[5]. The use of flaw-proof devices (Poka-Yoke) induces the process control during all production activities. These devices only make sense to use when the 100% inspection into the process. This way, once a problem appears at the root of the problem is inspected, the process is stopped (Poka-Yoke), feedback is provided and immediate actions are taken.

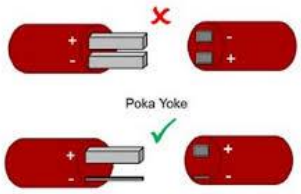

Figure 3 - *Poka-Yoke System* [6]

2.1.3 5S

5S was also created in Japan, after the Second World War [7] and is focused on the organization of the workplace, standardizing working processes and combining efforts to make work more efficient by eliminating obsolete instruments and materials, identifying materials, constantly cleaning the workplace and building a work environment that provides both physical and mental health, providing as well the will to keep the order in the place and to build the continuous improving motivation.

This is a profound philosophy but based on basic practices, providing and promoting one continuous growing of people work culture and the continuous improvement habits on the organization [9]. 5S is based on goals to promote quality, promoting changes on people behaviour, simplifying the work environment, reducing waste, eliminating activities that don't add value, increasing safety and obtaining higher levels of efficiency and quality levels[9].

The costs involving all the 5S process are so low that might be considered as one small investment that can create or provide great benefits [10]. 5S is based on five principles:

1. Seiri – classify and organize any kind of materials according to its nature;
2. Seiton – keeping the place tidy is indispensable to keep the place organized, to organize the materials, optimize the space, providing better access and to contribute to increase efficiency;
3. Seiso – during the cleaning actions emerge opportunities to detect abnormal behaviours on the machines, instruments or any kind of equipment's or technologies;
4. Seiketsu – to standardize or to create standards on the ways of doing things, we need to develop systems that keep the place organized and that keep monitoring the process continuously.
5. Shitsuke – to sustain or keep the changes we need to induce the ability and the discipline to do things right as they should be done.

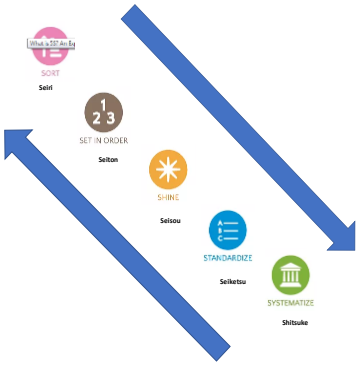

Figure 3 – *5S Method*

5S deployment needs to get all the activities involving the processes simplified at their most basic level so they can provide strength to build and maintain the quality process and quality levels. The main phases are linked with by the cycle PDCA (Plan, Do, Check and Act) where there is not important if they are a phase of the model or if they appear explicitly to the

workers [11], but they know from the beginning that is the right way to work and the best way to achieve and maintain high levels of quality.

2.1.4 Just In Time

There were detected three kind of problems that should be fixed so the industry can be more competitive [12]:

1. The automotive industry was focused in mass production, based on assembly lines where each vehicle produced needed several thousands of elements, therefore incorporating a large number of processes.
2. Each automotive company had a large scale of models and each model with a large range of combinations of the components and extras that change according to the demand of the models;
3. All car models are remodelled and the components suffer the same alteration.

Just In Time (JIT) emerges to avoid problems with inventory and helps to build a culture of correct use of resources. JIT is a tool that allows the creation of production processes that reduces the lead time since the source of the raw materials or since the materials are being processed and place an order at the warehouse until the moment that a vehicle is ready to be delivered.

2.1.5 Kanban

Kanban emerges as a mechanism to highlight each operation inside a process so, when the process needs to be supplied, it sends a message to the predecessor process [5]. This production control tool is also used to make sure that the manpower is used at full potential by:

1. Reduces the cost of data processing;
2. Get to the facts fast and precise;
3. Set limits to the capacity of all predecessor activities.

Using a Kanban system, the predecessor processes are asked to supply after the components are already in use, turning more reliable the production and avoids the excess of production. Kanban means a label or card and it represents one document that contains all the instructions to assemble one item. This way the predecessor process is linked and works like the shelf and the final costumer as the next process. Kanban system allows each station to avoid flaws or excess of materials, search for polyvalent labor, stimulate the continuous improvement processes and the reduction of waste.

2.1.6 Kaizen

Kaizen is an improvement process no matter the process dimension or size that always goes in the direction of Lean goals or in other words, the elimination of waste [13]. Kaizen is also used because one of the main concerns is the improvement of problem-solving, describing the process and process improvement, collecting and data analysis [5]. Usually, the improvement reached with Kaizen is a result of small and subtle changes but the final result is usually lasting and with a growing importance as time goes by. Kaizen is not limited to error eradication but has the important task to locate the root of the problem [13].

2.2 Inside the house

The value created through Lean must be defined in terms of specific products or services, with their own specification, price or cost for specific clients [14], the concept is always determined by the costumers, according to their particular needs, expectations and conditions of access to a particular product or service, with his own price and timeframe. So, each activity adds value to a process and at the end, that added value must be recognizable and identified by the customer. Only after knowing all the flux of inputs and outputs of added value in the process we can dedicate time into waste elimination. Only through the study and development of the following items, it's possible to create value:

Integration	Knowing the customer, suppliers, competitors and all partners will help understanding how to integrate all components and to make the project design covering the needs of all project intervenients
Innovation	The use of different and original elements, creating new solutions
Viability	Providing the best decisions avoiding costs and problems with products or services with inferior quality.

Figure 4 – *Value Creation* [15]

With the objective of knowing Lean philosophy, we need to know the 7 kinds of waste:

Overproduction	Producing large lots can generate economies of scale, but we also need to have into consideration the cost of keeping stocks.
Waiting Times	A process with a bad design leed into productivity losses and delivery delays.
Unnecessary Transports	Moving people, materials and machines without need, takes time, energy and money.
Inadequate Processes	Using high tech in simple processes, wrong use of tools or equipment, excess resources allocation,…
Excess Stocks	Excess stocks lead into aditional costs with transport, space and damage the materials. It hides as well problems with suppliers, transports and equipments.
Unnecessary Movement	A bad performance at work can be related to organization issues, consuming time, energy and don't add value.
Flaws / Defects	Problems with quality.

Figure 5 – *Lean Seven Kind of Waste - Toyota Company (2007)*

Initially there were only seven kind of waste and it was needed to include one new source of waste related with the inefficient use of Labor [17]:

Inefficient use of Human Resources	Waste of time, skills, lack of ideas and training the workers

Figure 6 – *Inefficient use of Human Resources* [17]

When the use of this method spread into other industries, including industries related with services, there where added six more kind of waste to the list [17]:

Using Unappropriated Systems	Inadequate software systems or technologies
Energy Waste	Fuel, Electricity, Gas…
Waste of Materials	Shelf life, potential re-use of the materials must be considered before designing the product and configuring the production design.
Office Waste	Irresponsible and inadequate use of office materials
Inefficient Inspections	In any process it's preferable that inspections due to flaws are reduced to the minimum so its necessary to reduce the probability for the problems to happen using anti-flaw systems (Poka Yoke)
Waste of Costumer Time	When the customer needs to wait for a service or information due to long processes, it can cause customer dissatisfied and the dissatisfaction cause may be related to the process design

Figure 7 – *Waste from Services Industries* [17]

The Lean tools are designed to maintain the involvement of the team on activities that can reduce waste and add value to the final product or service.

3. Lean Tools in Transport and Logistic Services

Transport and Logistic companies are facing new challenges and restrictions that require attention, financial efforts, methods and techniques that can help to place this companies in the line of efficiency, reducing costs and al redundancies that affect directly the financial and quality results.

In transport and logistic services if we ask to a group of 20 individuals from different companies how they perform their job describing their tasks step by step, the probability to have the same answer is very slim, probably we end of with 20 different descriptions about the same job. Therefore, we raise a question: How can we improve a process that is built by twenty processes? Or, how can we improve something that doesn't exist?

Combining these twenty processes we will compose a better process for everyone, a process that can make every task consistent and produce better results, using less time and reducing waste. The lack of standards and well documented processes is one of the reasons that improving processes in transport and logistic services can be a big challenge. Filling up

the gaps becomes a critical issue because it can induce the variation reduction and waste leading to significant earnings in quality, time and financial.

Combining Lean tools in transport and logistic services will improve the processes, financial incomes and will contribute to continuous improvement.

3.1. Deploying Lean Projects in Transport and Logistic Companies

Before deploying Lean projects in transport and logistic services, the companies should adapt and create a model that can provide an answer to their needs. Inside transport and logistic services there are some options where adapting this model can work:

3.1.1 Be Creative When Setting Up the Dates for Project Meetings

Looking inside the transport and logistic services company that supported the case study, when we decompose the transport service and look at the beginning, it's always someone from the traffic department that start the service by accepting the job. Then the executive chief of traffic control of the company needs to plan all daily schedule and places to go for every driver, times and places. After, when the driver is on his way back, it's important to define the loading times on the customer, so the service can be profitable. After creating all the schedules, the team must inform the driver when and where the cargo should be unloaded or loaded and the precise times along the driver daily route. In this particular case, the most important is for the vehicle to leave the dock full, perform all unloading activities and return to the warehouse with the vehicle full of cargo to be delivered on the next day, all over the country.

All staff involved opted to have the brainstorm meetings on the end of the day to provide all data about the exact places of unloading and loading of the day, the conditions and restrictions they had, so that on the next delivery or pickup, in the same place, the driver and the car should be ready to face all obstacles. After considering all data, where identified some restrictions that should be taken under consideration:

- The drivers legal schedule, 8 hours driving and 15 hours on the working day to finish the service during the day or 8 hours driving and 10 hours on the working day to finish the service during the night.
- The loading and unloading timeframes on the big retailer's logistic centers.
- The loading or unloading places with timeframes after the retailer's service.
- All the rest of the deliveries and pickups on time to get back on the base without extra hours.

This was the exact starting point for all the discussions and it took a few days to reach one agreement because each and every day new obstacles arisen and new opinions to solve the problem where presented to the group so the process could be improved. So, on the end of the first week the meetings where ended with a list of all the points that the project should take in consideration such as:

- The way that the vehicle is loaded - the cargo must be properly placed and secured.
- The cargo must be placed in order of unloading, or at least "almost" in order of unloading. The "almost" was taken in consideration when one pallet is too high and the next too small, so the cargo will not be secured and fall down.
- Beginning the loading operations in early morning, making the drivers move all cargo loaded in all following unloading places, losing precious time.
- The office providing help to find the final unloading places and contact the final destinations so they can be ready to unload the vehicle.
- The information must flow both ways between the traffic department and the drivers and also between all drivers that are at the same road so they can inform the colleagues about the traffic conditions or the final places of loading or unloading.

This informal meetings brought into the table options for improvement that where ultimately tested on their day-to day activities so the improvement proposals can be properly tested and taken as normal way to do the job by all the team and at the same time leaving some room for improvement or activities that can contribute for continuous improvement. All these activities can lead into better financial results, reduction on time wasted, effort, fuel, electricity…, and at the same time providing a top service and fulfilling the customer needs. All meetings and extra work hours dedicated to this project, were rewarded by the simple fact that the drivers are actually working less hours and with less effort.

3.1.2 Look for Opportunities that can Provide Fast Results

It was decided from the beginning to start the first small project on the Third Party Logistic (3PL) warehouse. All involved staff had identified actions that could improve processes and reduce accidents and incidents with the pallets inside the warehouse. So, it was only needed to set a few new rules to do the service as the way that the pallets are unloaded from the truck to the warehouse.

Initially, all pallets where unloaded to one particular place at the warehouse so the truck could be unloaded as soon as possible so that could leave the dock as soon as possible. The problem was that all pallet references where mixed and the time spent to check all pallets was too much, the truck and the driver where in fact in a short period of time at the dock but then, they were waiting for the time that the staff was checking the goods in to the warehouse, the quantity, grouping them by batch, checking pallets for damages and, finally signing in the goods. After that, the driver was released and then, the staff started to move the pallets to the 3PL warehouse and in racks according with the batch number.

Immediately they had recognized that this process was full of waste so they analyzed and mapped the process starting with a simple rule, Unload – Check Properly – Place according Batch and then, everything was placed on the 3PL warehouse. If some of the pallets had one problem, the customer was immediately informed and photos where provided. At the end of 3 weeks, 50% of the time was reduced by cutting non-value –activities. All the time that the driver spent waiting to be released was also reduced in 60%.

3.1.3 Including Kaizen to Accelerate the Process

Deploying Kaizen improvement processes on 3PL services, all actions involved a specific and intensive work on all improvement actions, mainly due to the time that staff dedicate to the project usually ended on the end of the project hours. During the rest of the hours, the staff was involved in another project to change the layout of the warehouse and the racks, providing more storage space on the 3PL warehouse and at the same time, providing space for the operations warehouse and also reducing the time spent on operations warehouse. All this improvement had also affected the problems, accidents and incidences with the pallets in more than 50%, increasing the customer satisfaction and reducing the loss.

This model was designed in working hours and without any kind of interference of the management and after the first week, the management team and all board of directors where amazed by the results achieved and both the enthusiasm carried by all people involved in the process. They all had seen the quick results, and the fact that they were having less problems and less extra hours.

This was a big win for the team, but there were other situations that it was very difficult to pull out the staff from their own “normal” activities to look at the processes, study and establish a plan for improvement. Even though and facing this situation, the staff started new ways to adapt and face the day-to-day problems and adapt to the new challenges and at the end, they had achieved extraordinary results. All kaizen tools adapted worked due to:

- They are based on people knowledge, the same people that do the work.
- They use data collected on the decision-making process.
- All begins with a small description of the problem or an opportunity ready to be placed in action.
- Verifying the goals each and every step of the way so these goals can be measured.

3.1.4 Try to go Further than the Limits of the Team Every Time You Can

When the staff conceived and presented a draft to improve the layout of the warehouses, a short while after they started to map and to study the process, it was created a new group that involved drivers, traffic department, cross-docking, warehouse operations and, 3PL staff and management where:

- Drivers – they had put on the table all their concerns with the time spent loading, unloading and the way that the cargo was placed on the vehicle.
- Traffic Department – they were worried with the flow moving the pallets and the general cargo at the warehouse, and the amount of time that the vehicles were on the dock.
- Warehouse Operations – they were worried with the space they had to move all the cargo, receiving and expediting, checking and storing in the minimum time possible and without incidents/accidents.
- 3PL Staff – worried the way that the cargo was received, checked, moved on the warehouse, stored and dispatched without accidents or incidents.
- Management and Administrative Services – worried with data flowing from the warehouses to the office, from the office to the costumers and, at the end, to keep the customer happy.

3.1.5 Establish Realistic Goals

All the actions connected to the project and initially deployed in the company had has an initial common goal to map and describe all processes and, after knowing the processes they could chose the ones to be targeted by Lean small projects and then, they developed improvement actions that could provide fast results and better fit the team.

In the beginning, it was difficult to start, no one wanted to spend more time at the company or "loose" time to be involved on the projects, a few staff members were "forced" to be a part of the first Lean Team, so, for the leaders of these projects the pressure was very high but, after the two weeks work and the first Lean small project finished (3PL), all teams and departments saw the results, and then all staff was eager to be a part of a project and started to give new ideas for new Lean small projects.

In the end, all of these Lean small projects got positive results, some of them even exceeded the expectations keeping all staff and the administration eager to be involved in future projects.

3.1.6 Be Careful Composing the Team

One of the problems that the first Lean team leaders found was the available that the staff had to be involved in the project, so it was a challenge to build a team that could be involved in the project, do the daily activities and deliver results. Initially, some of the staff members felt "forced" to belong in the team because they were the head of the departments or persons that their job makes them as a mandatory presence in the project because they were the ones that knew the project from the beginning until the end, so to identify and define the processes they were not replaceable. Even "forced" to be a part of the first Lean project, soon enough, the same persons where the key for the success, the first motivators to find new ways to improve the process and they kept on working the new ways of doing things.

On a second phase and still facing the success of the first Lean small project and the impact that all improvement actions had on the company branch, the staff got involved and made a personal effort to be a part of the next Lean small projects teams. That was a real turnover for the team leaders, the staff moved from "forced" to dispute a membership on the next small Lean project or creating brainstorm sessions to find new ideas, new ways to improve the service.

3.2. The Origin of Waste and the Need of Lean Tools

In services related companies there are a few reasons why their departments and the services they provide need Lean tools:

- The services process are slow, expensive and with low quality. They affect the costs, causing them to grow, creating non satisfied customers and compromising the company revenues.
- The processes are slow because they have too many work-in-progress (WIP), the origin of this WIP can be the reports stuck in a desk waiting for one approval, e-mails in the mailbox waiting to be taken care of, or sales pending because they are waiting for a simple Ok. When we have to much WIP, the effective work can be on hold around 90% of the time a fact that is not helping the customers satisfaction and injects costs on the process.
- In any slow process, 80% of the delay is caused by less than 20% of the activities related to the process. So we need to focus in 20% of the steps or activities of the process to gain time on the cycle reducing it by 80% and raising the percentage of the on time deliveries.

Lean when applied to service companies is based on a fast way to get results and these results can be seen from the beginning until the end of the process, supporting the strategic goals related to the project.
Before starting one *Lean* project, we need to make shore that all staff from all departments is involved on the project and working with the same goals, avoiding barriers to implement the project, making the improvements a day-to-day activity and contributing to a continuous improvement environment.

3.3 Challenges in Transport and Logistic Services Processes

The way that the transport and logistic services work can set multiple difficulties identifying what should be changed and how it's going to be repaired. It's not easy to get in a warehouse office and see how the work flows, the way that al materials flow inside the warehouse until are finally despatched. So, in logistic and transport services the challenges to find and improve the processes can include:

- Track back the work flow, encouraging the team to be creative and to identify the part of the process they are currently working on;
- The individual work, where the staff member is generally told what to do, how to do and what the company expects from his work and he is left to his own luck, doing his own way the daily duties that the company expects from him. Therefore, the easiest way we have to make the staff accept all the changes on the process by involving them on the decision making process.
- The lack of data to support decisions. We need to know the amount of work that is kept waiting on any time of the process. This work doesn't refer only on late deliveries, traffic, preparing the cargo on the warehouse, but all work supporting transport and logistic tasks. We need to know and keep on track the average time that spent on daily tasks, like phone calls, reports, orders…
- The processes connected with transport and logistic services are extremely dependent on human interaction. It's easier to reduce times in one equipment than to make a person related to traffic control of a transport company reduce the time of a phone call with a customer or a driver when he his receiving or transmitting instructions or when he is dealing and organising services requests from all over the country. We should consider all problems and difficulties with the staff in each and every step of the improvement deployment process, for that we need to involve the staff in a continuous improvement actions and turn this actions in day-to-day activities, supplying all training needed so they can understand the importance of the changing process.

These challenges can look a little frightening on the beginning but can contribute to improve the service process and at the same time to be gratifying to all people involved because they can put in action all their creativity. Since the results and the earnings with this kind of projects are fast, they can be seen by the staff and the staff can see all their contribute put in action into a common goal.

3.4 Recognizing Waste in Transport and Logistic Services

The greatest challenge when deploying *Lean* projects is in fact to be able to identify the waste and most of all, waste origins. Unfortunately, most of transport and logistic services the way of doing things are always the same and people tend to accept all kind of situations in an erratic or automatic way, walking around in every directions and simplifying only one little fraction how the work should be done. In transport and logistic projects part of *Lean* discipline consists in identifying the "*7 Ways to Produce Waste*", now adapted to transport and logistic services:

Waste 1 – Overpricing the Service – trying to give to a transport or a logistic service one value or price that the customers don't recognize or are not willing to pay for it:

1) This situation emerges when the company doesn't really know the customer needs and ends up to input more value that the customer is willing to pay for the service.
2) Allowing non-value-added activities inside of a process, turning al activities slower than they should be and increasing the working time inside of the process itself.

So facing this problem, the Lean team started to improve the processes and took actions that allowed reducing accidents and minimizing waste:

a) Including one person to help the driver in deliveries that need to be handled by hand.
b) The creation of specific prices to a specific service so the customer pays exactly for what he had the service contracted with the company.
c) Adjustment of the branch fleet according to the customer's needs and cargo destinations.
d) Adjusting the vehicles with equipment's to perform the job (pallet holder, GPS, trackers, scale).

Waste 2 – Unnecessary Movement of Products or Data – this is one of the biggest problems in this sector, because moving cargo more than we need means to spend more money with fuel, electricity, time, human recourses, machinery, the paperwork involved and increases the risk of accident while the cargo is moved from one place to the other.

Transport Service – we need to make shore from the beginning what we really to make the transport service, the conditions that the final destination have to handle the cargo, the roads (straight, traffic…), the unloading times, the roads that the driver can use, if the customer have space for the cargo, if is someone at the final destination to receive the goods… otherwise, the company needs to bring back the cargo, wasting fuel, time, driving time and space in the vehicle to the day's pickups. Once the traffic knows that the cargo is returning to the base, they need to perform an internal incident report, communicate the problem to the customer and to set up a new delivery date. Meanwhile, the cargo is coming back to the warehouse and the risk to have one incident increases because it's in the way of all the rest of the deliveries. Facing this problem, the Lean projects team took into action the following improvements:

a) Reducing distances with empty vehicles in 40% by finishing the deliveries near the first pickup.
b) GPS navigation and trackers to help the driver avoiding traffic and avoiding detours.
c) After the last delivery the vehicle only moves to go to the next pickup point.
d) Creating one office in the warehouse to avoid the drivers to go around the warehouse and the offices looking for documents or instructions.
e) Every time that is possible, the cargo is loaded on the vehicle according to the destinations. This rule is only broken when the size or the safety of the cargo don't allow to perform the service.
f) Confirming in advanced all conditions on the delivery places, avoiding the return of the cargo.

Logistic Service - the unnecessary movement of cargo leads us into a waste of human recourses time, materials, energy, and fuel creating serious delays on the service. When the process is not clear, it takes us to contract more cargo handlers and machinery. The risk of damaging the cargo increases every time the cargo is moved. Misplacing the cargo, loading on the wrong vehicle or even losing the cargo.

When the logistic services where analyzed, the major improvement actions involved:

a) Reducing or terminating the unnecessary movement of cargo inside the warehouse.
b) Identifying and Placing the cargo if possible, always near the place of storage or dispatch.
c) Keep the driver updated of any changing in cargo manifest or destinations.

Waste 3 – Unnecessary Movement of People and Materials – Moving people or material refers to the situations that the staff need to change between programs, printers, offices to perform their job, moving around the building picking up documents or delivering documents without need for that. One of the solutions is to rearrange the office and the staff desks near the places or equipment's they need to be, avoiding waking around the office to get one printed paper from one printer that should be near the desk.

Facing this situation, the improvement actions involved:

a) Placing the equipment's near the users.
b) Adapting informatics tools making them easy for the final users.
c) Creating routines avoiding getting in and out constantly the programs.
d) Creating routines avoiding unnecessary walks around the office or warehouse.

Waste 4 – WIP that Exceed the Customer Needs- WIP can create waste, cost related while they are waiting to be used and causes long lead times, increasing the probability of the service don't match with what it's really needed. To avoid WIP that exceeds the customer needs, the following improvements were taken into action:

a) Creating logical working sequences.
b) Replacing and eliminating forms that don't add value to the process.
c) Analyze all pending cargo and pending requests.
d) Quick response reports to the traffic and costumers with cargo accidents or incidents.

Waste 5 – Time Between the Beginning and the end of a Process and the Beginning of the Next Activity – in services, the amount of work between activities is almost invisible. The waiting times are a problem to transport and logistic companies, so we need to map the process to find delays and congestions. Mapping the process, we can see where the process is stopped and waiting for someone to do something.

To reduce the waiting times, the improvements where focused in:

a) Creating loading and unloading booking times in the main warehouse.
b) Booking unloading times in final destinations.
c) At the end of the day, analyzes everything that went wrong so the problem won't repeat.

Waste 6 – Any Aspect of the Service that doesn't Match to the Customer Needs – in transport and logistic companies delays, flaws or incidents can result on missing the delivery agreed time, lack of information passed to the driver,…, causing the customer to be not happy with the service and ultimately with the company. To improve this area Lean project focused in:

a) Giving clear written instructions to the drivers.
b) To be quick communicating accidents or incidents with a delivery to the traffic and to the customer.
c) Careful use of equipment's.

Waste 7 – Service Overproduction – The Work Involved is More than Necessary - Improving service overproduction involved actions that helped to:

a) Supply the service that the customer asked without using any other non-contracted tool except when it was helpful to the driver or the service itself.
b) Planning "exceptional" deliveries (due to the size, weight, the specific equipment's involved, unloading places…), the traffic should be informed in advanced off all accesses, unloading conditions so they can properly plan the delivery, avoiding the return of the cargo.
c) When it's necessary to bring back and deliver the same cargo on another day, this must be properly planned and the cost must be supported by the customer.

Overproduction causes service congestion with unnecessary non-value-added activities that the customer didn't ask or simply don't want, causing congestion on the internal services and waste. In the case of the transport, Lean team found and took action on the following:

a) When a customer wishes to get their POD's by e-mail, there is no need to print them out and sending them by mail, wasting time and money on post.
b) When they use one vehicle with help to unload one pallet in one place that have a fork lift, they were wasting one person only to travel, while he could be of better use elsewhere.

4. Conclusions

It is important to outline that all results achieved with the Small Lean Projects were the result off all team involvement on them, at first it was a little shy involvement and for some, "they were made to be a part of the project" but soon enough, everybody got involved and made their best to create and keep the results achieved. One "secret" of the success was the involvement of the owners and management team, they started the project as their own and made the first team, this way all company staff saw their will and personal involvement making it easier the improvement process and to keep the changing process. Without this personal involvement of the top management team all improvements, changing process and all results would be seriously compromised.

It's important to take into consideration the people that keep the process in action because they are the key for the changing process and all the improvement actions, their personal involvement will lead to better and faster results.

4.1 Small Lean Projects in Transport and Logistic Services Conclusion

The constant and fast changes in transport and logistic services force the companies to pay attention to the market, to have a close relationship with the customers so, when the time comes they can adapt to the changes and improve their services while fulfilling their needs and keeping the customers happy and improving financial results. There is no limit to the creativity or the service improvement, for example it's possible to place one cargo in all big distribution Hubs in 24 hours.

When applying Lean methodology and Lean Tools to transport and logistic services show that a systematic effort to detect, control and reduce waste and at the same time, reducing all cost involved in the process. At the same time, these tools are correcting and improving the processes, turning them into standard processes, allowing them to achieve high quality standards and improving financial results.

In the studied company the Small Lean Projects had reinforced the opinion of all authors quoted on this paper, since these projects brought to the company better quality and higher financial results and al the process improvement activities were kept in time and some of them where targeted in other projects to keep on the improvement process. The management team kept on the involvement on the changing process and the small projects, keeping all staff involved in the continuous improvement company actions.

All the achieved results kept the internal customers happy (Transports, Drivers, Warehouse, Cross-Docking, 3PL, Office…), keeping happy the company customers with the improvements on the services provided and reducing accidents, incidents and problems with the cargo. All these improvements had contributed to improve the company name and image in the market.

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TRIZ and Lean Philosophies applied to Management Activities

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ABSTRACT

In the current market, the Portuguese industry faces strong competition from countries with substantially lower operating costs. The agri-food industry is also subject to increasing competitiveness, both nationally and internationally. The utilization of methodologies that, in addition to continuous improvement, provide the development of creative and innovative solutions may be relevant for highlighting and differentiating between organizations. In this work, *Teoriya Resheniya Izobretatelskikh Zadach* and Lean Philosophies have been implemented together. Methodologies as Matrix Ideality, Matrix of Contradiction, Single Minute Exchange of Die, 5S and the Substance-Field analyses were used as complemented tools to improve the production management activities of agri-food sector. Strongly focused on the issues of time wastage and the organization and management of the filling line, the implementation of these methodologies led to a reduction of *setup* times, of the operators' movement and an improvement in the line's management and organization, and improve the results of 5S audits, depending on the work station.

Keywords: Matrix of Ideality, Matrix of Contradictions, SMED, 5S, Substance-Field Analysis

1. Introduction

The agri-food sector is currently the largest industrial sector in Portugal and Europe, representing 16% of the manufacturing industry in Portugal. Nationally, it is composed of small and medium-sized enterprises, highly dispersed, employing about 114,000 workers, divided by about 11180 organizations [1, 2]. In 2018, this sector had a turnover of around 16,952 million euros, an increase of around 3,000 million euros when compared to the year 2010 [2]. The detailed analysis of the agri-food industry is represented in table 1, through a SWOT analysis [3].

Table I. *SWOT analysis in the agri-food industry*

Strenghts	**Weaknesses**
Largest industrial sector in Portugal and Europe	Consisting mainly of small and medium-sized enterprises
Highly diversified sector	Necessity of certification
	Lack of negotiating capacity in relation to distribution
	Lack of specialization
Opportunities	**Threats**
Custumer proximity	Raw material price growth
Turnover growth	Decrease in consumption
	Competition

In European terms, in 2017 the agri-food industry had a turnover of around EUR 1089 billion, employing about 4.25 million workers for about 289,000 organizations. As a highly diversified industry, its turnover is divided by several specific sectors, such as dairy products, drinks, fats and oils , bakery and farinaceous products, among others [4]. The division of turnover by all sectors at European level is shown in figure 1.

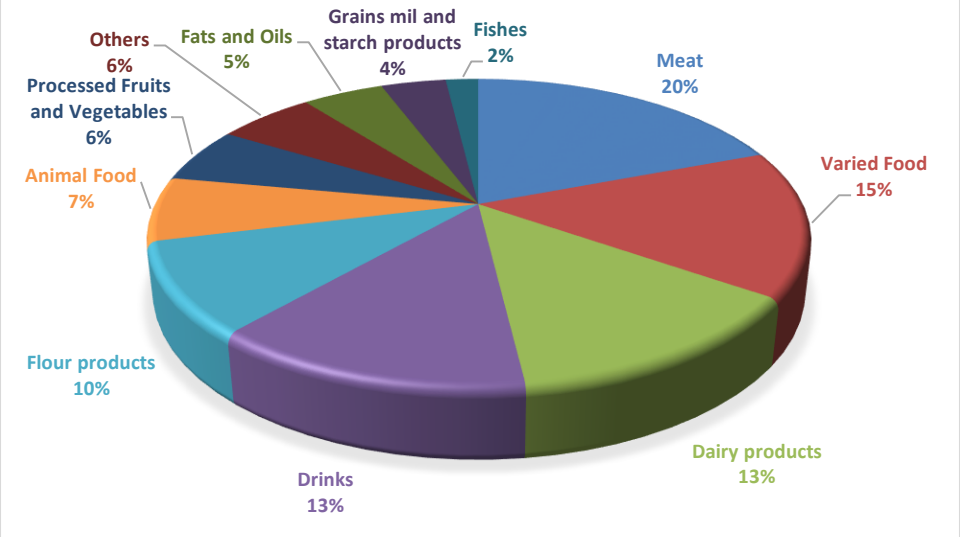

Figure 1. *Division of turnover by food sector at European level*,

In this work a methodology was developed to reduce waste present in a can filling line, aided by the use of TRIZ methodologies and Lean analytical tools identifying the improvements and implementation of solutions. In this way, several activities were defined, carried out in a logical order.

1.1 Lean Philosophy

In the early twentieth century, Henry Ford introduced mass-production techniques in automobile manufacturing, by changing the standard of handicraft manufacturing to series production. The production method has changed from small workshops with highly skilled workers to large work areas with specialized, high-cost equipment, reducing the need for manpower. Increasing the complexity of the processes resulted in a greater supply of products which, in turn, led to stock

accumulation and increased process times, increasing customer response time and customer complaints. Coupled with the new industry processes implemented by Henry Ford, customer expectations grew rapidly, requiring greater final product customization, reduced process times, better quality, and lower prices. To respond to customer demands, the industry, notably the Japanese, led by Toyota, has redesigned the rules of industrial management [5].

Toyota Production Systems (TPS) originated the concept of ***Lean***. Created in 1940 by engineer Taiichi Ohno. TPS was developed as a philosophy oriented to the efficient satisfaction of the customer needs and expectations, based on the desire to produce through a continuous flow that did not depend on mass production to be efficient. What is currently referred to as ***Lean thinking*** is an extension of Toyota's production system. The comparison between the mass production techniques developed by Ford and the ***Lean*** production developed by Ohno is presented in table 2 [6]

Table 2*. Comparison between Mass Production systems and Lean Production*

	Mass production	**Lean Production**
Base	**Henry Ford**	**Toyota**
Workers - design	Semi-skilled workers	Team of multi-skilled workers
Workers - production	Unskilled or semi-skilled workers	Team of multi-skilled workers
Equipament	Expensive equipment with a single purpose	Manual and automatic systems capable of producing large volumes and variety
Production method	Large volume of standardized products	To produce what the customer ordered
Organizational Philosophy	Hierarchical - management takes responsibility	Value flow using appropriate levels of power
Philosophy	Search for "sufficient"	Search for perfection

1.2 Triz Philosophy

The increasing need to increase quality, lower costs and, at the same time, remain competitive, leads organizations to aim for process improvements that result in efficiency gains. However, improvements in existing technology are no longer enough, and a radical increase in the resource efficiency use is needed [7]. To this purpose, companies focus on innovation as a means of survival, resulting in inventions that solve problems in an efficient, effective and creative way [8]. It was for this purpose that Genrish Altshuller, engineer and Soviet inventor, developed the TRIZ methodology.TRIZ, acronym of *Teoriya Resheniya Izobretatelskikh Zadach*, is equivalent to Inventive Problem Solving Theory. This methodology is characterized by the use methodologies in order to generate creative ideas in the process of product development and problem solving [9].

TRIZ began to be developed by Genrich Saulovich Altshuller in 1946, through the study of more than one and a half million patents from different areas, in order to search for alternatives to the methods of creative solutions then available. Altshuller's analysis of the patents and the solutions described in their application revealed the existence of five inventive levels, leading to the conclusion that the inventive value of different inventions is not the same. The five inventive levels are represented in Table 3 [10].

Table 3. *Five inventive levels*

Level	***Level Description***	***Patents***
1	Routine solutions using methodologies known in the field	30%
2	Minor fixes on existing systems, using methods known in the area	45%
3	Significant improvements that solve contradictions in systems of a specific area branch	20%
4	Solutions based on the application of new scientific principles	4%
5	Innovative solutions based on untapped scientific discoveries	1%

Solution development may follow different procedures, depending on its inventive level [7]:

- Conventional improvement of existing systems (level 1 and 2);
- New procedures with existing operating principles (level 2 and 3);
- Creation of a new system with new operating principles (levels 4 and 5).

TRIZ has as main objective to assist in the projects of levels 3 and 4, where general engineering solutions do not produce the desired results [10]. From Altshuller's point of view, level 1 and level 5 projects are ignored since, respectively, they are not innovative and require a high level of knowledge [11].

TRIZ introduced a methodology that circumvents the idea that the most significant methods for solving technical problems would be unique for each engineering area [12]. This methodology, illustrated in figure 2, generalizes specific problems to identify examples of solutions that may be particularized in specific solutions for each problem.

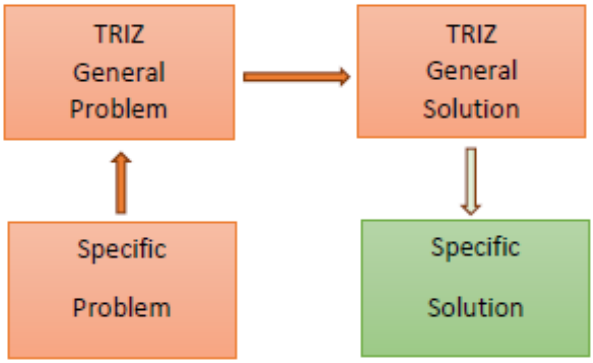

Figure 2. *TRIZ Implementation Methodology*

2. Methodology

The development of this work was performed in a can filling line of 33cl and 37.5 cl, having the filling capacity of 60,000 cans per hour. The line is composed of 9 main machines.

The presence of 2 types of packaging machines (Hi-Cone and OCME VEGA) and a packer (OCME TH) allows the line to be extremely versatile, allowing the production of 10 different final product formats. The machines that make up this line are:

1. Depalletizer: puts the empty cans in the line, which are supplied in pallets of 23 rows.
2. Filler, harrower and level 1 inspector: fill the beer / coolant cans, which are then closed on the harvester and inspected at level 1 inspector.
3. Pasteurizer: heat the product to 70 ° C in order to eliminate microorganisms. It increases the life of the product and ensures that it is safe for consumption.
4. Daters and level 2 inspector: marks the cans with expiration date and lot. After dating, the cans go to the Level 2 inspector.
5. Hi-Cone Packer: Pack the cans with Hi-Cone film.
6. VEGA OCME wrapping machine: packs cans with retractable film.
7. OCME TH Packer: packs loose packs or cans with carton and retractable film.
8. Palletizer: palletizes the packs packaged / packaged in half-pallet and whole pallet.
9. Wrapping and labeling of pallets: involves the pallets with transparent retractable film, and these are then labeled, through the pallet labeler.

The final product formats of the fill line 94 are as follows:

a) 37,5cl can- Pack 24 of loose can
b) 37,5cl can- Pack 24 (Pack 8 x3)
c) 33cl can- Pack 24 (Pack 6 Hi-Cone x4)
d) 33cl can- Pack 24 of loose can with cardboard
e) 33cl can- Pack 24 of loose can
f) 33cl can- Pack 18 with cardboard
g) 33cl can- Pack 12
h) 33cl can- Pack 24 (Pack 6 x4) with cardboard
i) 33cl can- Pack 6
j) 33cl can- Pack 6 Hi-Cone

The first phase of the study focused on the analysis of the filling process, including equipment stops, set-up times, sequence of activities performed during the various setups and all the fundamental concepts and activities associated with the can filling process in the line.

In the initial analysis a Pareto diagram was performed with the total stop times of each equipment. Defining 3 aspects to be addressed in the study to be carried out, followed the identification of the critical points to be improved [14]. In order to identify the priority parameters of the line to be developed and improved, a brainstorming was conducted with a heterogeneous group of factory workers, including the filling head, engineering chief, engineering trainees and line operators. Based on this brainstorming was built the Matrix Ideality. The "Setups" and "Costs" were identified as the most relevant parameters for a possible improvement in the value of ideality.

In order to complement the parameters chosen in the previous step, the parameters were adapted to the Contradictions Matrix, a TRIZ tool that allows the selection of inventive and innovative principles that best suit the problems in question. From the implementation of this methodology resulted as methods of improvement the Prior Action and Continuity of Useful Action, both of which are reviewed in the application of the Lean tool, SMED- Single Minute Exchange of Die.

Prior to the application of SMED, it was necessary to carry out a prior analysis of the types of setup, due to the existence of a large amount of them. For this, the average duration times and the frequency of each were considered. Defining the 3 types of setup to be improved, the SMED methodology was implemented.

To standardize the setups and reduce the variation between shifts, several operator support documents were developed, such as format change manuals, checklists, and work instructions.

Another of the points to be addressed was the organization and management of the line. For this, the Lean 5S methodology was used. Through a 5S audit and using a checklist, several critical points were identified.

In order to determine the methods for solving the identified problems, another TRIZ methodology, called Substance-Field Analysis, was used, which, through 7 general solutions, allows the development of specific solutions for each problem.

3. Results and Discussion

Prior to any proposed improvements, it was imperative to carry out an initial situation analysis of line stops. Based on the data collected, a Pareto diagram was developed (see Figure 2), which allows an easy visualization of the most important problems of the filling line, leading to a prioritization of the most relevant.

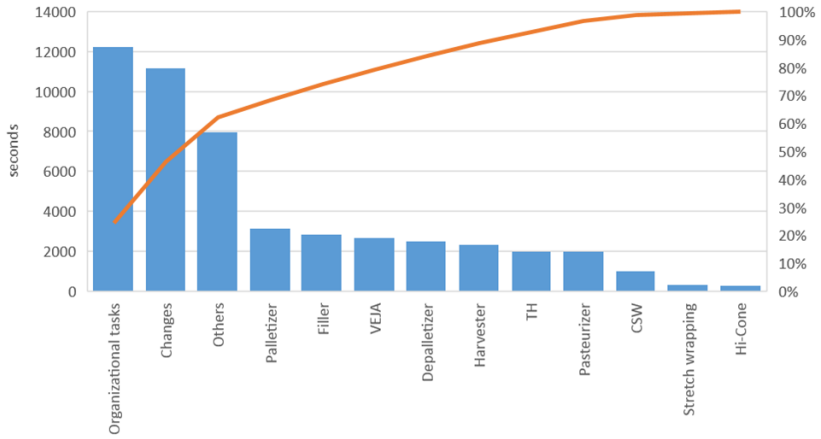

***Figure 2**. Pareto diagram of the line 94 filling stops*

Observing the Pareto diagram (Figure 2), it can be seen that this does not follow the rule called 80/20, where 20% of the stop types give 80% of the total stop time. In this case, 20% of the stop types originate only between 46.27% and 62.03%. From another point of view, 80% of the total stop time of the line is caused by 46.15% of the stop types.

It is noted that there is no concentration of the total stop time in a small number of stop types, so it is necessary to define a point that balances the two parameters. The following stopping causes were defined as follows: organizational tasks, which correspond to stops due to departments outside the filling, such as logistics, quality, syrup and manufacturing, and tasks related to the organization and management of the line; product / format exchanges; other stops, which represent line stops due to unspecified machines. These three types of stops make up 23% of all stopping causes and give rise to 62% of the total stopping time. Due to the nature of the stopping type, the topic of organizational tasks was addressed with limitations, being restricted to the topic of organization and management of the filling line.

Table 4 presents the Matrix Ideality that allowed the identification of interactions between requirements and distinguish positive and negative effects. Through the analysis of the Matrix Ideality (Table 4) it was possible to determine the value of System Ideality through Matrix Contradictions and Engineering parameters [7, 13].

The engineering parameter that presented the greatest number of contradictions in the Ideality Matrix was "Time wastage". The principles associated with the parameter "Waste of time " were identified, and it was possible to identify which of these are possible solutions to the problem in question: "Prior action" and "Continuity of a useful action". The 2 principles are related, and can be applied together through a Lean tool, SMED. Table 5 shows the results obtained in the improvement of setup times after SMED application in the 3 different setups.

Table 4. *Matrix Ideality*

	Parameters	1	2	3	4	5	6	7	8
1	Productivity							-	-
2	Setups	-				-	-	-	-
3	Versatility		+			-		-	-
4	Reliability	+					+	+	-
5	Automation	+			+		+	-	+
6	Availability	+			+			+	-
7	Maintenance	+			+		+		-
8	Costs		-	-	-	-	-	-	

Table 5. *Time improvements achieved through the SMED application*

	INITIAL SETUP [min]	FINAL SETUP [min]	IMPROVEMENT [%]
PRODUCT EXCHANGE (REFRIGERANT)	66.1	27.0	59.1
PRODUCT EXCHANGE (BEER)	19.7	6.0	69.5
FORMAT EXCHANGE (HS MP FOR P12P	89.3	35.9	59.8

Table 6 shows the results obtained through the application of SMED, in the improvements related to operator movements. It is possible to observe a considerable reduction in the movements, a reduction that is directly related to a reduction in equipment downtime (see table 6).

Table 6. *Improvements related to movements obtained through the SMED application*

	INITIAL [m]	FINAL [m]	IMPROVEMENTS [%]
MOVEMENTS	116.8	86.2	26.2

One of the focal points in the filling line was the organization and management of the work space, evidenced by the Pareto diagram shown in figure 2. The Lean 5S methodology was applied, which focuses on the organization of the work place and the standardization of processes, with the objective of simplifying the stations and reducing waste. For that, a checklist was prepared with elements of all 5S senses, which was used in the audits performed before and after the implementation of the improvements. The percentage representation of the implemented improvements is presented in table 7.

Table 7. *Improvements achieved through the implementation of 5S*

	INITIAL AUDIT [%]	FINAL AUDIT [%]	IMPROVEMENT [%]
STATION 1	80	93	11.6
STATION 2	85	91	9.3
STATION 3	74	89	12
STATION 4	80	94	11.8

4. Conclusions

From the initial analysis of the Pareto diagram, it was verified that of the equipment stop times, the ones with the greatest influence on the total standby time of the line were:

• Organizational tasks, which correspond to tasks related to the organization of the line and activities performed by departments external to the filling, such as logistics and quality;

• Exchanges, which correspond to line stops resulting from changes in format and product;

• Other stops, representing stops due to failure of conveyors and machines not specified.

These three stop types give rise to 62% of the line stop time.

From the brainstorming performed with a heterogeneous group of factory workers, which included the filling head, engineering chief, engineering trainees and line operators, resulted in the 8 parameters with which the Ideality Matrix was built. The study of this matrix identified the two most relevant parameters to improve the value of ideality. The Matrix of Contradictions was used to select inventive and innovative principles that best fit the problems in question. From the implementation of this methodology resulted as methods of improvement the Prior Action and Continuity of Useful Action, both of which are reviewed in the application of a Lean tool, called SMED.

Prior to the application of SMED, it was necessary to carry out a prior analysis of the types of setup, due to the existence of a large number of them. For this, the average duration times and the frequency of each were considered. Defining the 3 types of setup to be improved, the SMED methodology was implemented. Following a specific methodology, the 3 changes of formats were improved, obtaining reductions of setup times of 60% to 70%, depending on the setup, and reductions of the operators' movements of 26.2%, only for the 3rd setup analyzed.

To standardize the setups and reduce the variation between shifts, several operator support documents were developed, such as format change manuals, checklists, and work instructions.

The Lean 5S methodology was used, which aims to reduce waste, control and organization of the workplace and increase productivity of the line, to organize and manage the line. From this application the following solutions were obtained:

- Organization of the visual management panels on the worktable of the filler, keeping only the information essential to the proper functioning of the workstation. Organization of the worktables of the other stations of the line;
- Insertion of records of compliance in the worksheets of all the jobs;
- Placement of cleaning stations along the filling line;
- Organization and labeling of the place of storage of the packaging pieces of format;
- Placement of storage shelf with circular supports in the wrapping machine.

The application of the solutions allowed an improvement in the results of 5S audits from 9% to 12%, depending on the job.

It is concluded that after the solutions were applied, it is essential to follow them, monitoring the associated parameters and maintaining the demand for continuous improvement, avoiding stagnation in terms of process improvement.

The use of Lean and TRIZ methodologies was essential for the identification and resolution of problems present in the line, promoting the reduction and elimination of waste through innovative solutions. However, the future success of the application of these tools depends on the motivation of the workers and their willingness to improve and break their routines.

It is important to note that, during the study, several difficulties and barriers to the application of the TRIZ and SMED methodologies emerged, fortified by the resistance to change by the operators and the factory manager. However, the application of these tools proved to be beneficial both in terms of productivity and efficiency of the line as well as in motivational terms, allowing a constant evolution of trust and motivation that, in turn, has promoted an environment conducive to improvements and the argumentation of solutions to the critical problems in wokplaces.

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TRIZ Methodologies for Improving LEAN Production Processes

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ABSTRACT

The application of Lean principles and tools as identifiers of improvements has become a dominant paradigm in organizations, that against of new customer requirements may be facing increasing limitations, specifically in response times and customization. In this context, the present work aims to explore the "how" and "why" of synergies and dysfunctions between Lean practices, TRIZ tools and operational performance. Based on three case studies, a discussion is made of how TRIZ can complement the potential limitations in three different sectors of technological intensity: high, medium and low. Although the different environments analyzed (machines and electrical equipment, automobiles and food, respectively), the final results are the same, the TRIZ methodology can be considered as a promising solution to obtain significant improvements in the efficiency of the processes carried out by the company. Using a comparative analysis, it was possible to generalize the results obtained and to define the performance behavior obtained from the association of the application of Lean and TRIZ tools. In this work is demonstrated that the methodology used is applicable to any type of organization, regardless of the type of business, sector, size or Lean applied tools.

Keywords: LEAN Production, TRIZ, Innovation, Performance, Ideality

1. Introduction

TRIZ, acronym of *Teoriya Resheniya Izobretatelskikh Zadach*, began to be developed by Genrich Saulovich Altshuller in 1946, through the study of more than one and a half million patents from different areas, in order to search for alternatives to the methods of creative solutions then available. Altshuller's analysis of the patents and the solutions described in their application revealed the existence of five inventive levels, leading to the conclusion that the inventive value of different inventions is not the same [1, 2].

The Lean philosophy had its origin in Japan within the car manufacturer Toyota Company, by the engineer Taiichi Ohno in 1940. The production system of Toyota, best known as, Toyota Production System (TPS), was based in the desire to produce a continuous flow process, which did not depend on long production runs to be efficient. This was exactly the opposite of what was done in the Western world, where mass production, initially developed by Henry Ford, was based around the planning of material requirements and complex systems. This production method was based on the production of high volume of stock [3]. When Taiichi Ohno began to build the foundations of Lean Production, he began by analyzing the production systems used in the West, which in his opinion contained two failures. The first failure was the high production lots that result in excessive inventory, it would cause to increase capital costs and warehouse space used. The second failure consisted of inability to adapt to customer preferences for greater product diversity. Therefore, Taiichi Ohno main concerns were mainly the reduction of production cost by eliminating waste [4].

Several authors point to the proximity between the LEAN philosophy and the TRIZ methodology in common points. They discuss as TRIZ methodology can become a powerful mechanism, reinforcing tools and Lean thinking. However, it is possible to verify the different approaches of each of these concepts and the joint use in favor of a common objective [5, 6, 7].

The TRIZ methodology does not compete with other methodologies, nor does it intend to replace them, but can be used to highlight its weaknesses, and can synergistically complement other methodologies, namely LEAN. In analyzing the theme, Radeka identifies a parallelism between TRIZ and LEAN [6]. The first step in solving a problem through TRIZ is to analyze the problem by finding ways to frame it in order to create an ideal solution. Through TRIZ it is sought that the problem has an ideal final result, that is, a solution that avoids unnecessary waste and damages. As an example, in the automotive industry, the ideal final result is the customer-ready car, without him having to think about the quality, labor, raw material or supply chain involved. This is, a result that falls within the scope of Lean practice, namely the fifth principle of Lean thinking, perfection.

The combination of the various instruments to generate a LEAN - TRIZ joint use environment presents important advantages when, in their individual use, application limitations of the various tools occur. The approximation of TRIZ to LEAN, in the context of value creation, is called TRIZ Plus, where its objective meets the objective of the principle of LEAN "value"(Value, Value Flow, Flow, Pull, Perfection) [2].

In Table 1 it is possible to compare the TRIZ Plus and LEAN approaches in analogy to the "value" in relation to the seven major wastes and in Table 2 it is possible to visualize the TRIZ Plus instruments in relation to the "value flow".

***Table I**. Comparison of the "value" approach by TRIZ Plus and Lean*

LEAN	TRIZ Plus
Overproduction	Excessive functions
Stocks	Corrective Functions
Overprocessing	Providing and corrective functions
Unnecessary movements	Providing and corrective functions
Defects	Insufficient, excessive or harmful functions
Waiting time	Insufficient functions
Unnecessary transport	Providential Functions

***Table 2**. Value stream approach by TRIZ Plus and Lean*

LEAN	TRIZ Plus
Value Chain Mapping (current situation)	Functional Process Model
Value Chain Mapping (future situation)	Removal, Cause-Effect Chain Analysis
Value Chain Mapping (internal)	Whole System Functional Model
Product Family Matrix	Functional Models of Separate Product Lines

For the implementation of this stream, the Lean philosophy presents a set of fundamental tools such *as Takt Time, Standardization, 5S, Work Balancing and Leveled Production*. TRIZ Plus comprises several instruments capable of addressing the entire production flow without interruptions or delays. The last approach presented is related to the capacity of product delivery to the customer according to the urgency of this one, designated by Pull principle [7]. The comparative description of the *Lean Pull* and TRIZ Plus instruments is shown in Table 3.

***Table 3**. Pull approach by TRIZ Plus and Lean*

LEAN	TRIZ Plus
Kanban Production / Instructions	Inventive principles, Standard solutions (class 4), Removal
Kanban Collection	Inventive principles, Standard solutions (class 4), Removal

In the context of continuous improvement, not all TRIZ instruments can be applied directly even though some Standard Solutions and some inventive principles are appropriate. It turns out that implementation and development within organizations, using the different tools of TRIZ and Lean independently are subject to limitations. However, if these are used in a way that complements each other, and thus, building an environment of use in equilibrium will have guarantees in the management of innovation and development in value of the organization [7].

Based on the above, the present study explores the "how" and the "why" of synergies and dysfunctions between LEAN practices, TRIZ tools and operational performance. Based on case studies an approach is taken on how TRIZ can complement potential limitations of the lean.

This paper is structured in seven chapters, starting with Introduction chapter where a state of art is made, followed by Theoretical Foundations. The methodology used and the three study cases are presented and explained in the third chapter. The results obtained and the respectively discussion is made in the fourth chapter. In the fifth chapter are presented the relevant conclusions. And the bibliographic references are in the sixth and last chapter.

2. Theoretical foundations

The application of Lean principles and tools as identifiers of improvements has become a dominant paradigm in organizations, that against of new customer requirements may be facing increasing limitations, specifically in response times and customization. In this context, the present work aims to explore the "how" and "why" of synergies and dysfunctions between Lean practices, TRIZ tools and operational performance.

The Inventive Principles constitute a tool of the Theory of Inventive Problem Solving. Genrich Altshuller identified 39 Technical Parameters. A conflict of a system, or a contradiction, occurs when the improvement of certain attributes results in the deterioration of others. Altshuller found that, despite the great technological diversity, there were only 1250 typical conflicts in a system. All of these could be solved through the application of only a limited number of principles. The 40 Inventive Principles are then defined, often referred to as conflict-fighting techniques. However, most of the principles of invention have a specific technical meaning introduced by Altshuller [9].

Once the conflicts are identified, the Matrix of Contradictions can be applied. This tool is probably one of the most used by the TRIZ methodology, consisting of 40 inventive principles [10] (table 4) and 39 engineering parameters [9] (table 5).

***Table 4**. Pull approach by TRIZ Plus and Lean*

1	Segmentation	**11**	Previous damping	**21**	Rush Racing	**31**	Use of porous materials
2	Extraction	**12**	Equipotentiality	**22**	Conversion of loss benefit	**32**	Color change
3	Local quality	**13**	Inversion	**23**	Reception	**33**	Homogeneity
4	Asymmetry	**14**	Sphericity	**24**	Mediation	**34**	Rejection and recovery of physical or chemical state

5	Combination	**15**	Dynamism	**25**	Auto-service	**35**	Transformation of physical or chemical state
6	Universality	**16**	Partial or excessive action	**26**	Copy	**36**	Phase change
7	Nesting	**17**	Transition to a new dimension	**27**	Economic object with short life rather than other expensive and durable	**37**	Thermal Expansion
8	Counterbalance	**18**	Mechanical vibrations	**28**	Replacing the mechanical system	**38**	Use of strong oxidants
9	Against prior action	**19**	Periodic action	**29**	Use of pneumatic or hydraulic systems	**39**	Inert Environment
10	Previous action	**20**	Continuity of a useful action	**30**	Flexible membranes or thin films	**40**	Composite materials

***Table 5**. Technical or Engineering Parameters according to TRIZ*

1	Weight (mobile object))	**11**	Tension Pressure	**21**	Power	**31**	Harmful side effects
2	Weight (immovable object)	**12**	Form	**22**	Power loss	**32**	Manufacturing
3	Length (mobile object)	**13**	Stability of the object	**23**	Weight loss	**33**	Use convenience
4	Length (immovable object)	**14**	Resistance	**24**	Loss of information	**34**	Maintenance
5	Area (mobile object)	**15**	Durability (mobile object)	**25**	Loss of time	**35**	Adaptability
6	Area (immovable object)	**16**	Durability (immovable object)	**26**	Quantity of matter	**36**	Device complexity
7	Volume (mobile object)	**17**	Temperature	**27**	Reliability	**37**	Control Complexity
8	Volume (immovable object)	**18**	Clarity	**28**	Accuracy of time	**38**	Automation level
9	Velocity	**19**	Energy dispensed (mobile object)	**29**	Manufacturing accuracy	**39**	Productivity
10	Force	**20**	Energy dispensed (immovable object)	**30**	Harmful factors that act on the object		

All these parameters can be used, or one can exclude those that do not have application for the case in study. The construction of the Matrix of Contradictions is done through the following steps [10]:

1. Identification of the engineering parameter to be improved (exposed in the lines);

2. Identification of the contradiction, as a consequence of the improvement of the engineering parameter chosen (exposed in the columns);

3. Cross the line with the column in order to determine the corresponding inventive principles.

The inventive principles are heuristic or proposed potential solutions to a given problem. The principles considered were obtained through the generalization and grouping of solutions repeatedly used in the creation, development and improvement of technical systems in different areas.

The engineering parameters correspond to generic quantities, present in technical problems of different areas. The contradictions in the original problem must be translated in terms of a first engineering parameter, which one wishes to improve, and a second that, on the other hand, is worsened by the improvement of the first one [1].

The process of query to the matrix starts with the identification in the rows of the engineering parameter to be improved and in the columns of the parameter that is impaired with the improvement of the first one. At the intersection of the parameter to be improved with the parameter affected negatively, are the inventive principles considered most useful, in the survey carried out by Altshuller (1969), for the resolution of the contradiction [11].

Genrich Altshuller, developed an approach to the theme of innovation levels and their measurement, by analyzing a significant number of patents, over one million patents. Altshuller concluded that the inventive value of different inventions is not always the same, and that using only a few principles of invention one could solve most of the problems, even though they were in totally different fields. The solutions found were systematized and divided into five levels [12], presented in Table 6.

***Table 6**. Five inventive levels of Altshuller*

Level	Description	% of analyzed patents
1	These are routine solutions using well-known methods in the respective area of specialty	30%
2	Minor corrections in existing systems, using methods known in industry	45%
3	Important improvements that resolve contradictions in typical systems of an industry branch	20%
4	Solutions based on the application of new principles	4%
5	Innovative Solutions Based on Scientific Findings	1%

2. Methodology

Case studies are the most appropriate methodology considering the exploratory nature of a survey [13, 14]. They allow exploration of the reasons why coordination problems arise, identify possible cost implications, lead times and capacity for innovation and approach how they can be solved.

The case study is also more appropriate to answer "why?" and “how?" [14] and although a purely conceptual approach can achieve the same end, case studies provide the depth needed to determine whether propositions are plausible and, if so, to develop a theory with guidelines for transferring them to business reality [15, 16].

During the analysis of the empirical work developed by other authors, a gap was observed regarding the results obtained in the application of the Lean and TRIZ tools, since they are based on particular sectors and there are no studies that make a general analysis. In this way, the methodology developed in the scope of this work included the selection and analysis of case studies, to fill this gap. In Figures 1 is presented the methodological structure developed and the hypotheses formulation are presented in Figure 2.

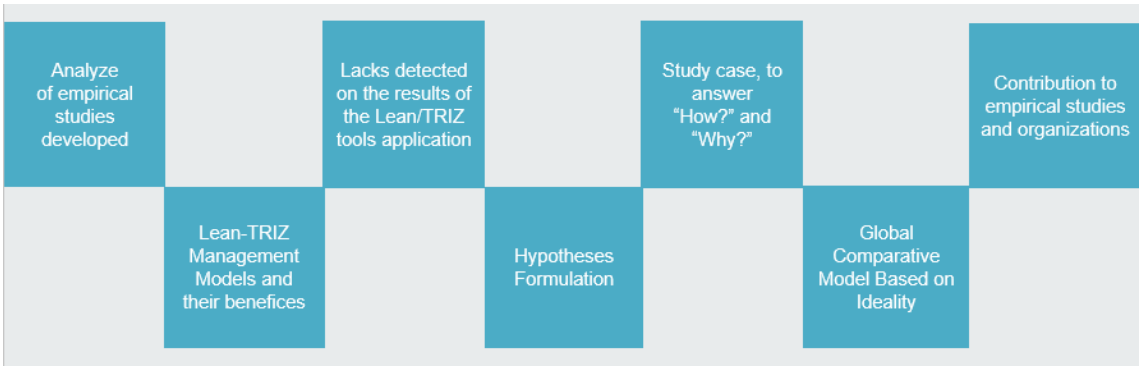

***Figure 1**. Methodological structure developed*.

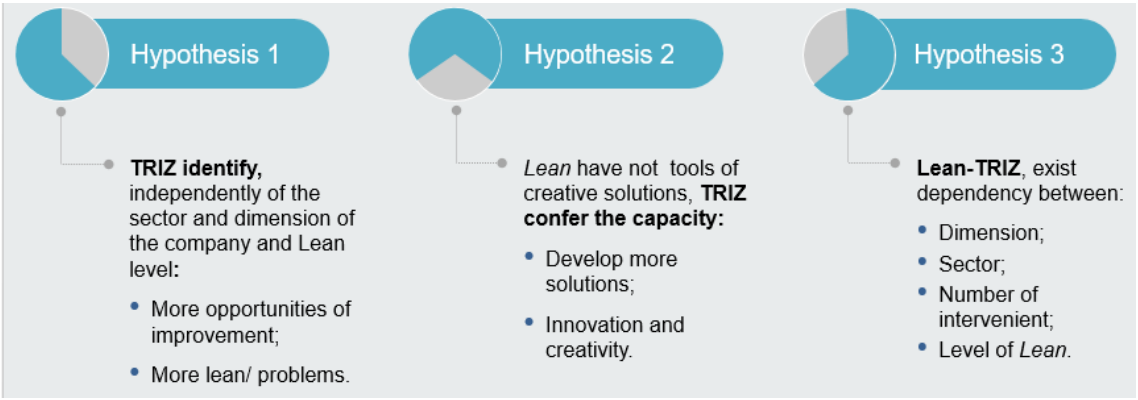

Figure 2. *Hypotheses formulation tested.*

The three study cases have been chosen based in dimension, sector, number of intervenient and level of Lean implemented. In section 2.1 is presented the three Portuguese private companies where this methodology was applied. For the present study, the case studies are also especially appropriate to evaluate the processes of longitudinal change.

The next stage involved the identification of the TRIZ tool that allowed a catalytic effect in the joint application with the Lean tools, and in this way to provide the elaboration of a general comparative analysis. The level of ideality was the most adequate comparison indicator for the enrichment of a comparative analysis, which is derived from an innovative tool, the Matrix of Ideality.

After this stage, the authors studied the identification of the initial levels of ideality, values obtained before the application of the TRIZ tools, and the values of the final levels of ideality, after the application of the TRIZ tools [2]. In this way and considering the diverse factors involved in the case study, a comparative table was constructed, which allowed to gauge the level of performance obtained by each company.

The equation 1 was used to calculated de ideality level.

$$Ideality\ level = \frac{Number\ of\ useful\ function}{Number\ of\ prejudicial\ functions} \quad (1)$$

Where the Number of useful functions included principal, secondary and auxiliary functions [17]. These functions given positive effects to the system and are identified in Ideality matrix [2]. And the Number of prejudicial functions includes all the negative effects associate to the system [18].

The achievement of general results allowed, through the thematic analysis, the expansion and application of the knowledge for a more global vision, without focusing particularly on the specific case study. In this way, this study can give organizations and empirical studies a general understanding of the joint application of the Lean and TRIZ tools, as well as a useful orientation if they intend to adopt principles of continuous improvement and innovation. However, it should be mentioned that the implementation of these proposals for improvement must, a priori, be subject to a thorough individual analysis of the case study in question and then to continuous monitoring, since the benefits are intended to be continuous and sustainable.

2.1 Case studies

In the scope of this work, a Portuguese metalworking company of the high tech sector, founded in 1979 and composed of two production units, located in two separate parishes of the same municipality was studied [19]. The study refers to the production unit that is restricted to the production of ventilation units and air handling units. This production unit consists of a storage area, a production area and a reception / dispatch zone. Although the study focused on the storage area, the lack of a Lean level led to the need to expand the application of Lean tools to other operational areas of this production unit in order to identify problems of management and spatial organization and achieve an improvement in the efficiency of organizational processes. Initially, Lean tools were used that did not exist in the company, to perform a first audit in the analyzed area (warehouse). Through a control document and the creation of a checklist, based on 5 senses, it was possible to identify which factors to consider and where to act.

The second case study is a multinational company in the automotive sector, consisting of seven different assembly lines. In this case the coating line was studied. This production line has the capacity of twenty-eight jobs [19]. In this case, the

LEAN philosophy is fully implemented, with audits for problems encountered with greater complexity and resolution specificity. In this case, this work consisted in the elimination of waste, in problems due to existing ergonomic mismatch. TRIZ appears as the problem-solving and systematic innovation tool that supports issues that may arise along improvement and / or implementation processes.

The third case study is a company of Portuguese nationality, founded in 1978, with operations in the food sector. This company has a total of 19 production lines, distributed by two manufacturing units of different municipalities [19]. The development of this work focused on the production line of crackers. In order to measure and analyze line productivity, we used the *Overall Equipment Effectiveness* (OEE) performance indicator. The implementation of the TRIZ Methodology arises from the need to use a tool to solve the problem and not only identify it as an opportunity for improvement.

3. Results and Discussion

The first case study is based on a company in the high-tech sector, which had a totally non-existent Lean and TRIZ level, which is why it was initially possible to apply Lean-TRIZ tools. A 5S audit was elaborated at organizational level, which led to the identification of several problems in several processes. After a comparison of the existing problems, it was inferred that it is in the warehouse that the problems reside and, for this reason, there is a low level of ideality. In Tables 7 and 8 are presented the Ideality Matrix initial and after application of Lean-TRIZ tools. With the changes made, it was possible to reach a final level of ideality of about 500% higher than the initial one (see equation 1).

Table 7. *Initial Ideality Matrix of the first case study (metalworking company)*

		1	2	3	4	5	6
1.	**General Company Organization**		-	+		-	
2.	**Information Management**	-		-		-	-
3.	**Productivity**	+	-		+	-	+
4.	**Implementation of new informatics systems**			+		-	
5.	**Labour Costs**	-	-	-	-		
6.	**Quality**		-	+			

Table 8. *Ideality Matrix after Application of Lean-TRIZ tools (first case study - metalworking company)*

		1	2	3	4	5	6
1.	**General Company Organization**		+	+		-	+
2.	**Information Management**	+		+	+	-	+
3.	**Productivity**	+	+		+	-	+
4.	**Implementation of new informatics systems**		+	+		+	
5.	**Labour Costs**	-	-	-	-		
6.	**Quality**	+	+	+			

Note that similar tables were made for the other two case studies to obtain the level of ideality.

In the second case study, a large-scale automotive company belonging to the medium technology sector already existed a Lean level successfully implemented. However, this did not eliminate the contradictions and consequently have an improvement in the efficiency of the process. Hence the need to apply TRIZ tools. It was verified that the existing level of ideality was already high, but the problems existed. Therefore, through the application of Substance-Field Analysis in problematic processes, solutions were found, but also contradictions that were solved iteratively with the application of several Substance-Field analyzes. After the solutions were implemented, a much higher final level of ideality was reached, about 512% higher than the initial situation and the initial problems were solved. It was also evident that there was a need for investment in training in ergonomic good practice to avoid risk factors or suggestions for improvement.

In relation to the medium-sized, low-tech food company, where the Lean level was very insipid, the problems encountered in the analyzed production line presented a more redundant charisma, thus giving a much lower efficiency level than expected. The Lean tool (OEE) only revealed one problem and did not provide a concrete solution. With the implementation of the TRIZ tools, it was possible to verify that the initial level of ideality for the studied production line was very low due to the high number of negative interactions present in the continuous process, but also identified contradictions, which were initially not quantified. After solving the problems, the proposed level of ideality was increased by 250%, which resulted in higher line productivity, reduced waste and consequently reached a higher level of OEE than expected.

4. Conclusions

Having, as a line of comparison, the level of ideality and analyzing the individual performance of the case studies, it was concluded that the application of TRIZ tools has a catalytic effect in improving processes in scenarios with a non-existent Lean level. Concluding, therefore, the implementation of TRIZ tools always gives processes performance improvements.

However, it is important to highlight that the potential of TRIZ tools is driven more directly by the joint application of Lean methodologies. TRIZ focuses on the optimization of specific elements, while Lean takes into account the total system in order to identify potential ways to improve. The complementation of the two TRIZ and Lean tools is the identification of problems through the Lean methodologies and specific resolutions for the problems encountered by TRIZ's solution generation tools, as well as the identification of new problematic situations, improving thus in a systematic way the processes and consequently conferring an approximation to the ideality.

Using a comparative analysis between the sectors under study, the size of the company, the initial Lean level and the number of participants involved in each process, a global analysis was obtained. That allowed the conclusion that the discrepancies obtained regarding the ideality levels of each case study, are triggered by the number of participants with active participation in the processes under study, regardless of the level of Lean initially implemented.

Resistance to change, with the introduction of new innovative forms of work, lack of specialized training, due to companies' inability to provide investment for this purpose, as well as mental inertia, condition the application of the solutions found for problems solving by the tools, thus leading to a lower growth of the level of ideality.

It is concluded that investment in training is an important factor in achieving better levels of performance than the application of innovative methodologies and tools. In this way it is possible to overcome the resistance of the participants to change and the organization if it can impose itself if it is defined in the market as innovative, differentiating in the performance and competitive level.

With this study it was possible to prove the hypotheses developed, as well as to define a general empirical analysis, which makes possible the evolution of the performance of production systems using the levels of ideality as indicator. This analysis is applicable to any type of organization, regardless of the type of business, sector, size or Lean applied tools.

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LEAN Manufacturing - Adding Competitive Advantages in the Mould Industry

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ABSTRACT

The optimization of internal processes is assumed as a critical factor to be capable of answering to the high-tech industries as is the case of automotive and aeronautics industries. Currently, the rapid change in global market imposes faster mould design and manufacturing in order to reduce the time-to-market, along with higher quality, greater efficiency and lower costs. Consequently, it has been considered essential to adopt high-valued methodologies to support tooling industry in order to achieve global competitive advantages. For that purpose, this work aims to apply LEAN principles and techniques to support mould design and manufacturing processes. Taken in to account these specific characteristics of moulds sector, namely the design and manufacturing of unique and unrepeatable tools through a job shop production environment, significant adjustments were introduced in order to adapt some of LEAN techniques, such as Value Stream Mapping (VSM) and Overall Equipment Effectiveness (OEE).

Keywords: Injection Mould, Lean manufacturing, VSM, OEE, waste;

1. Introduction

Most injection mould manufacturers in Portugal are generally characterized by their high technological standards, high engineering knowledge and high performance in terms of overall mould quality and customer service. However, the injection mould industry has faced several challenges posed by globalization [1]. This create a set of threats, promoting competitiveness, and compels companies to be more efficient, by seeking new opportunities for innovation and for market and also with the improvement and effectiveness on yours internal processes.

The production process of injection moulds has several difficulties to overtake namely the uniqueness of each mould, the simultaneous production of myriad components from several moulds and recurrent mould design changes asked by the customer [2]. However, these companies have a challenge to remain at the level of excellence by responding to an increasingly demanding market in terms of mould complexity, ever shorter delivery times and a continuing and growing environmental concern, together with waste minimization. The challenge listed above result in the need to reduce waste and time without added value, where maximizing the use of high technology resources is relevant and differentiating [3]; [4]; [5]. This complexity manufacturing results in a very unstable and dynamic process flows and, as such, waste in the mould production chain is difficult to identify and assess. For overtake this difficulty this paper presents the results of a research aiming to understand the applicability of Lean tools to the mould making industry. The underlying principle at continuous improvement is it guided towards the efficiency of the global process [2].

One objective of this study regarding the applicability of Lean tools to the mould industry is keep the information available and disseminated. If possible that information must be available in Knowledge database. The process of knowledge management results from the need to survive in a world dominated by innovation, and the need for its management is based on the creation of value. So, databases might be a solution to promote creation of value and scientific production [6].

Due to the increased competitiveness, the mould makers are under huge pressure in order to reduce their costs and provide products of higher quality in shorter lead times. This is possible if they improve their performance. Lean manufacturing can be used by manufacturing organizations to achieve these and obtain a competitive advantage over their rivals [7-9]. This competitiveness is obtained by increasing efficiency and decreasing costs through the elimination of non-value added steps and inefficiencies in the production process [10]; [8]. Lean was first introduced by Womack and Jones in 1990 [11] in their book “The Machine That Changed the World”, which describes the Toyota production system (TPS) [11]; [12].

Nowadays, the optimization of internal process is assumed as a critical factor to be capable of answering to the high-tech industries, namely the automotive and aeronautics industries. Currently, the rapid change in global market imposes faster mould design and manufacturing in order to reduce the time-to-market, along with higher quality, greater efficiency and lower costs. Consequently, it has been considered essential to adopt high-valued methodologies to support tooling industry in order to achieve global competitive advantages. For that purpose, this work aims to apply LEAN principles and techniques to support mould design and manufacturing processes. The injection mould is a high precision tool responsible for the production of most plastic parts used everywhere. Its main purpose is to replicate the desired geometry of the final plastic part by transforming molten plastic into its final shape and dimensional details. Thus, these tools are custom designed and built. Taken in to account these specific characteristics of moulds sector *(Engineering & Tooling)*, namely the design and manufacturing of unique and unrepeatable tools through a job shop production environment, significant adjustments were introduced in order to adapt some of traditional LEAN techniques, such as Value Stream Mapping (VSM) and Overall Equipment Effectiveness (OEE), to this sector.

2. LEAN Manufacturing

Lean manufacturing is a management approach to make organizations more competitive by increasing efficiency and decreasing their costs and providing products of higher quality in shorter lead times e.g. promote the elimination of non-value added steps and inefficiencies in the process [8]. It is associated to the continuous improvement since that requires constant improvement of its practices [13]. The major challenge to industry applying lean manufacturing is to implement a culture that will create and sustain long-standing commitment in the organization [14]. To maintain the culture of continuous improvement we can used de PDCA cycle or a Kaizen what is methodology for a systematic approach that focuses on customer needs, oriented to the process and encourages the participation and proactivity of all collaborates [15].

As Taiichi Ohno [16] refers, the products delivery between the supplier and the costumer's order should be studied, and the wastes identified should be eliminated in order to reduce deadline of delivery. The original seven common wastes in an industrial environment that were identified [16]. are:

- Defects;
- Inventory;
- Motion;
- Over processing;
- Over production;
- Transportation;
- Waiting periods.

The Human talent is an additional waste more recently been pointed out as important and, should therefore, has been considered in the list [17]. So, in addition to this, other types of waste can still be identified, namely; Waste of materials, Energy and Water; Pollution and Time.

The authors Womack and Jones [18] referred Lean thinking as the "way to specify value, line up value creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively". Five Lean principles were introduced to address the various challenges that occur within and between business units from the differences in business culture and management thought process. The Lean principles [18]. are:

1- Define value from the customer;
2- Identify the value stream mapping;
3- Establish a continuous flow;
4- Implement pull system production;
5- Continuously search for perfection.

These principles (Figure 1) have the goal to establish a perfect value stream by continuously identifying, and eliminating activities considered waste and focus on activities that create value.

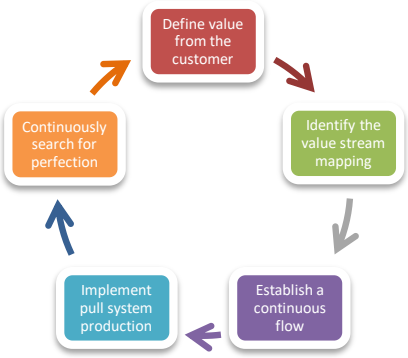

Figure 1. *Lean principles*

Lean Manufacturing is a concept used in production systems through continuous improvement, elimination of waste and non-value-added operations by using a series tools and techniques [19]; [20]. Lean was first

introduced by Womack and Jones [11] in their book "The Machine That Changed the World", which describes the Toyota production system (TPS) [11]. Womack and Jones [9] describes Lean as: *"The most powerful tool available for creating value while eliminating waste in any organization"*.

The fundamental principles of Lean are visualization and "go and see" [21]. These principles have been leading in the development of tools and techniques to achieve the target of continuous improvement (Figure 2). There are many Lean techniques and tools design for waste reduction which can be applied to promote efficient material flows, shorten lead-time, and minimal waste of time [22]; [23].

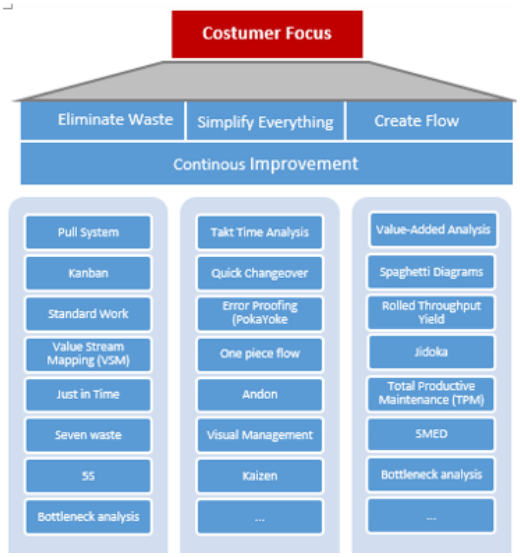

Figure 2. *Lean tools*

The mainly tools used in this research to obtain waste were:

2.1 Kaizen/ Continuous Improvement

This signifies improving continuously in a short space of time or at low cost, supported by a team brought together to achieve goals. This tool have the same base of PDCA cycle, the quality management [24]. Kaizen is based on the principle that everything can be improved. Kaizen cycle for continuous improvement have seven steps that should be repeated on an ongoing basis, with new solutions, when appropriate, or with new problems. This seven steps are;

1- Get employees involved;
2- Find problems and potential opportunities;
3- Request creative solutions;
4- Test the solution;
5- Analyze the results;
6- Standardize;
7- Repeat these steps.

2.2 Seven Basic Tools of Quality

The Seven Quality Tools are simple statistical tools used for solving quality problems e.g. are used to find out root causes and eliminates them, thus the manufacturing process can be improved. These tools were either developed by the Quality Gurus such as Deming, Ishikawa and Juran. These are the most useful and simple to use. Kaoru has stated "that these seven tools can be used to solve 95 percent of all problems". The Seven Quality Tools used are; Check Sheets/ Check List; Pareto Diagram; Ishikawa (Cause & Effect) Diagram; Histogram; Control Charts; Scatter Diagrams and Graphs [25-27].

2.3 5S Methodology

The 5S is a systematic technique used by organizations for workplace organization promoting its efficiency and decreasing the waste and consequently increasing the quality and productivity through an organized environment [28]. The 5S methodology has 5 phases which use five Japanese words:

- Seiri/Sort (organize);
- Seiton/Set in order (create order);
- Seiso/Shine (cleanliness);
- Seiketsu/Standardize (standardized cleaning);
- Shitsuke/Sustain (discipline).

It is known that 5S techniques support the Organization's objectives to achieve continuous improvement and higher performance and, consequently, promotes a positive impact on organizational performance.

2.4 Value Stream Mapping (VSM)

VSM it allows the visual representation of all company processes, making the process analysis simple and intuitive, from the client request till the final delivery of products. VSM is a powerful tool to support continuous improvement and to decide and design improvement overall effectiveness of the process. The VSM has with objectives [29] the follows:

-Make the current process visible;

- Facilitate the identification of problems and opportunities for improvement;

- Establish a reference for evaluating impacts of improvement actions;

- Establish a working basis for the creation of an improved state of the process.

According to Hines and Rich [30] associated it to seven waste are the seven value stream mapping tools, as indicated below:

1- *Process activity mapping Industrial engineering*
2- *Supply chain response matrix Time compression/logistics*
3- *Production variety funnel Operations management*
4- *Quality filter mapping New tool*
5- *Demand amplification mapping Systems dynamics*
6- *Decision point analysis Efficient consumer response/logistics*
7- *Physical structure mapping*

2.5 Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) is a Key Performance Indicators (KPIs) and a metric for evaluating the progress of Total Productive Maintenance (TPM). This is obtained with cumulative measure of three separate factors: availability, performance and quality. Together they can provide, with a good measure, of how well your plant is producing [31-34]. OEE can be improved through analysis of the six big losses, and according to Tajiri and Gotoh [35] the relationship between OEE and losses depends on equipment availability, their performance rates and the quality of the product. These authors classified major losses into six groups, where the breakdown losses, setup and adjustment losses are downtime losses and contribute to determine a true value for the availability of a machine. The losses including minor stoppage and reduced speed losses and are known as speed losses. They are contribute to measure of performance rate of a given machine. Finally, rework and yield losses are defined as quality losses to determine the quality rate for the equipment.

In summary, it can be considered that: the availability factor measures the total time that the system is not operating; the performance rate measures the ratio of the actual operating speed of the equipment as compared to its ideal speed and the quality factor measures the proportion of defective production to the total production volume [36].

3. Methodology / Experimental procedure

This study was carried out in a mould maker located at Marinha Grande using a direct observation on the shop floor to see in firsthand the production process. The data collection was conducted in the field by following one particular mould component that was deemed most important to the mould manufacturing, the core, and time were mesured between and within all stages of it is manufacturing process, from the steel acquisition to the

mould try-out. All the data gathered allowed to build one VSM - Value Stream Mapping, where different events were evaluated, namely:

- Setup (or change-over): Fix the piece, Center the piece, Program, Exchange of die, Move or turn the mould, amongst others tasks;
- Wait: Machine failure, Wait for the program, Wait for information, Wait for the availability of the crane, Search for tools, Unavailability of the operator, etc;
- Others: Transporting piece, Examine, Clean piece, etc.

The different waiting time between steps, in Setup or in turn off have been analyzed, by histogram chart, to verify de reason of this waste. Regarding the different stoppage events, a detailed analysis through Pareto diagram was also performed in order to identify the main factors for stoppage.

Parallel to this study, the overall performance of automated equipment's, Machining Centers (CNC), of the company industrial park was analyzed through the Overall Equipment Effectiveness (OEE) assessment. The OEE can establish a working basis for the creation of an improved state of the process with propose of implementation of Lean tools to improve production performance.

In this study has also used a hybrid concept based on continuous improvement of PCDA / DMAIC [37]. It is considered that DMAIC is an evolution of PDCA where it started to use statistical tools with analytical power. It is important to reinforce that each step taken, supported by the PDCA / DMAIC cycle, is continuously repeated until perfection is reached. This instrument consists of several activities to achieve a certain improvement, based on the purpose of making processes clearer and more agile [38]. Briefly, the steps to go in achieving this type of process are [39] (Figure 3):

- PDCA methodology: Plan; Do; Check and Act, and
- DMAIC methodology: Define; Measure; Analyze; Improve; Control.

<table>
<tr><th>PDCA</th><th>DMAIC</th></tr>
<tr><td rowspan="3">PLAN</td><td>DEFINE</td></tr>
<tr><td>MESURE</td></tr>
<tr><td>ANALYZE</td></tr>
<tr><td>DO</td><td>IMPROVE</td></tr>
<tr><td>CHECK</td><td rowspan="2">CONTROL</td></tr>
<tr><td>ACT</td></tr>
</table>

Figure 3. *PDCA vs DMAIC*

Data processing is done by PDCA /DMAIC cycle [40]. The first stage is identification of production waste during production of moulds parts. In the Measure phase, Pareto diagram is used to determine the critical wastes. Measurement of waste was carried out by qualitative assessment. Then root cause analysis is done to evaluate several factors causing waste. In the improve phase, alternative solution are given to reduce production waste and improve production performance.

4. Results and Discussion

The main results are following.

4.1 Value Stream Mapping (VSM)

The gathered data, thorough continuous observation of mould's core, allows to building of the VSM type illustrated in Figure 4. Based on that, it is possible to observe that the lead time is 12 weeks, which corresponds to approximately 164h of Cycle time (OCT), 23h related to Change-over (C/O), totaling in average of 60% availability time. One can also concluded that rework was 29 hours and the total number of hours that the core was remained stopped between the various stages of manufacture was 201 hours.

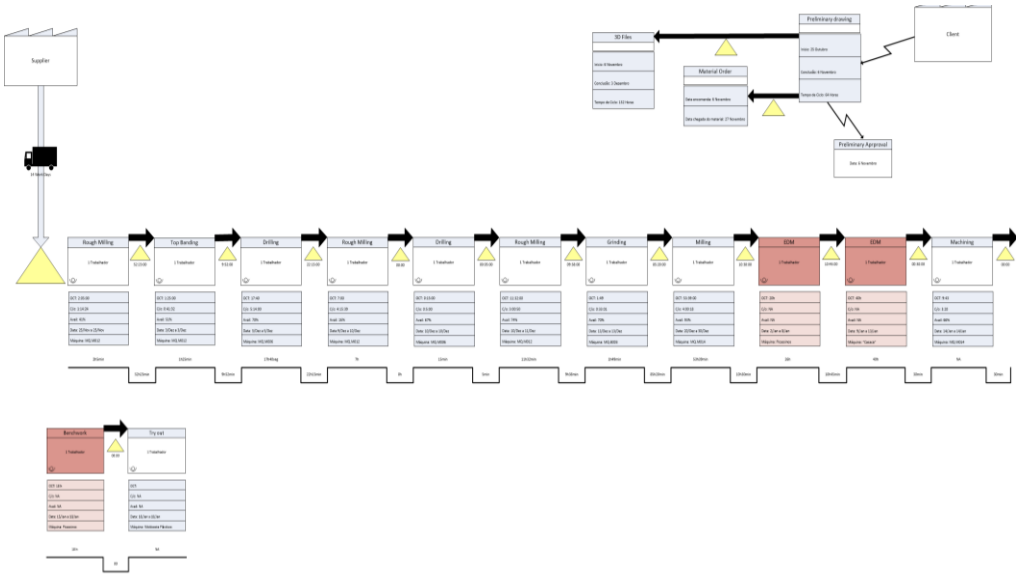

Figure 4. *Overview of the VSM aspect generated.*

4.2 Waste Analysis

With an analysis of the various types of stoppages, it can be observed that the milling process was the one that exhibits a larger timeout (40%), which is expected since it is the most time-consuming stage (see Figure 5).

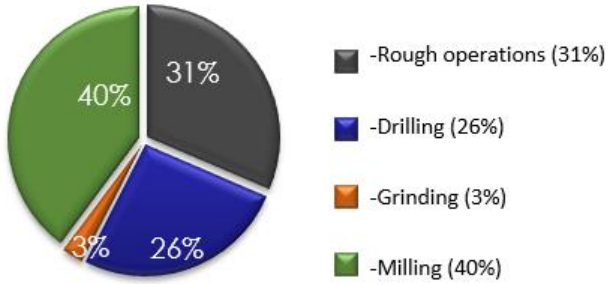

Figure 5*. Stoppages by sectors*

The time values between the various manufacturing stages, is present in Figure 6 in which the core has been stopped without any intervention of any kind. It is important to highlight that for the calculation of the stoppage time, was considered 5 days of manufacturing with a daily load of 20 hours.

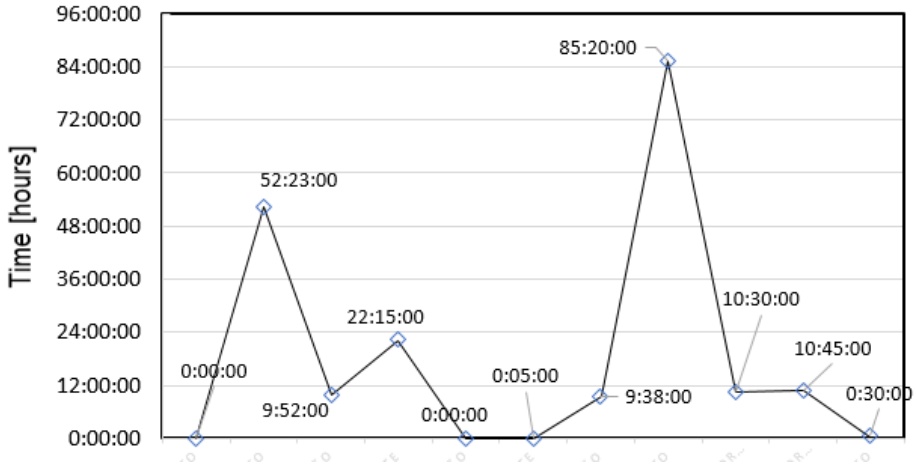

Figure 6. *Waiting time between steps*

Pareto analysis was carried out to show that events that contributes the most to the stops. The results were: unavailability of the operator (16.4%), programming the machine (14.4%) and tool exchange (12.4%) (see Figure 7).

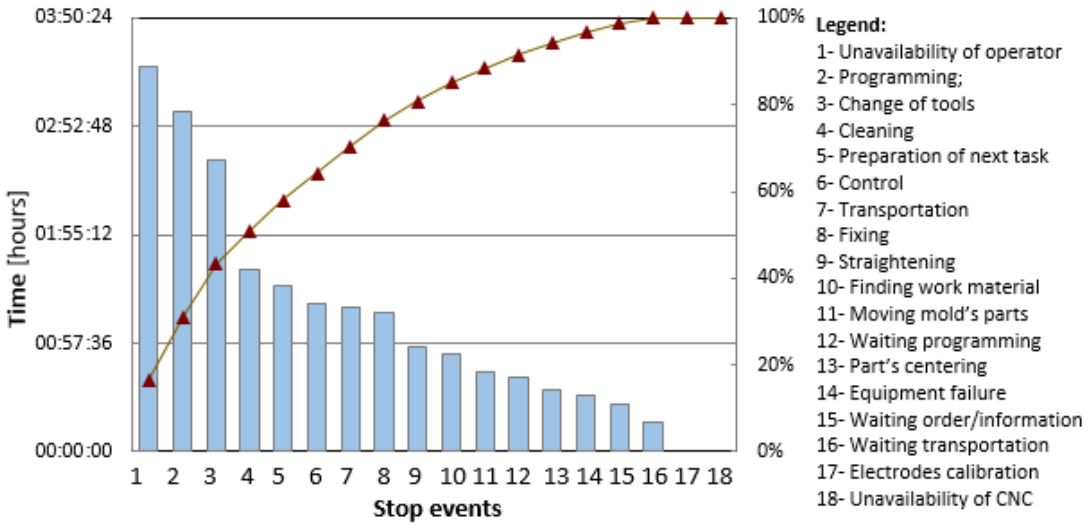

Figure 7. *Contribution of the different stoppage events.*

Machine states have been recorded. The state of: machine running; machine stop; or machine in Setup were analyzed by histogram to verify the reason for this waste (see Figure 8).

About the global of analyzed machines it is verified that about 42.9% of the machines with state "running" is below the machines with "average state of machine running" (46.9%).With the same tendency, machine state setup average is 14.5%, and have been recorded 47.6% of the machines with state "machine in setup" above this value. That suggest unbalance production.

One of the problems detected is related to incorrect task planning. Therefore, the work planning method should be analysed in order to reduce waiting times, operating time, setup time ...and for this can improve the planning tasks with an enterprise resource planning (ERP) system.

SMED methodology can be implemented to reduce the setup time. With this implementation it is intended to improve some factors, namely: reduction lead time and increased capacity; increase of quality and less process variability; increased flexibility to meet client demands; and better utilization of your workforce and lower manufacturing cost.

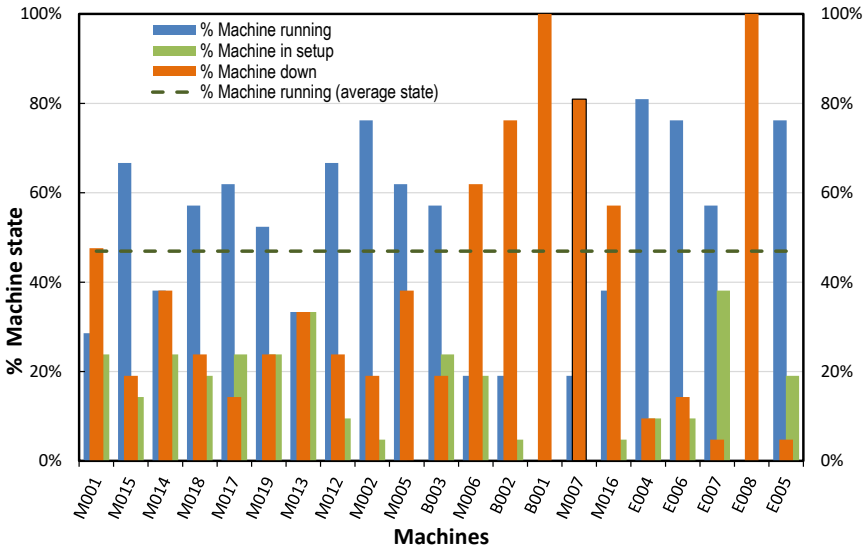

Figure 8. *Machine states.*

4.2 Overall Equipment Effectiveness (OEE)

The assessment of OEE was performed for machining centers during a 9 hour shift for six equipment's. Regarding OEE calculation, the following factors were considered:

- Availability - Production Time versus Programmed Time;
- Performance - Real Production versus Ideal Production;
- Quality - Total Conforming Parts versus Total Produced Parts.

Thus, the results obtained for the automated equipments' Machining Centers (CNC), is show in the Table 1, where it can be observed that the availability factor is the main problem.

***Table 1**. OEE of CNC machines - Above and before*

CNC machines	Above improvement continuos program				Before improvement continuos program			
	Availability	Effectiveness	Quality rate	OEE	Availability	Effectiveness	Quality rate	OEE
1	26%	89%	87%	20,1%	48%	93%	89%	39,7%
2	38%	100%	98%	37,2%	68%	100%	98%	66,6%
3	97%	97%	100%	94,1%	98%	97%	100%	95,1%
4	40%	85%	92%	31,3%	62%	95%	97%	57,1%
5	73%	95%	100%	69,4%	88%	98%	100%	86,2%
6	50%	88%	100%	44,0%	80%	96%	100%	76,8%

The key performance indicators OEE was calculated on CNC Machines at the beginning of the study and a global OEE of CNC Machines about 50% was obtained. This was followed by the implementation of a (basic) continuous improvement program using Lean techniques such as: 5S methodology, SMED methodology; Visual Management and Standard Work. Before a pre-implementation, the OEE was recalculated. An improvement of each machine's OEE was achieved and the Global OEE improved by about 30%.

5. Conclusions

The results attained highlight the great potential of the proposed framework to achieve mould production improvements, with consequent time earnings for the entire mould fabrication process, since it illustrates where the problems are (such as higher change overs and waiting time).

Notwithstanding, the data sample collected is very small, and it is therefore appropriate to complement this study, so that one can extrapolate the results obtained in order to sustain improvement actions to reduce, for instance, waiting time.

At the same time, and since the unavailability of resources is identified as the most important cause of waiting time, one considers especially important to create a planning support tools that mitigate all the waiting factors.

Implementation of lean manufacturing tools and practices in the mould industry can bring many benefits, such as reducing waste and creating the value-added products to customers.

This paper provides positive evidence regarding the effects that Lean tools and techniques have on the performance of organizations. This research offers to the mould industries, a better understanding of the relationship between the Lean strategy/ management and the performance of their operations.

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