



The 3rd International Joint Conference ICIEOM-ADINGOR-IISE-AIM-ASEM (IJC2017) PROCEEDINGS

“New Global Perspectives on Industrial
Engineering and Management”



Editors: Raúl Poler, Josefa Mula, Manuel Díaz-Madroñero and Raquel Sanchis

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and Management

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FOREWORD

The IJC2017 Proceedings contains the contributions presented in the 3rd International Joint Conference ICIEOM – ADINGOR – IISE – AIM - ASEM : “XXIII International Conference on Industrial Engineering and Operations Management”, “International ADINGOR Conference 2017”, “International IISE Conference 2017”, “International AIM Conference 2017” and “International ASEM Conference 2017”.

This International Joint Conference is a result of an agreement among ADINGOR (*Asociación para el Desarrollo de la Ingeniería de Organización*), ABEPRO (*Associação Brasileira de Engenharia de Produção*), IISE (*Institute of Industrial & Systems Engineers*), AIM (*European Academy for Industrial Management*) and ASEM (*American Society for Engineering Management*). The conference has been organised by the Research Centre on Production Management and Engineering (CIGIP) at Universitat Politècnica de València (UPV). The IJC2017's motto is: “New Global Perspectives on Industrial Engineering and Management”. The mission of the International Joint Conference is to promote links between researchers and practitioners from different branches and to enhance an interdisciplinary perspective of industrial engineering and management. IJC2017 has been a conference of very high standards, built on the experience of previous editions of ICIEOM, ADINGOR, IISE, AIM and ASEM conferences.

We would like to thank all those who have sent in their work, because these works, after their revision and acceptance, constitute the essential nucleus and *raison d'être* of this conference. In addition, we give an especially warm welcome to our keynote speakers, coming from business and academic world, whose presence at the plenary sessions is an honour for us and which makes the conference more relevant. Likewise, we would like to express our recognition of the effort and work put in by all those people who have made it possible to organize IJC2017. We pay tribute to the Scientific Committee who with the thoroughness of their supervision have assured the quality of the accepted papers, to the institutions and sponsors for their trust and support, and to the members of the organizing committee for their keen motivation to ensure there were no loose ends, an almost impossible mission, and to all the people who have directly or indirectly influenced in the smooth progress towards the conference.



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Education

Are we doing the right thing for Industrial Engineering Students? – a work in progress

Zylberglejd R¹, Gandhi SJ²

Abstract In today's rapidly changing business environment, industries and companies are continuously evolving. This includes introductions of new and varying technologies, the issue of sustainability and new tools that are applied in various industries. This continuing evolving nature of today's businesses is one of the primary reasons that make industries adopt different methods and tools, seek new goals and recreate themselves. The Industrial Engineering field is one of the domains where changes have been noticed in the past 10-15 years. The skills and knowledge required are likely to have changed in this time period and new graduates from industrial engineering programs should be aware of the job market's current needs. Given this change in industry, the Industrial Engineering curriculum at the undergraduate level should be updating itself, with the intention to better prepare the students to be able to keep up with these changes happening in industry. The match between the skills required and college courses are not always as close as they should be. In this paper, the authors will discuss industry needs and how well the undergraduate curriculum is keeping pace in order to produce industrial engineering graduates who can integrate faster into industry. Along with identifying the current status of industrial engineering programs and how they prepare students in comparison to the current needs of industry, the authors will also look at how the undergraduate curriculum can be modified, if needed.

Keywords: industrial engineering, industry academia gap, industrial engineering curriculum, industry skills for industrial engineers.

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1. Introduction

The shortage of appropriately skilled labor across many industries, including various fields of engineering, including industrial engineering, is emerging as a significant and complex challenge to many countries. According to Burrow (2015), industrial engineering is one of the most in-demand engineering occupations and also one that is most heavily staffed with older workers. In fact, as of 2015, close to 26% of the industrial engineering workforce would be eligible to retire within five to ten years.

One of the reasons hypothesized about why this is happening is because of the gap that exists between academia and industry. In fact, one of the primary topics of discussion between academia and industry is the existing gap between how academics train and prepare students during their years at university versus what the actual need of industry is when they graduate and try to be hired by those companies (Mehra, L., 2017). These gaps exist from the degrees at the bachelor's level all the way to students earning PhD degrees. One of the concerns of industry professionals is that students who graduate from university at best have “tunnel vision,” which is where all they know is the subject matter content related to their field of expertise (Pianin, E., 2014).

The above-mentioned gap also exists in various fields of engineering. Furthermore, in a field like engineering, changes happen very rapidly in today's dynamic business environment. It is thus important that both industry professionals as well as students graduating from university keep up with these changes.

The goal of this paper is to evaluate the current state of the industrial engineering curriculum with respect to industry needs. This need of such a project is also portrayed by the fact that large publishers such as McGraw Hill, are working on a new, more updated edition of their industrial engineering handbook, to help practicing industrial engineers as well as students majoring in industrial engineering to be able to better meet the needs of the current employers in this domain.

2. The Gap between academic (programs of study) and industry needs

It is a noted fact that students are finding it increasingly challenging to find a job after graduating. There have been several studies done to identify the cause for this challenge that students are increasingly facing such as “Closing the skills gap: creating workforce-development programs that work for everyone” (Laboissiere, M. and Mourshed, M., 2017) and “Education to Employment: Designing a System that Works” (Barton, D., Farrell, D., and Mourshed M., 2012). An important point

that some studies revealed is a gap between the academic programs and the industry needs is the necessity for fluency in English. With globalization, distances have been shortened and the exchange between cultures has increased. It is common, today, for companies to hire people from different parts of the world. With English being considered a global language, companies have required their employees to have mastery over the language. However, not all universities around the world have modified their curriculum to offer courses and classes to develop these abilities in their students (Sparks, 2012).

Another possible cause of this great difficulty to find a job is the fact that there is not much data about what is required for students to transition from college to employment. Per a McKinsey & Company's report (2012), "This information gap makes it difficult to begin to understand what practices are most promising—and what it will take to train young people so that they can take their place as productive participants in the global economy." (Mourshed, M., Farrell, D., and Barton, D., 2012, p.11). In other words, the students do not know which practices and skills they need to succeed at work. To help with that, employers, education providers, and the students should step into one another's worlds.

According to Alya Mishra (2014), another problem has been the flak in recent years that universities have faced, due to "inflexible curricula, rote teaching and learning and lack of experiential learning outside classroom" (Mishra, 2014). But other than that, Mishra also highlights the fact that academics complain that industry expectations are often "unrealistic and misguided." According to Shanti Jagannathan (2014), senior education specialist at the Asian Development Bank in Manila, employers "want everyone to come prepared and ready. Employers need to invest in their own employees" (Jagannathan, 2014). It can be said, therefore, that the lack of communication and collaboration between colleges and industry can be one of the major causes of the gaps between what is taught to students and what the market actually needs and requires.

It can be said that this gap, which exists in all parts of the world and in most fields, is still far from being completely fulfilled. In fact, it is very difficult for the student to leave fully prepared for the job market, given that each company has its peculiarities. However, reducing this gap will mean that the newly graduated will need less time to adapt and companies will have at their disposal better prepared professionals.

3. Explain the Motivation for this research project

The gap between academia and industry that has been mentioned above is not only a problem for companies looking to hire students but has also become a major issue for students who find themselves not prepared to the extent that their employers would expect them to be -- thus resulting in companies not wanting to hire them (Pianin, E. 2014). Thus knowing the industry's needs is essential for a

student, so he/she can be better prepared to hit the ground running. Such students are also preferred by industry to hire as industry professionals then need to spend less time training them, which translates to a reduced cost for the company hiring them. With this in mind, all the students, including one of the authors of this article who is an industrial engineering major, can better prepare themselves for what is to come after college. Additionally, considering that industrial engineering is one of the engineering professions with the highest average age with above a quarter of all industrial engineers ready to retire in the next 5-10 years, it is important to examine and evaluate the current curriculum in industrial engineering to make sure that the next generation of students going into the work force are prepared to address the challenges of the 21st century.

3.1. Research Methodology

For most students, the purpose of graduating from college is to be well equipped with skills and knowledge, in their chosen major, for job opportunities in evolving fields. Each school, though, has their own set of courses and related assignments and activities to provide students with the knowledge necessary to acquire a job in the industrial engineering field. The main goal of this article is to find out if the skill set taught to these Industrial Engineering majors meet the industry needs.

To do that, the authors reviewed the undergraduate curriculum from the top 20 Industrial Engineering programs in the United States, so they could identify trends of courses commonly offered as well as trends of topics that were taught to the students majoring with a bachelor's degree in industrial engineering. The universities that the authors focused on were picked from the US News listing of the top 20 industrial engineering programs in the United States. (US News, 2016). These schools include: Georgia Institute of Technology, University of Michigan, Ann Arbor; Purdue University, West Lafayette; University of California, Berkeley; Virginia Tech; Stanford University; Northwestern University; University of Wisconsin, Madison; Massachusetts Institute of Technology; Pennsylvania State University, University Park; Cornell University; Texas A&M University, College Station; Columbia University; University of Florida; North Carolina State University; University of Southern California, Viterbi; University of Illinois; Iowa State University; Arizona State University, Fulton; and Ohio State University.

On studying the curriculum covered at these universities', the authors identified the following topics as the ones that had been covered in the majority of the programs: decision making, operation research, stochastics models, quality control, risk analysis, organizational behavior, management, financial engineering, manufacturing processes, ergonomics, occupational safety, logistics, economic analysis, design, supply chain, innovation, and lean manufacturing.

Once the topics covered in the undergraduate degree program were researched, the authors started focusing on the industry needs in the field. Since the Industrial Engineering field is expansive and includes jobs with a wide variety of titles, the first step to identify these industry needs was to look toward the jobs and positions an industrial engineering student could take up upon graduation. For this purpose,

the authors visited a number of websites such as <https://www.mymajors.com/career/>, and <https://job-descriptions.careerplanner.com>, which list industrial engineering jobs and their requirements. After finding and reviewing several dozen postings, the second step was to find out what are the tasks, abilities, knowledge and skills that the companies usually require for these occupations. With all the information gathered, the authors could analyze and highlight the trends focusing on common needs that were required by almost every company. Thus, it was possible to obtain a relevant idea of the current market needs. Some of the main skills required by the current market are: leadership, decision making, management, fluency of ideas, problem sensitivity, critical thinking, mathematics, engineering and technology, and production and processing.

The authors' focus was to find out if the industry needs are met by what is taught at the universities in the United States in the industrial engineering programs. In other words, the study has the main goal to discover if the student is ready for entering the job market when he/she leaves college.

4. Initial Findings from the study

As the authors have mentioned before, there is a gap between what today's university curricula offer to their students and what the industry needs are. The main purpose of this article is to analyze this gap and think of ways to reduce it and address it as best as possible.

The first step was to consider all the top 20 American universities curriculum and create a list of the classes that most of them offer to the students. This would be an indication that if all (or almost all) of the best universities in the country were offering that course, that knowledge was considered very important and necessary for the future engineer. After that, it was necessary to create the list of skills that are required from current engineers by most companies. We analyzed not only the technical skills needed, but also the overall abilities and knowledge, so we could provide comprehensive information about the student skills sets to be considered a good candidate for industry positions in the industrial engineering field.

As shown in Table 1, a lot of classes that universities currently offer provide students with sufficient knowledge for the technical part of industry's current needs. However, much of what the market wants and needs for the profession are not merely the technical skills, but in addition also skills, such as critical thinking, deductive reasoning, ethics, fluency of ideas, inductive reasoning, information ordering, leadership skills, mathematical reasoning, negotiation skills, originality and problem sensitivity.

The authors do notice that these other additional skills are not addressed explicitly in the industrial engineering curriculum. Due to variations in the technical aspect of jobs in the industrial engineering profession, most companies include this as

part of their training but do not provide opportunities for students to beef up on their soft skills which are an absolute necessity in most industrial engineering positions.

Based on the above information, the authors concur that the main gap between what universities have been teaching their students and what industry needs of them is what we call soft skills (Itani & Srour, 2016) as well as other skills like ethics and negotiation. Being multicultural in practice, for example, is something that universities do not offer much to their students, despite academic exchanges. Some schools in the United States that have diverse student bodies tend to offer this experience to their students by virtue of their geographic location. However, it is not something that is specifically addressed in the industrial engineering curriculum. Today, it is known that in any large company there is an immense variety of cultures among the workers, and dealing with this is an important characteristic for various positions related to the industrial engineering domain such as manufacturing engineer, systems engineer, supply chain manager, or a supplier administrator. All these positions could likely involve responsibilities that involve working with colleagues internationally and understanding different cultures.

Another practical example is teamwork. In classrooms, for example, although teachers propose different assignments in groups, students often join friends and people they already know to perform tasks in teams, particularly if the teams are not created by the instructor themselves. Thus, the students do little to develop the ability to share their ideas and reach a final agreement with team members who are completely new to them. This is an identified gap because for most jobs, including industrial engineering, the workers will rarely choose who he/she will work with, so they need to know how to behave, as well as how to express their ideas to others, listen to what others have to say, and come to conclusions together.

The authors can also cite the ability to lead and manage others as a skill needed for these positions. Except for those who venture into a junior business, clubs, academic centers, sports teams, fraternities or other student movements, rare are the chances that the undergraduate student has to train in the art of leading a team. And that requires emotional intelligence, resilience, speech clarity, good oral expression the ability to delegate and motivate people.

The study above revealed that most of the classes are given to teach some technical skills, but most importantly, they do not help the student to develop all the abilities cited above, as students will need. Because of that, the conclusion for now is that the biggest gap between the Industrial Engineering curriculum and the industry needs are the soft skills as well as ethics and leadership courses. Students must have the opportunity to develop these skills not only with extracurricular activities, but also inside the classes they are taking.

5. Recommendations

Based on these initial findings, the authors would recommend that the industrial engineering curriculum should include elective courses on topics such as leadership, ethics and soft skills. These skills are more relevant to students who major in industrial engineering versus traditional engineering majors and hence it is important that students in industrial engineering programs be given the opportunities to take elective classes focusing on these areas from either the business schools or similar courses should be developed within schools of engineering for offering to the students. In some schools, industrial engineering and engineering management programs are housed in the same department. In such situations, the management courses talked about above could be offered to the industrial engineering students from the engineering management program as typically industrial engineering programs are thought to be more numbers focused whereas engineering management takes the management side more into consideration.

Lastly, the authors also recommend that industrial engineering majors be exposed to an entrepreneurial mindset. This includes various skills such as understanding topics such as identifying a target market, creation of a value proposition for their customers as well as various costing aspects of the project. All these skills can be incorporated into the curriculum by including a business model canvas in the senior design project as is being currently done at many universities.

6. Conclusion

As described by the authors above, the primary gap between what academia provides to industrial engineering students and what industry expects is related to the soft skills as well as other leadership skills that the students are not exposed to a great extent. These soft skills include critical thinking, decision making, deductive reasoning, understanding team dynamics, leadership skills and communication.

In order to overcome this gap, in addition to the recommendations made above, the suggestion that the authors make is to implement an action plan which consists of assignments that are designed in a way to instill these skills into students. This is because adding new courses or going over the prescribed number of credits for a program is extremely difficult in most universities and hence it would be much easier to design assignments for various courses that addressed the specific skills gaps. For example, writing assignments are an excellent way to promote critical thinking. Students should be asked to write a paper on a chosen topic and provide valid evidence and arguments in favor of claims that they support and those they don't. Based on this evidence, they can also work on making an overall decision about the paper. Thus, the paper would expose the student to both critical thinking

as well as decision making. An increasing use of case studies instead of traditional assignments could also help increase student awareness and understanding about critical thinking and decision making.

Additionally, there should be team assignments given to the students so they are immersed in working in a team environment and thus get an understanding of team dynamics, the challenges it poses and how to deal with such situations. For this experience to be realistic and similar to what they would experience in industry, the students should not be allowed to create their own teams. Team assignments should be submitted to the instructor and include a PowerPoint presentation so that the students are also exposed to both written and oral communication skills. Making the students work in teams and by incorporating project based learning, the students also must elect a “project manager” who will be exposed to leadership skills that he/she will have to implement in order to make sure that the assignment is completed and turned in as a final deliverable to the instructor.

Lastly, as part of the senior design class, the incorporation of the business model canvas (BMC) will result in the students being exposed to concepts such as identifying the target market, creating value propositions for each customer segment, identifying key activities, key resources as well as key suppliers who need to be involved with a project. This powerful tool, when incorporated into the senior design class, helps students understand these much-needed concepts without adding any new courses formally to the curriculum.

References

- Ashton, W. , Hurtado-Martin, M. , Anid, N. , Khalili, N. , Panero, M. , et al. (2017). Pathways to cleaner production in the americas i: Bridging industry-academia gaps in the transition to sustainability. *Journal of Cleaner Production*, 142, 432-444.
- Barton, D., Farrell, D., and Mourshed M. (2012). Education to Employment: Designing a System that Works. McKinsey & Company. [online] pp. 11-16. Available at: <http://www.mckinsey.com/industries/social-sector/our-insights/education-to-employment-designing-a-system-that-works> [Accessed 12 Feb. 2017]
- Benamati, J. , Ozdemir, Z. , & Smith, H. (2010). Aligning undergraduate is curricula with industry needs. *Communications of the ACM*, 53(3), 152-156.
- Burrow, G, (2015), Does the US have an Industrial Engineers Shortage? Accessed at <http://www.economicmodeling.com/2015/10/27/does-the-us-have-an-industrial-engineers-shortage/> on May 5, 2017
- Chookittikul, W. , Kourik, J. , & Maher, P. (2011). Reducing the gap between academia and industry: The case for agile methods in thailand. *Information Technology: New Generations (ITNG)*, 2011 Eighth International Conference on, 239-244

- Garg, K. , Varma, V. , Giridhar, K. , & Mishra, A. (2006). Security: Bridging the academia-industry gap using a case study. Software Engineering Conference, 2006. APSEC 2006. 13th Asia Pacific, 485-492.
- Itani, M. , & Srour, I. (2016). Engineering students' perceptions of soft skills, industry expectations, and career aspirations. *Journal of Professional Issues in Engineering Education and Practice*, 142(1),
- Laboissiere, M., and Mourshed, M. (2017). Closing the skills gap: Creating workforce-development programs that work for everyone. McKinsey & Company. [online]. Available at: <http://www.mckinsey.com/industries/social-sector/our-insights/closing-the-skills-gap-creating-workforce-development-programs-that-work-for-everyone> [Accessed 13 Feb. 2017]
- Malik, R. (2012). Management education and corporate expectations: Bridging the gap. *Drishtikon : A Management Journal*, 3(1), 191-219.
- Mandal, K. , & Banerjee, C. (2012). An empirical identification of performance gap in engineering education program from the perspective of stakeholders. *International Journal of Trade, Economics and Finance*, 3(4), 281.
- Mehra, L. (2017). Bridging the skills gap with industry: academia partnerships. Cisco. [online] Available at: http://www.cisco.com/c/en_in/about/knowledge-network/academia-partnerships.html [Accessed 12 Feb. 2017]
- Mishra, A. (2014). Growing mismatch between graduate skills, market needs. *University World News*, [online]. Available at: <http://www.universityworldnews.com/article.php?story=20140204171742828> [Accessed 11 Feb. 2017]
- Pavon-Marino, P. , & Izquierdo-Zaragoza, J. (2015). Net2plan: An open source network planning tool for bridging the gap between academia and industry. *Network, IEEE*, 29(5), 90-96.
- Pianin, E. (2014). The Surprising Reason College grads can't get a job. [online] CNBC official website. Available at: <http://www.cnbc.com/2014/01/29/the-surprising-reason-college-grads-cant-get-a-job.html> [Accessed 12 Feb. 2017]
- Raver, R. (2012). One Step at a Time: Bridging the Gap Between Academia and Industry. [Blog] *The Grad Student Way*. Available at: <http://thegradstudentway.com/blog/?p=251> [Accessed 12 Feb. 2017]
- Sparks, S., & Sparks, S. (2012). Study pinpoints educator-employer disconnects; "education to employment: Designing a system that works". *Education Week*, 32(14), 5.

A Free Application Engineering Economics Developed in C++ to Improve the Teaching Process in Distance Learning

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Abstract The present work was developed in a high education institution of Brazil. Because to the difficulty of many students of the superior technology in Industrial Production Management in the study of the discipline of Computer Science where the main objective is to learn computer programming, we chose to work together with the discipline of Engineering Economics to motivate and help in understanding concepts related to the C++ language as well as to promote improvements in the programming steps. Each team of 4 or 5 students developed an application that has the main tools of Engineering Economics and, for social purposes, these students provided free share the respective applications and posted the link in social networks. It was observed that there was a 44.83% improvement in the performance of the students in the course evaluations after their participation in the project. It was also possible to observe the good acceptance on the part of the users regarding the applications developed and shared free.

Keywords: distance learning; pedagogical practice; engineering economics; C++ programming

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1. Introduction

Computer programming corresponds to a sequence of steps that direct the processing of a flow of operations that have a utility.

It is an activity that involves art, engineering and science (Sebesta, 2012). To create a computer program is necessary to follow syntactic and semantic rules. Through programming is possible to specify what data to process, how to do it, and what results to display. Currently there are several programming languages that allow the transformation of these steps in machine language that will be executed by the computer. Among several languages, C++ is a universal programming language (Schildt, 2003). The use of the C++ language is interesting because of its powerful performance. However, many students have problems with learning logic and programming language. Often the methodology and examples used in teaching a programming language are not able to initially show its importance.

As we are in a constant search for improvements in the teaching and learning process, we need to think about new methodologies that can improve the learning process. Freire (2002) affirms that it is important to reinforce curiosity of the students and critical ability to achieve their integral education. Behar (2009) believes that there needs to be interactions between students and teachers around the con-tent to be addressed. It is also important that there is meaning for the topics covered in the lessons (Schell & Javicki, 2013). There is concern that reflective practices result in better teaching and better educational outcomes (Jaeger, 2013). The use of technology motivates students to interact more, and Murphy, Walker, and Webb (2013) give some insight about how this is possible. Is clear that if the performance of the students is not good as the expected, it is necessary to make some arrangements for changes in this context.

To promote improvements in the teaching and learning process, once a difficulty in understanding the discipline was detected, we developed a project integrating the disciplines of Computer Science and Engineering Economics, both in the modality of distance learning. In this project, students could program different methods addressed in the discipline of Engineering Economics and intended to solve real problems. With regards to this work, the main objective was to promote improvements in the learning process of students of the Industrial Production Management in relation to the discipline of Computer Science. It was also part of this work to provide family members, friends and people in general access to the possibility of obtaining results related to Engineering Economics such as capital recovery, return of investments, calculation of project viability, among others.

2. The importance of both C++ and engineering economics

C++ is a compiled language. For a program to run, it takes text that will be processed by a compiler and will generate an executable program (Stroustrup, 2013).

This text has a logical structure that involves an often-sequential reasoning. Basically, data are reported, processed through binary operations, arithmetic, repetition structures, and later the results obtained are presented. Currently there are several programming languages, such as C, C++, Java, Python, PHP and others.

C++ is a powerful and widely used language. In face-to-face courses, there is already a very satisfactory methodology for teaching a programming language and it is not usual to search for innovations. However, in distance learning we need to promote improvements because of the expansion of this modality of teaching and the need for students to learn more and more. Because learning occurs in a virtual classroom, the existing computational resources provide a wide variety of options that can and need to be explored. In a classroom, students do not always have this access, but in distance education the student is quite inserted in the virtual world. It is possible to use the computer so that this use contributes to the learning process and facilitates the understanding of concepts related to the studied subjects (Bittar, 2011). It is also important to relate face-to-face and distance contexts when dealing with content management and learning systems (Tori, 2010).

Regarding the subjects of the Computer Science, the students are initially presented with the importance of programming today. Then the design and programming are displayed. The notion of design and programming can be detailed as:

- Expresses ideas in codes.
- Expresses independent ideas in independent codes.
- Represents by means of code relations between ideas.
- Combines ideas expressed in code.
- Expresses simple ideas in a simple way (Stroustrup, 2013).

After these initial presentations, students have access to the first contacts with the C++ language and concepts related to variables, arithmetic, constants, and loops (if, while, for). Also discussed are pointers, matrices, and other important topics. The programming logic is worked in parallel to the programming language.

With regard to Engineering Economics, the main concepts for engineers are addressed (Newnan, Eschenbach, and Lavelle, 2004). Among several topics, we can highlight: single payment, uniform series, capital recovery, arithmetic gradient uniform series, geometric series present worth, continuous compounding at nominal rate, continuous uniform cash flow, depreciation, and more.

All the subjects studied in the discipline of Engineering Economic have relations with real problems very close to the performance of the students, both in business and personal life.

These themes are very important to assist in the study of project viability, for example. Economic decisions differ in the fundamental way from the types of decisions typically encountered in engineering design (Park, 2004).

In the Industrial Production, the knowledge related to the discipline of Engineering Economics are important in what concerns the study of the feasibility of buying or exchanging equipment. They are also important in other decision-making problems such as the best choice for raising funds or the ideal time frame for exchanging equipment.

The problems encountered in the discipline of economical engineering and, consequently, in several real situations can be solved by means of specific formulas. The use of calculators or spreadsheets is very useful. But for this you need knowledge related to the subjects of the discipline. Therefore, the development of a free and self-explanatory application allows anyone to solve these problems.

3. The pedagogical practice

Students who attend Industrial Production Management in the distance learning have access to the contents available in the learning management system. The online classes contain videos elaborated by the professors of the discipline, books, texts, examples and exercises solved. All students have access to centers of classroom support, a total that corresponds to more than 430 places distributed in several cities in Brazil.

At each center, there are instructors that can assist these students. Students also receive online support. In the learning management system, there is a link for students to contact the instructors. Guidelines are made in writing, by voice or video. It also encourages the formation of study groups and participation in the forums. In addition to face-to-face support and support in the environment management system, students also receive e-mail, chat and telephone support.

The development of the work was done in two stages. In the first stage the 1032 students enrolled in the course had access to the material online, attended the classes, did the activities and performed the evaluations without the relations with the discipline of Engineering Economics that was being offered at the same time. In the second stage, the students participated in the interdisciplinary project. At this stage, in parallel to the regular classes, participated in the development of the application and used the knowledge previously acquired as well as the new knowledge.

The guidelines for the development of the application were: to cover all the subjects of the discipline of Engineering Economics, to have a simple and intuitive interface. Have a brief description of the concepts of each application function and inform how the data entry should be done. Present the results in a simple way and with the appropriate conceptual explanations.

The applications developed by the students were done in blocks. Each block was intended for a specific function of the application. One of the blocks refers to the calculation of the net present value (NPV) and the respective payments.

The basic structure of this block can be seen below.

```
#include <stdlib.h>
#include <math.h>
int main(){
    int a,n;
    float taxa, vpl, vaue, x;
    printf("Calculo do VPL e VAUE.\n\n");
    printf("Informe o numero de periodos: ");
    scanf("%i",&n);
    printf("\nInforme a taxa (em porcentagem): ");
    scanf("%f",&taxa);
    taxa=taxa/100;
    printf("\nInforme o valor do fluxo de caixa na data 0: ");
    scanf("%f",&x);
    vpl=x;
    for (a=1;a<n+1;a=a+1){
        printf("\nInforme o valor do fluxo de caixa na data %i: ",a);
        scanf("%f",&x);
        vpl=vpl+x/pow(1+taxa,a);
    }
    vaue=vpl/(((pow(1+taxa,n)-1)/(pow(1+taxa,n)*taxa)));
    printf("\nVPL: %.2f\n", vpl);
    printf("\nVAUE: %.2f\n", vaue);
    system("PAUSE");
    return 0;
}
```

It is important to note that this application was intended for people who do not necessarily have technical knowledge related to Engineering Economics, but who need to obtain useful information regarding economics problems.

To the analysis of the results, the development of the project was observed and analyzed to verify the influence of this pedagogical practice in the better understanding and application of the subjects of the Computer Science discipline. In addition to evaluating the application produced in terms of operation, user interface and programming logic, the usual activities and evaluations of the course were carried out.

In order to compare the performance of the students in the phase where the application was developed with the performance of the students during the traditional classes was considered the average obtained by the students in the two phases of the project.

It was observed that initially the performance of the students was lower than expected. The average obtained in the first evaluation was equal to 58. With participation in the project, the average student increased to 84, which corresponds to an increase of 44.83%. In the evaluation research carried out with the students it was evident that the practice contributed to improve the understanding of the subjects studied.

In addition to the improvement in academic performance, there was an increase in participation of the students in study groups and a more active stance on the taste for the study of Engineering Economics.

4. Conclusions

In distance learning one of the great aim is to make the students feel that they belong to the environment management system and that the topics addressed as well as the way these subjects are offered are close to the reality of the students. It is also important to encourage students to constantly seek knowledge and applications of this in other areas and in everyday situations. Often the examples presented in a discipline differ from the reality of the students. This is not bad, but when the applications are closer to the context in which students are inserted the better is the achievement.

In the case of the Computer Science discipline, it was identified that initially the students were not really involved with the topics addressed. The understanding of concepts related to variables, repetition structures and, above all, the importance of the acquisition of knowledge related to computer programming was not effective. Creating the applications and making these applications available to the public was important in perception of the students that computer programming can be useful, not only for their own benefit, but can also help others solve their problems. After analyzing the comments posted by the users of the applications produced, it was possible to identify the satisfaction and gratitude of these users. As for the students, the improvement in the performance in relation to the subject of Computer Science was quite significant. The grades obtained in the evaluations increased by 44.83%. Analyzing the postings of the students and the answers given in the periodical institutional evaluation questionnaire, an increase in their satisfaction with the way the project was developed was also identified. Of course, when it comes to computer programming, there is a lot to study. In the subject of Computer Science, the topics covered correspond to a small part of a great universe of knowledge and possibilities.

References

- Behar, PA (2009). Modelos pedagógicos em educação a distância. Porto Alegre: Artmed
- Bittar, M (2011). A abordagem instrumental para o estudo da integração da tecnologia na prática pedagógica do professor de matemática. *Educar em Revista*, 1, 157-171
- Freire, P (2002) *Pedagogia da autonomia: saberes necessários à prática educativa*. São Paulo: Paz e Terra
- Jaeger, EL (2013) Teacher reflection: Supports, barriers, and results. *Issues in Teacher Education*, 22(1), 89-104
- Murphy, D, Walker, R, Webb, G (Eds.). (2013). *Online learning and teaching with technology: case studies, experience and practice*. Routledge
- Newnan, DG, Eschenbach, TG, Lavelle, JP (2004). *Engineering economic analysis*. (9th ed.). Oxford university Press, New York
- Park, CS (2004) *Fundamentals of engineering economics*. Pearson, New Jersey
- Schell, GP, Janicki, TJ (2013) Online course pedagogy and the constructivist learning model. *Journal of the Southern Association for Information Systems*, 1(1), 26-36
- Schildt, H (2003) *C++: The complete reference*. (4th ed.). McGraw-Hill, New York
- Sebesta, RW (2012) *Concepts of programming languages*. (10th ed.). Pearson, New Jersey
- Stroustrup, B (2013) *The C++ programming language*. (4th ed.). Addison-Wesley, New Jersey
- Tori, R (2010) *Educação sem distância: as tecnologias interativas na redução de distâncias em ensino e aprendizagem*. São Paulo: Senac.

The Improvement of Learning Results in Fluid Mechanics Topics through the Transversal Competence Autonomous Learning

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Abstract: The implementation of new plans into higher education, in addition to the institutional project of transversal competences of the Universitat Politècnica de València, promotes the need to complement the traditional learning methods with active methodologies. The continuous learning through programmed activities combined with traditional master class are a powerful strategy. The obtained results in Fluid Mechanics topics in Bachelor Degree are favourable, improving the final evaluation of students regarding to the acquisition of the different competences such as autonomous learning, solving of problems, and design and project in their first domain level.

Keywords: Transversal competence; Hydraulic Engineering; continuous learning; Master student;

1. Introduction

The implementation of the new plans into higher education has promoted the need to complement the traditional learning methods with effective techniques (Morales & Landa 2004). New plans reduce the face-to-face class occurrences, increasing

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the time in which the student can freely prepare the subject by using active methodologies (El-Tannir 2005; Masoliver et al. 2017). Besides, some universities have launched institutional projects in which cross competences should be developed and acquired by the students (UPV 2017). Therefore, to vary the planning of the different subjects is recommendable to reach the learning results of the students since the face-to-face classes are reduced, while retaining the subject content. The change of planning should be focused on developing active methodologies. Such methodologies motivate students through the use of new information and communication technologies (Álvarez et al., 2005).

To develop the autonomous learning and responsibility competences in the students is an essential objective along the student's learning from scholar to university stages. Currently, these new strategies expect to convert students into the principal actors of their learning process. The final objective of these strategies is to reach the maximum development of the planned learning results. Therefore, teaching by competences includes the addition of knowledge, abilities and attitudes, which were not considered in the previous education plans. Moreover, the training by competences considers the active attitude of the trainee in his/her learning, supporting in the constructivism (Fernandez, 2010).

2. Objectives

The objective of the present research is to develop a new planning of the Fluid Mechanics topics. This planning, which is being progressively introduced in the subject matter, mixes traditional teaching techniques with active methodologies (*e.g.*, learning object, homework, development of case study) so that the student reaches the learning results, promoting autonomous learning.

3. Methods

The combination of the traditional master class, computer practices, practical activities in addition to autonomous work are the key elements to reach the proposed learning objectives. The strategy is focused on optimizing the face-to-face time as well as encouraging their autonomous learning. This planning enables students to acquire the developed theoretical concepts with the professor, improving the obtained results and increasing their active participation. Students were proposed to complete seven tasks, which are related to the six teaching units of the subject Fluid Mechanics.

The developed methodology searches to increment students participation in the development of the matter as well as improving the learning results. To do so, a strategy has been designed to enable, on the one hand, the development of

theoretical concepts in class, and on the other hand, the implementation of online work, which promotes students' autonomous learning supported by the use of the information and communicative technologies (ICTs). This plan was organized in two different phases, which are developed by the student at the same time. These phases have face-to-face and non-face-to-face format. The planning of the subject is attached in Figure 1.

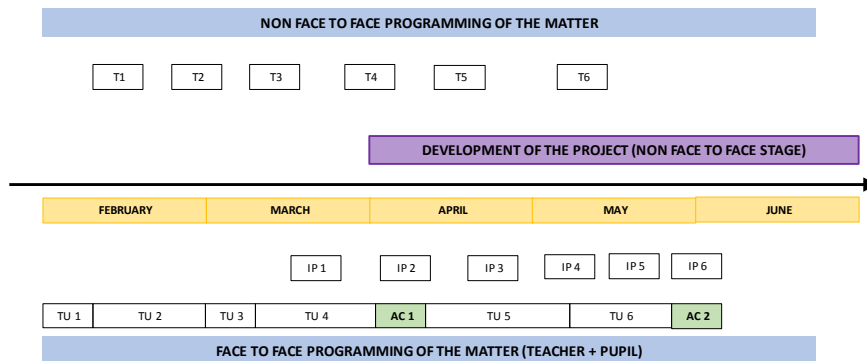


Figure. 1 Teaching planning along the course

3.1. Face-to-face stage

This stage contains the master class and informatics practises, in which the student receives the basic concepts to understand the subject. Concurrently, he/she can begin to work at the non-face-to-face stage. In this phase, the professor teaches the theoretical concepts, which are distributed to six different units. At the same time, the student participates in six sessions of the informatics practises, in which, the pupil learns to manage a specific software. This software will be later used to be implemented in a project related to fluid mechanics, particularly, with the pressure hydraulic in water networks.

3.2. Non-face-to-face stage

This stage is crucial because this phase enables the pupils to develop its autonomous learning through the different tasks and one project, which are proposed along the course. The students carry out these activities taking advantage of the taught contents in face-to-face class (theoretical and practical) as well as the learning objects, in which, the students use the asynchronous teaching to adapt their acquisition of knowledge depending on their available time (Pérez-Sánchez 2017).

The learning strategy is supported by the available informatics tool 'Tasks', which is included in the *PoliformaT* platform. This tool forms part of the virtual campus of the Universitat Politècnica de València and is based on 'Sakai' project. The teacher uses this tool to upload tasks weekly, which are related to the taught contents. The second part of the learning strategy encourages the student to interrelate the learnt contents in the development of a draft. In this activity, the

student has to design a water distribution networks through the constrains defined by the professor.

4. Results

The experience is carried out in the Fluid Mechanics subject, which is taught in the second course of Mechanic Engineering Bachelor Degree. The development of applied methodology causes a positive impact on the obtained results, improving the acquisition of the learning objectives, as well as increasing both the deep learning and the retention students' concepts.

These tasks are enumerated in Table 1 that shows the high participation of the students. The average participation was 80.58%, considering these activities were not obligatory and were not included in the qualification. In contrast, the participation of the student in the development of the project was 100% because this task was included in the final qualification, being its weight in the final mark equal to 20%.

Table 1 Proposed tasks and participation percentage of the student

Tasks	Title	Teaching Unit	Participation percentage of the student (%)
1	Piezometers	2	95.04
2	Hydrostatic forces	2	80.58
3	Mass balance	3-4	84.71
4	Energy balance	4	66.15
5	Linear momentum equation	4	77.27
6	Bernoulli equation	4	79.75
7	Pressurized water systems and open channel flow	5-6	*

(*) This task wasn't finished when the manuscript was written.

Therefore, the high participation showed the success of the proposed activities as the unifying thread of the non-face-to-face time, helping the students to plan their available time and improve their acquisition of the transverse competences, particularly, the autonomous learning and analysis and problem solving, which are evaluated in this matter.

To know the opinion of the students, a survey was developed in the middle of the fourth-month period. The survey showed the good reception of these tasks by the students, of which 86.74 % of the student were in favour of the development of the tasks, although there were near 21% that they would like to remove the tasks

because they lacked time to do it. Only 6% of the pupils were against to develop the activities. These results are shown in Figure 2.

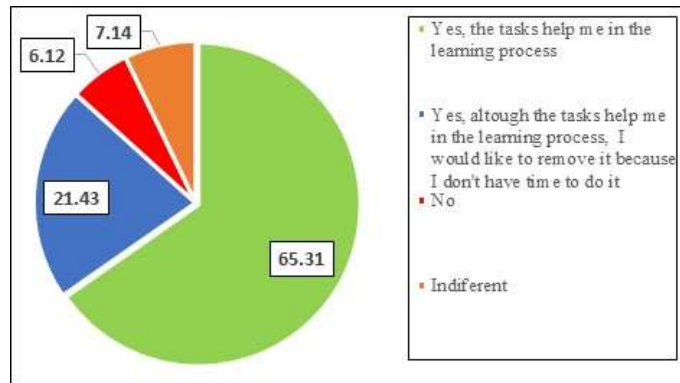


Figure 2 Obtained results in the developed survey

Figure 3 shows the comparative between the obtained marks in the first exam from academic course 2014/2015 to 2016/17 related to the degree of achieving of the transverse competences.

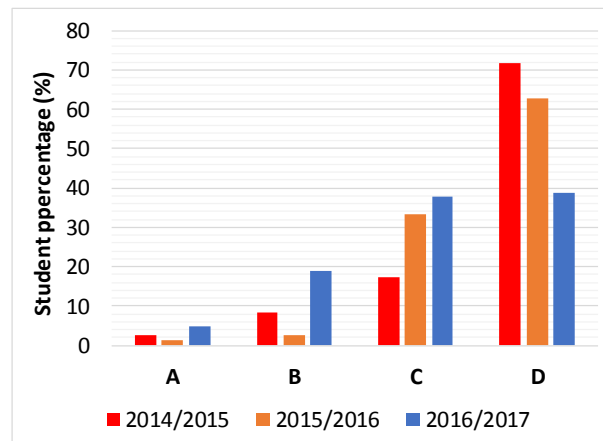


Figure 3 Obtained results in the developed survey

The use of active methodologies, which try to improve the use of the non-face-to-face time of the students by activities for guiding their learning process, increased the acquired level of the competence, reducing 38.04% the number of students, which didn't reach the learning results when the academic course 2016/17 and the rest of years were compared.

5. Conclusion

A description of the implementation of re-thinking practical techniques applied to the autonomous learning in fluid mechanics topics for engineers has been presented. In these plans, the non-face to face time is increased, awarding the student greater freedom to acquire the contents of the subject. The proposed strategy has been implemented in a particular subject matter, showing very favourable results both in the reach of the proposed learning results and in the acquisition of the different competences such as autonomous learning, analysis and problem solving, or design and project in their first domain level.

References

- Álvarez, B.; González, C. y García, N. (2007). La motivación y los métodos de evaluación como variables fundamentales para estimular el aprendizaje autónomo. *Red U. Revista de Docencia Universitaria*, Número 2. pp 1-12
- El-Tannir AA (2005). Education + Training The corporate university model for continuous learning, training and development. *Journal of European Industrial Training Journal of Workplace Learning*, 44(04), pp.76–81.
- Fernández March, A. (2010). La Evaluacion Orientada Al Aprendizaje En Un Modelo De Formación. *Revista de Docencia Universitaria*, Vol.8 (n.1) 11-34 ISSN:1887-4592 22
- Masoliver G, Pérez-Sánchez M, López-Jiménez P.A (2017). Experimental model for non-Newtonian fluid. *Modelling in Science Education and Learning*, 10(1), pp.5–18.
- Morales P, Landa V (2004). Aprendizaje Basado en Problemas. *Theoria*, 13(1), pp.145–157.
- UPV, 2017. Competencias Transversales: UPV. Available at: <http://www.upv.es/contenidos/COMPTRAN/> [Accessed February 26, 2017].
- Pérez-Sánchez, M., López-Jiménez, P.A. (2017) “The Use of Learning Objects in Environmental Education: The Experience of Distance Asynchronous Teaching in Pollutant Dispersion Topics”. *Environmental Education: Perspectives, Challenges and Opportunities*

Knowledge and Project Management

Value Chain Mapping Methodology: a proposal for a process mapping project.

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Abstract A value chain enables a flow understanding regarding product or service value aggregation of an organization by visualizing the existing processes in a systematic and integrated manner. This research strategy is based on a case study that proposes a methodology development for Value Chain Mapping (VCM) which was implemented in a process mapping project. The VCM methodology was developed for the logistic processes of a Brazilian public organization that covers the entire national territory and presents specific means of approach and documentation. The project context was analyzed and the VCM methodology proposal was originated, thus giving a qualitative aspect to the research. The technique used for data collection is based on structured interviews and documentation. The result was surprising, since all the Value Chain processes were identified and used in the subsequent work of process modeling.

Keywords: Value Chain Mapping; Methodology; Process Mapping Project; Process Modeling.

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1. Introduction

The success of an organization depends on the addition of value in the products and services offered to consumers. One way to add value is to differentiate them in its processes. To achieve this, it is needed to know them in the level of activities in order to manage them efficiently (Liczbinski et al., 2002).

The value chain as a management tool enables the manager to visualize in a systematic and integrated way the operation of the set of processes that exists in the organization. That way, the comprehension of cause and effect relations, interfaces and overlaps, as well as the results and impacts contribute to the efficiency of data flux and identification of value and benefits aggregated in the processes.

With the identification of processes that add value to products and services, the design of the value chain can help managers prioritize the improvement of these processes and achieve an increase in efficiency.

The main objective of this article is to propose a standard approach process for Value Chain Mapping. The construction of the Value Chain is part of Planning and Strategy phase of the BPM cycle and provides input to the subsequent stages of process analysis, design and modeling. The idea for this proposal arose from the lack in literature on Value Chain methodology and the opportunity to report the practical application of the development of this methodology in a project mapping the logistic processes carried out in a Brazilian public organization, which is the focus of this study. The methodology presented can be extended to other organizations.

This article has five sections. The theoretical concepts are described in section 2. Section 3 presents the research method adopted. Section 4 presents the context of the process mapping project studied and subsection 4.1 presents the methodology proposal. Lastly, section 5 presents final considerations.

2. Value Chain

According to Porter (1989), the value chain is a representation of the activities performed to design, produce, commercialize, deliver and sustain a product. These combined activities compose the company and aligned with strategy help in understanding the behavior of costs and their existing sources as well as competitive potentials. Dicken (2007) defines it as a sequence of interrelated activities in which each activity adds value to the product or service, a value that motivates the consumer to pay for that product or service.

Understanding the value-added flow of a product is made possible by mapping its value chain, which describes the activities required for the existence of a product

or service, from conception, passing through the different phases of production, delivery to consumers and final disposal after use (Kaplinsky; Morris, 2001).

Kaplinsky and Morris (2001) patronize that value chain analysis that focuses on the dynamics of interrelationships within the productive sector is able to go further than traditional modes of economic and social analysis, especially taking into account the way that companies and countries are globally integrated. It is important for new producers that are trying to insert themselves in the global market with the intention to ensure a sustainable growth of income.

Therefore, the value chain contributes to the identification of opportunities for improvement to achieve greater efficiency of public organizations. It also provides an alignment between the organization's strategy and the activities performed by it from the unfolding of the macro processes identified in processes and subprocesses, forming an integrated architecture (Torres et al., 2013).

2.1. Value Chain Approaches

Porter's (1989) approach is focused on the organizational value chain, even with concepts evolving into the global value chain, which according to Ndyetabula et al. (2016) encompass actors from different levels of value chains. But in this study, the focus is on the value chain for the organization.

The management by processes applied in an organization premises the existence of value chains that represent the logic of interrelation of the macro processes. The value chain can be represented by a continuous left-to-right flow of processes that assist to produce value for customers. The design of the value chain should be based on the activities of the company (Pavani Junior; Scucuglia, 2011).

Value chain optimization does not only guarantee efficiency, but also serves to implement a competitive advantage strategy that difficult the replication by competitors. When the value chain is integrated, it can produce strategic results for the organization with low cost, lead-time reduction and high quality. Many companies that have large-scale processes that repeat themselves often require efficient processes that are rigorously integrated. In this situation, it is important to model the processes in a value chain in order to increase its efficiency (Broke; Rosemann, 2013).

According to ABPMP (2013), the value chain is a process modeling notation, which relates processes and activities that add value to products or services delivered to customers and presents an overview of processes and their levels within the organization. The value chain is applied to the corporate modeling used at the planning level. The ABPMP (2013) indicates that value chain notation should use symbols that represent the value aggregation or steps needed to achieve a goal.

There are few value chain approaches in literature and they usually give little or no guidance on how to proceed to build a value chain for the organization, simply defining what the value chain is and its content. This research aims to fill this gap

by developing a methodology to map the Value Chain in the organization. Section 3 presents the method used in the research.

3. Research Method

The research strategy adopted was the case study carried out in a public organization to identify the logistic value chain. This strategy can be justified by Yin (2010), who says that the case study is characterized when there are several sources of information, benefiting from a previous development of theoretical propositions to conduct the collection and analysis of data.

The research approach was qualitative because it had focus on interpretation rather than quantification, on subjectivity rather than objectivity, on process orientation rather than results and on context since the behavior of the people involved and the situation are based on experience formation (Cassel; Symon, 1994).

The research for understanding the Value Chain Mapping was made on the Scopus, Scielo and Web of Science databases. The keywords used were “value chain” and methodology, and the type of document chosen was article. The years of search were from 2008 to 2017 resulting in 28 articles in the Scopus database, 12 articles in the Scielo database and 299 articles in the Web of Science database. Then, the latter was limited from 2012 to 2017, resulting in 205 articles, totaling 245 in the three databases. Of this amount, only two were consulted and bring the global value chain approach, which is outside the scope of this work. The other articles do not address on the subject.

The data used to support the development of the proposal for a Value Chain Mapping methodology were obtained from a process mapping project, through documents and interviews with the managers. The contextualization of the project and the proposal of the methodology are presented in sections 4 and 4.1.

4. Context of the Process Mapping Project

The research used data from the process mapping project developed within a public organization. The project includes undergraduate students, professors and professionals with degree in Production Engineering, Software Engineering and Network Engineering, all linked to a Federal Public University.

The project's work structure is formed by eight teams focused on process mapping. Each team consists of a leader called a research assistant, a mentor teacher, four trainees, and a requirements analyst. In addition to these teams, the process office is responsible for managing the project both for product standardization issues and validation of the mappings, as well as time management

and control. This team consists of a chief research assistant, two specialists in Business Process Modeling Notation (BPMN), a project manager, the general coordinator of the project and two trainees.

In the beginning of the project, 220 processes were estimated to be mapped. Before starting the process mapping, it was necessary to identify the Value Chain and the listing with the exact number of processes to understand and classify the primary and support processes. In this way, the project team conducted the Value Chain Mapping and developed a methodology that allowed the accomplishment of the planned activities, due to the absence of a methodology in the literature.

Therefore, this article is based on the proposal of a methodology for Value Chain Mapping carried out by the project team and made available for the authors to realize the study presented here.

4.1. Proposal of a Methodology for Value Chain Mapping

With the lack of a methodology disseminated in the literature, the Value Chain Mapping was based on a process of approach that was elaborated in a collaborative way between the project team and the internal team of the studied organization, in order to guarantee the accomplishment of the work with the desired quality. This process was divided in three main phases as demonstrated in Figure 1.

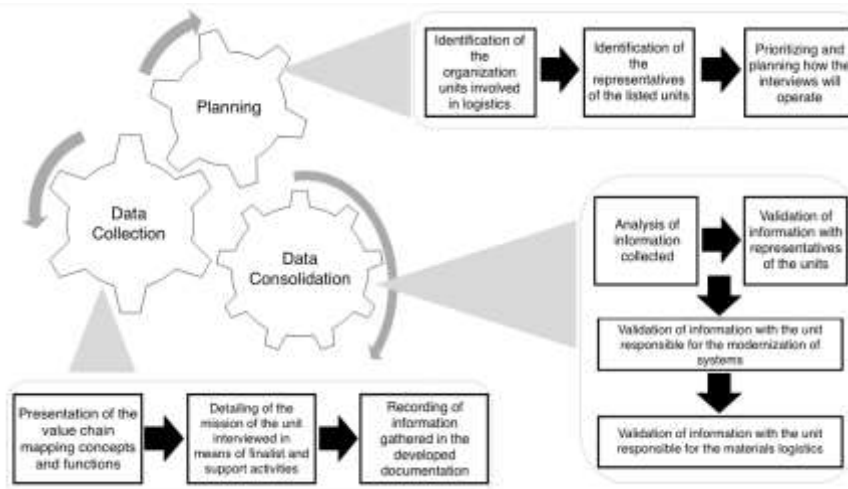


Figure 1 The three steps of the approach process.

The first phase of the approach process is the "Planning". Its purpose is to identify the strategic information sources of the organization, prioritize the data collection and define how these data will be collected.

This planning resulted in the definition of structured interviews for the collection of data with the identified key people. The modeling process planned during this

first stage is based on a detailed study of internal documentation of the organization, in addition to the literature already presented.

The "Data Collection" is the second phase and consists of the operationalization of interviews together with the collaborators previously identified. This step aims to design the vision of logistics processes within the organization units, ensuring that the key people are involved.

This round of data collection consists of two main activities. The first is the presentation of the value chain concept and function, in order to mobilize the interviewee to participate in the modeling of the logistics processes that he is consciously involved. The second is the delineation of the mission of each organization unit interviewed to identify the value activities performed, as well as the support activities required to support the primary activities.

The meetings were initiated with the introduction of the team and alignment of objectives and development of the work exposing the benefits of the value chain. These benefits were presented in the form of a flyer. Its structure is presented in Figure 2.

The flyer was based on the definitions already cited in the theoretical section and by Torres et al. (2013) who states that even if public organizations do not aim at profits, it is beneficial to identify opportunities for cost reduction and efficient use of resources so that they can maintain their operations with quality service.

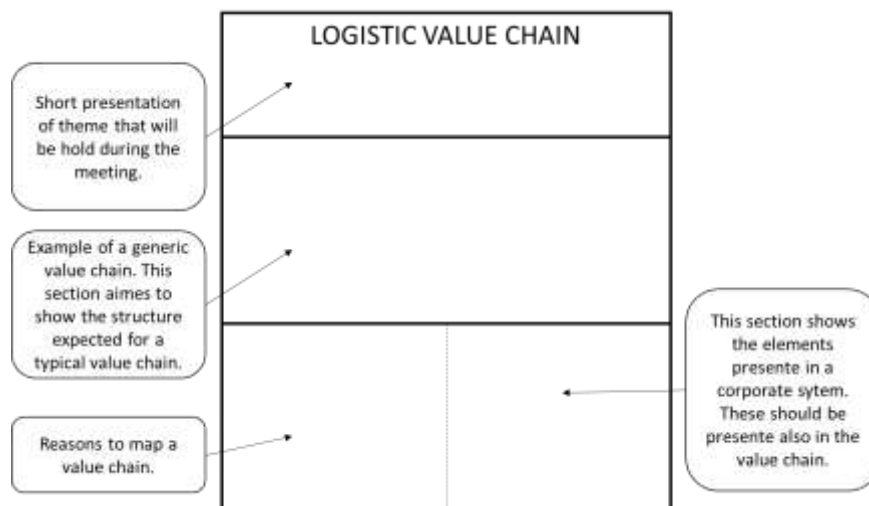


Figure 2 Structure of the value chain flyer.

Each of the data collection meetings aimed at conducting the interviews with the objective to consolidate the systemic vision of logistics of the interviewees and to identify the main processes carried out in each organization unit. Thus, two

meetings took place with each identified organization unit, the first one for gathering data and the second for ratification of it.

The last phase of the approach process is the "Data Consolidation", finalizing the Value Chain Mapping. After this consolidation, a validation was carried out together with the organization units responsible for the product to validate the end of the work. Table 1 summarizes the techniques used in data collection for the Value Chain Mapping.

Table 1. Synthesis of the main techniques used in data collection

TECHNIQUES	DESCRIPTION
Structured Interview	It was made based in a script of questions related to the mission of the organization unit, how to achieve the objectives of this mission and its relationship with logistics. The interview was held by two people. One of them conducted the meeting while the other recorded all the information provided. At the end all information was ratified. A total of sixteen organization units were consulted.
Pilot Study	The interview was made with an organizational unit indicated for verification and adjustment of the method. After this study, questions were added to the interview script regarding more detailed information of the processes such as inputs and outputs. Also, a second round of meetings was added to validate the information handled and classified according to the value chain.
Content Analysis	Made with basis in documentation from interviews and comparison with existing literature.

The three phases were performed using the techniques presented in Table 1. With the sequential application of the three phases and the use of the material and support techniques, the methodology for the mapping of the Value Chain is constructed.

After that, it was possible to design a Logistic Value Chain for the public organization studied and to identify 236 processes classified in two categories: primary and support. This number approached the number of 220 processes estimated at the beginning of the project, which shows that the applied methodology was pertinent and adequate for the achievement of the proposed objectives.

5. Final Considerations

The present work fulfilled the proposed goal of presenting a standard approach process for Value Chain Mapping, contributing to knowledge about the value chain and how to do it. To carry out the mapping, it is necessary that the interview be performed with the person who has the macro view of the processes performed

by the organization. There is a risk of obtaining a restricted and unrepresentative vision of reality if this does not occur.

During this work, it was difficult to identify the key people. This resulted in delays in interviewing, requiring further scheduling and an extensive number of meetings as consequence. At times, an interviewer that did not participated in the introductory meetings of the mapping project and had no knowledge of the benefits generated by it was assigned. As a result, part of the interview time was spent straightening out interviewers and interviewees to establish a common goal.

In addition to these difficulties, there was a challenge in establishing a relationship of trust. This is due to the apparent distance of the interviewing staff from the interviewees. It is necessary to establish mechanisms that safeguard the information provided and guarantee the relation of the service provided. The project team is not able to extract critical information without this trust.

Having mentioned the difficulties, the benefits generated are even more important. This work is part of the first phase of the process modeling cycle. The identification of the value chain is the most important step in the process modeling work, because the processes to be modeled are identified in this phase and they provide a real knowledge of the work being done.

Furthermore, the value chain structure helps the process modeling team understand the relationship between processes and boundaries between organizational units. In this way, modeling becomes a work of detailing what has been observed in the value chain and ensures that the identified activities are related to the mission of the organization.

References

- ABPMP. CBOK: Guia para o Gerenciamento de Processos de Negócio. Versão 3.0. 2013.
- Broke, V.; Rosemann, M. Manual de BPM: gestão de processo de negócio. Bookman, Porto Alegre, 2013.
- Cassel, C.; Symon, G. Qualitative methods in organizational research. Londres: SAGE Publications, 1994.
- Dicken, P. Global Shift: Mapping the Changing Contours of the World Economy, 4th ed., 2007.
- Kaplinsky, R.; Morris, M. A Handbook for Value Chain Research. 2001. Available in: <http://asiandrivers.open.ac.uk/documents/Value_chain_Handbook_RKMM_Nov_2001.pdf> Access in: april 28th of. 2016.
- Liczbinski, C. R.; Kelm, M. L.; Abreu, A. F. Informações fundamentais ao gerenciamento das atividades da cadeia de valor – o caso das pequenas empresas industriais de produtos alimentares. In: XXII ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO, Curitiba – PR, October 23th to 25th of 2002.

- Ndyetabula, D. W.; Sørensen, O. J.; Temu, A. A. Agribusiness development and the role of value chain business associations. The case of dried fruits and vegetables in Tanzania. *African Journal of Economic and Management Studies*, Vol. 7 No. 4, 2016 pp. 510-534.
- Pavani Junior, O.; Scuccuglia, R. Mapeamento e Gestão por Processos – BPM. Gestão orientada à entrega por meio de objetos. M.Books do Brasil Editora Ltda, São Paulo, 2011.
- Porter, M. E. Vantagem Competitiva das Nações: Criando e Sustentando um Desempenho Superior. Campus. Rio de Janeiro, 1989.
- Torres, M. C. G.; Paiva, A. O. R.; Ferreira, V. C.; Rocha, A. M. C. Cadeia de Valor: Os benefícios do Alinhamento entre a Estratégia Governamental e a Operacionalização de seus Processos. In: Congresso Consad De Gestão Pública, 6, 2013, Brasília.
- Yin, R. K. Estudo de caso: planejamento e métodos. 4. ed. Porto Alegre: Bookman, 2010.

Sustainability Assessment Framework to Effectively Manage Architectural Projects

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Abstract: Sustainability is one of the main aspects of today's architectural practice. In the past, any building with any environmentalist feature was defined as environmentally conscious and sustainable, however under the umbrella of sustainability, economy and community as well as environment need to be taken into account. The aim of this research is to develop a holistic framework for sustainability assessment with the integration of economic, environmental and social aspects in the architectural projects. Discussions are focused on modelling of a holistic sustainability assessment framework to manage architectural projects effectively. Specifically, the proposed framework also considers the input/output information needed for assessment process and stakeholders' involvement. Additionally, the proposed framework is used to assess the sustainability of a real-world architectural project that has been design for a multi-functional building.

Keywords: Architectural Project; Sustainability Assessment; Project Management; Systematic Framework

1. Introduction

The realm of sustainability is an integrated context of today's architectural practice, while sustainable development is a competitor understanding as other important aspects. These aspects form the sustainability intellection by using varied materials, technologies and methods as well as design approaches in architectural practice. Mostly it is the low impact on the environment and energy efficiency, in terms of climate responsiveness that focuses on environmental

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sustainability and in long term, which leads to the conclusion of economic sustainability. However if the focus is sustainability as a whole, also social sustainability needs to be taken into account (Gibson, 2006).

Considering these facts, this study focuses on modelling the sustainability assessment framework to manage architectural projects from a holistic context. The objective of this study is to develop a systematic framework method containing different perspectives of sustainability; i.e. environmental, social and economic. In order to develop this holistic framework, a multi-criteria assessment technique is used within the project management perspective of knowledge areas. This study not only explores a multi-criteria decision assessment methodology application/practice (Finkbeiner et al, 2010); but it also explores a holistic assessment framework using the context of knowledge areas.

2. Literature Review

2.1. Sustainability Indicators

Sustainability is usually considered as an abstract issue, where applicants have no idea on how to measure and assess. However, sustainability can be measured within the context of indicators determined for each situation. An indicator can be defined as a parameter that provides information about a phenomenon and are developed for a specific purpose (OECD, 1993). The indicator has significance that extends beyond the properties directly associated with the parameter values.

The birth of sustainability concept relies on sustainable development where first sets of indicators were developed by United Nations (UN, 2007). These first sets of indicators include sociological and physical aspects. Later, United Nations Commission on Sustainable Development (UNCSD) improved this classification including four pillars of sustainable development. In this classification, 44 sub-themes with several indicators under social, economic, environmental and institutional aspects are defined (see Figure 1).

From the perspective of architectural projects, there have been a quite number of researches focusing on sustainability indicators. Edum-Fotwe and Price (2009) focused on apprising construction project sustainability through a social ontology. Later in 2010, Sanchez and Lopez identified sustainability indicators especially for construction together with a methodology. In the same year, Chen, Okudan and Riley proposed composite sustainability index in order to select construction method in concrete buildings. In 2016, Dobrovolskiene and Tamosiuniene also proposed a composite sustainability index and used it in a case study for Lithuanian construction sector.

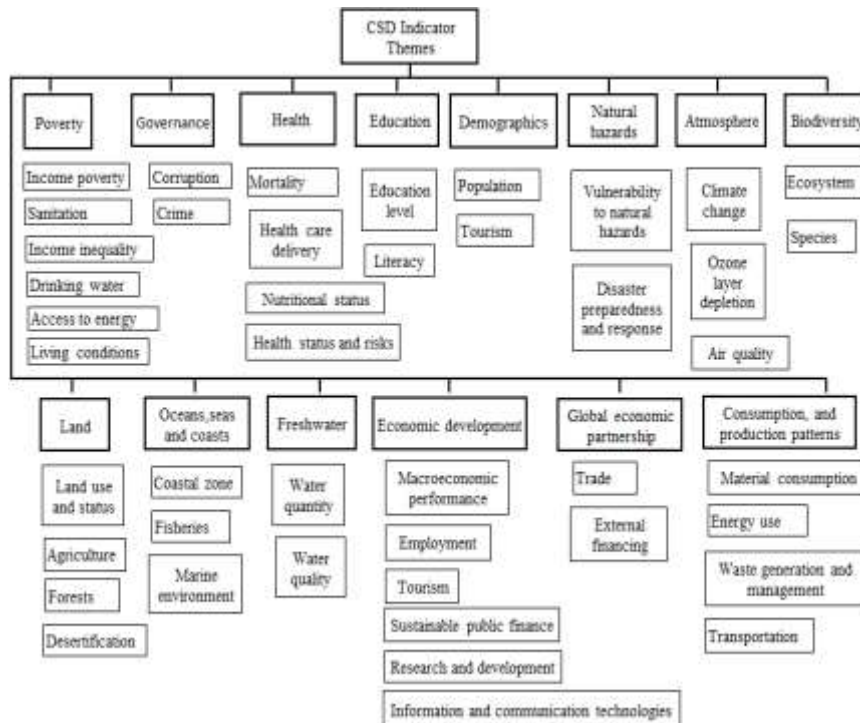


Figure 1. UNCS D theme indicator framework

2.2 Sustainability Assessment

As defined by OECD, the process of sustainable assessment consists of six analyses, i.e. relevance, scoping, impact, comparative, associative and political analysis. On the other hand, these analyses require the need of methodologies and tools for practical applications. Ness, Urbel-Piirsalu, Anderberg & Olsson (2007) categorised the tools used for sustainability assessment based on the temporal focus along with focus objective. According to the temporal focus, they investigated retrospective studies, prospective studies or integration of both. Figure 2 illustrates the classification framework proposed by Ness et al. (2007).

3. Proposed Framework for Sustainability Assessment

3.1. Nature of Architectural Projects

The architectural projects can be defined as a project, which are planned and designed by architects according to the needs, and demands of customers, for built environment. This built environment can be of a smaller scale to a larger scale that can contain the purpose of residential, commercial, educational, public,

multipurpose, etc buildings. In the process that began with the definition of the concept of sustainability, applicability to various fields was determined. One of these areas includes the development and management of healthy built environment in the construction sector, which started in the 1990s. According to Kibert (2016), sustainable construction involves development and management of environmentally conscious built environments. This definition only focuses on one pillar of sustainability, which has the environmental point of view. However sustainability should be developed with triple aspects, i.e. environmental, economical and social, together.

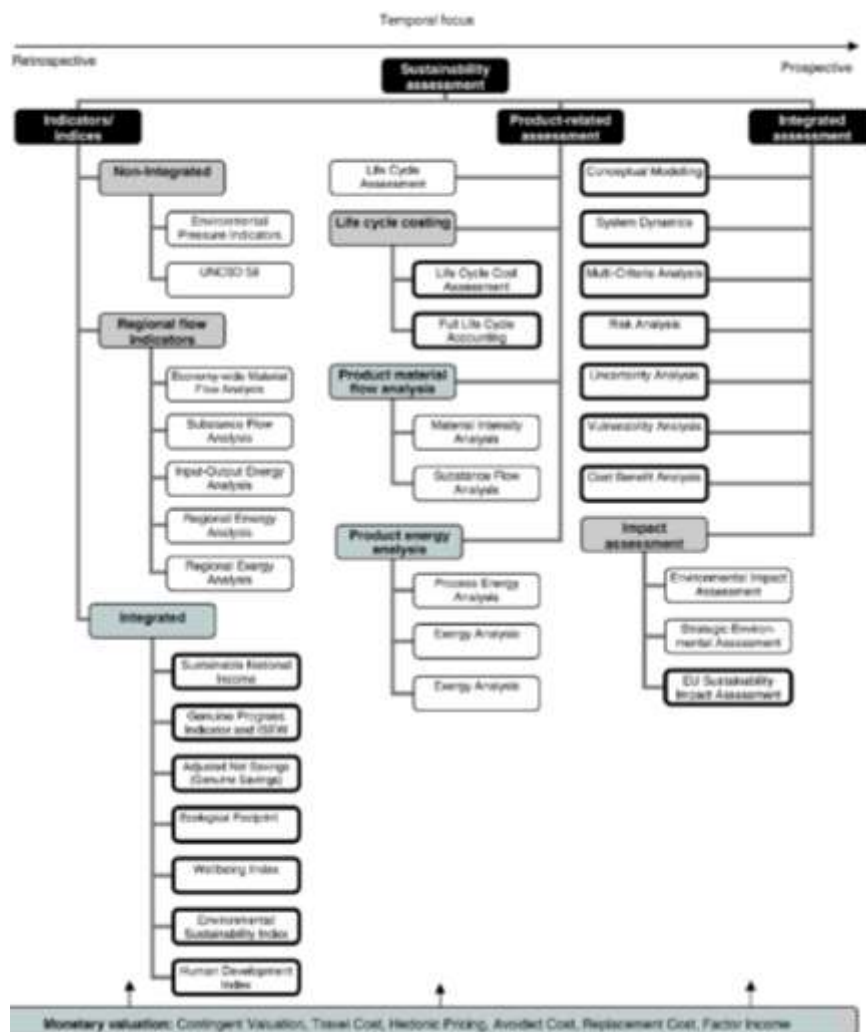


Figure 2. Framework for sustainability assessment (Ness et al., 2007)

For environmental aspects, the buildings can be assessed environmentally by several international systems, e.g. LEED, BREEAM, CASBEE, BEPAC. Economical aspect is usually covered with construction project portfolio management. On the other hand, social aspect of sustainability was mostly neglected in architectural field.

In this study, the focus of sustainability is considered through three pillars as a whole. Therefore, environmental, economical and social indicators for assessing sustainability are taken into account (see Figure 3).



Figure 3. Classification of sustainability indicators for architectural projects

Environmental indicators are grouped as energy, materials, water, waste and emissions; economical indicators are grouped as company economics and building project economics; and social indicators are considered as worker health and safety, and working conditions and opportunities.

3.2. Methodology: Multi-criteria Assessment

As mentioned before, this research focuses on sustainability by means of architectural practice. The proposed sustainability assessment framework can be summarized in six phases (see Figure 4). The first phase focuses on architectural project recognition and stakeholder identification to pursue long-term vision of the project/company. The second phase is to identify the contributors of the sustainability framework that continues with the third phase as to choose or construct sustainability indicators in order to achieve the long-term vision. In the fourth phase, the multi-criteria perspective of the sustainability assessment is constructed using the Topsis methodology. The fifth phase is to calculate the suitable sustainability indicators of the architectural project. Finally, the last phase focuses on interpreting the results of the assessment while guiding the architectural design decisions from a stakeholder point of view together with revision of the project strategies.

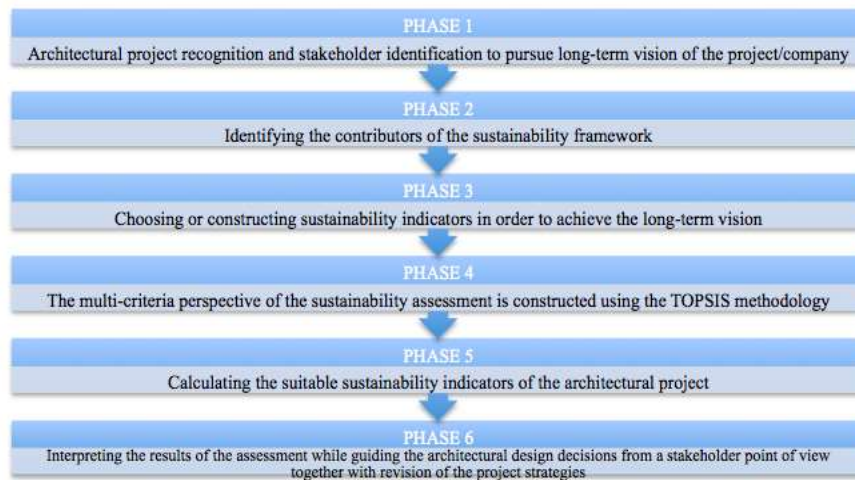


Figure 4. Phases in methodology

Among multi-criteria assessment tools, Technique for Order Preference by Similarity to Ideal Solution (Topsis) is used in this study. In Topsis the ideal solution is defined as the hypothetical solution that corresponds to maximum attribute of all attribute values where comprising the satisfying solution and the negative ideal solution is defined as the hypothetical solution as a consequence that all attribute values corresponds to minimum attribute values of all attribute values (Hwang and Yoon, 1981). Particularly, Euclidean distance from the ideal solution to the chosen alternative is expected to be the shortest, whereas Euclidean distance from the negative ideal solution to the chosen alternative is expected to be the longest (Rao, 2007).

4. Application on a real Architectural Project in Turkey

4.1. Project Information

This part of the study concentrates on a construction company located in Izmir, Turkey. The company is constructing a multifunctional building complex called Mistral Towers. In order to apply for LEED Green Building Certification, several calculations are being done for this building complex. Environmental, economical and social related reports of Mistral Towers are investigated to collect data required for the calculation of sustainability indicators.

4.2. Sustainability Indicators

After revealing the all the relevant data from the reports, suitable indicators are chosen considering the applicability. The indicators and their indicated meanings are presented in the Table 1

Table 1. Sustainability indicators for architectural projects categorized according to the main aspects of sustainability

Main Aspect	Variable	Definition	Indicator Formula
<i>Environmental</i>	<i>I_{1,1}</i>	Energy use ratio (MJ/L)	Energy usage / constructed amount in m ²
	<i>I_{1,2}</i>	Energy intensity (million MJ/million TL)	Total energy consumed /Net Sales
	<i>I_{1,3}</i>	Specific energy consumption (million MJ/million unit box)	Energy usage /project completion ratio
	<i>I_{1,4}</i>	VOC ratio	VOC (g/L)
	<i>I_{1,5}</i>	Recycling ratio (%)	Absolute value
	<i>I_{1,6}</i>	Water use ratio (L/L)	Water usage per m ²
	<i>I_{1,7}</i>	Water intensity	Total water consumed/Net sales
	<i>I_{1,8}</i>	Specific water consumption (million m ³ /million unit box)	Water use amount/Sales volume
	<i>I_{1,9}</i>	Solid waste ratio (g/L)	Solid waste per m ²
	<i>I_{1,10}</i>	Specific solid waste mass (thousand ton/million unit box)	Total solid waste/Sales volume
	<i>I_{1,11}</i>	CO ₂ emission ratio (g/L)	CO ₂ emission per m ²
<i>Economical</i>	<i>I_{2,1}</i>	Construction time sales (month/TL)	Number of months/ Net sales
	<i>I_{2,2}</i>	Maintenance ratio	Maintenance cost/ all cost
	<i>I_{2,3}</i>	Cost sales ratio	All cost/ Net Sales
<i>Social</i>	<i>I_{3,1}</i>	Fatal Accident ratio	Number of fatalities/total number of workers
	<i>I_{3,2}</i>	Accident ratio	Number of accidents/ total number of workers
	<i>I_{3,3}</i>	Occupational disease ratio	Number of reported occupational diseases /total number of workers
	<i>I_{3,4}</i>	Employment status ratio	Number of permanent workers/total number of workers
	<i>I_{3,5}</i>	Local employment ratio	Number of local workers/ total number of workers

Within this scope, sustainability indicators are calculated to evaluate such data for the chosen case study. In this study, architectural project data for a multi-purpose

building is gathered and used to illustrate the applicability and also to pinpoint the possible improvements of the sustainability assessment framework. All the sustainability indicators for Mistral Towers in Izmir were calculated.

5. Conclusion

In this study, not one but all the three pillars of sustainability are simultaneously taken into account. This study is aimed not only to deal with only environmental aspects of sustainability assessment framework but also economic and social aspects, as whole evaluation purpose in order to manage and enhance sustainable architectural projects. Particularly, in order to successfully implement the ideas of sustainability, the architectural companies need a framework for monitoring and controlling the sustainability of their project, whereas the proposed framework can be also used for this purpose. However, the reader should bear in mind that performing an assessment requires the storage of relevant data in a unified data repository.

References

- Edum-Fotwe, F. T., & Price, A. D. (2009). A social ontology for appraising sustainability of construction projects and developments. *International Journal of Project Management*, 27(4), 313-322.
- Chen, Y., Okudan, G. E., & Riley, D. R. (2010). Sustainable performance criteria for construction method selection in concrete buildings. *Automation in construction*, 19(2), 235-244.
- Dobrovolskienė, N., & Tamošiūnienė, R. (2016). Sustainability-oriented financial resource allocation in a project portfolio through multi-criteria decision-making. *Sustainability*, 8(5), 485.
- Finkbeiner M, Schau EM, Lehmann A, Traverso M (2010) Towards life cycle sustainability assessment. *Sustainability*, 2(10): 3309-3322
- Gibson RB (2006) Beyond the pillars: sustainability assessment as a framework for effective integration of social, economic and ecological considerations in significant decision-making. *Journal of Environmental Assessment Policy and Management*, 8(03): 259-280
- Hwang, C.L., & Yoon, K. (1981). *Multiple attribute decision making: methods and applications*. New York: Springer-Verlag.
- Kibert, C. J. (2016). *Sustainable construction: green building design and delivery*. John Wiley & Sons.
- Ness, B., Urbel-Piirsalu, E., Anderberg, S., & Olsson, L. (2007). Categorising tools for sustainability assessment. *Ecological Economics*, 60, 498-508. Organization for Economic Co-operation and Development. (n.d.). Sustainable manufacturing indicators. Retrieved at

January 14, 2017 from
http://www.oecd.org/document/48/0,3746,en_21571361_47075996_47855728_1_1_1_1,00.html

Rao, V. R. (2007). *Decision making in the manufacturing environment*. London: Springer-Verlag.

Sánchez, G., & López, F. (2010). A methodology to identify sustainability indicators in construction project management—Application to infrastructure projects in Spain. *Ecological Indicators*, 10(6), 1193-1201.

United Nations (2007). *Indicators of sustainable development: Guidelines and methodologies* (3th ed.). New York: United Nations Publication

Process mining projects: a case study in a software development enterprise

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Abstract. The objective of this paper is to propose a project structure to perform process mining in documented projects based on a case study of a software development company. The company adopts advanced practices in software development project management based on the CMMI maturity model, being certified in CMMI Level 3. Prior to the process mining itself, a series of activities must be conducted to prepare the logged events for analysis. After this preparation, process mining techniques were employed and analyses were carried out on the processes and activities of the software development projects. The main outcomes of this research are the detailing of the activities needed for a process mining project and the practical results of the performed analysis.

Keywords: process mining; project management; data mining processes; data mining project.

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1. Introduction

Van der Aalst et al. (2012) mentioned that process mining techniques are able to extract knowledge from event logs commonly available in today's information systems, and that these techniques provide new means to discover, monitor, and improve processes in a variety of application domains. However, prior to the application of process mining techniques, several activities must be performed to prepare the logged events for process mining itself. According to van der Heijden (2012), there is a lack of a methodology that helps put process mining into practice.

A project is a temporary endeavor undertaken to create a unique product, service or result (PMI, 2013). According to the PMBoK, published by the PMI (2013), even if some elements are repetitive, they do not change the fundamental nature of the project of having unique characteristics. Projects are often used by organizations to implement the strategic plan and achieve strategic goals.

Project Management is the application of knowledge, skills, tools and techniques to project activities to achieve project requirements (PMI 2013). Project management is accomplished by the application and integration of logically grouped processes of project management, as stated in PMBoK (PMI 2013).

Through a case study, this paper aims to propose a project whose objective is to perform process mining by using registered events from seven software development projects of a CMMI⁵ Level 3 software development company.

In order to organize the process mining project, IDEF0 was used to create a clear description of the steps followed. IDEF stands for Integration Definition for Function Modelling and it is a function modeling methodology, which offers a functional modeling language for the analysis, development, reengineering, and integration of information systems; business processes; or software engineering analysis. IDEF0 is part of the IDEF family of modeling languages in the field of software engineering, and is built on the functional modeling language Structured Analysis and Design Technique, or SADT (FIPS PUBS 1993).

To conduct the analysis work, process mining techniques were used to build qualitative and quantitative analysis regarding project activities. The purpose of the analysis is to infer about the processes and activities of project management used in software development.

Two main contributions can be identified: a way to organize a project of process mining in an organization and the results from the analysis of the logged project events.

⁵ CMMI® (Capability Maturity Model® Integration) models are collections of best practices that help organizations to improve their processes. These models are developed by product teams with members from industry, government, and the Software Engineering Institute (SEI)(CMMI Product Team, 2010).

2. Methodology

For the development of this paper, the case study methodology was used. This method was chosen because it was considered strategic to guide the work, once it contains techniques and resources to guarantee the quality and exemption in the procedures (Cauchick Miguel, 2007).

As suggested by Voss et al. (2002), this method was chosen for the development of an exploratory approach. Hence, the research was guided to promote the analysis of the processes, resources and activities of the studied cases.

Based on scientific works that use case studies, Cauchick Miguel & Sousa (2012) present a framework to conduct a case study. In the present paper, the case study guide represented in Figure 1 was applied.

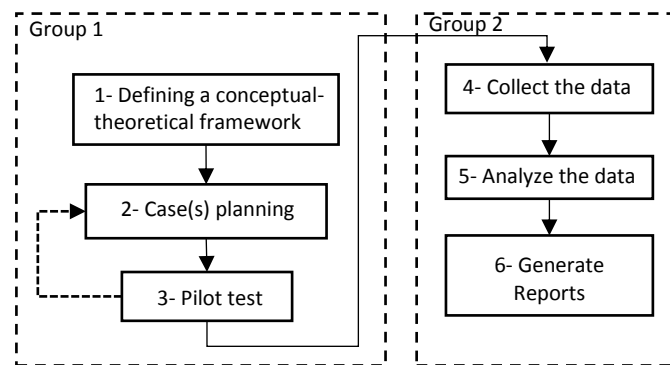


Figure 1. Case study guide, adapted from Cauchick Miguel & Sousa (2012).

Based on this approach, the research is divided in six steps and two groups of activities. Steps 1, 2 and 3 were used for the planning phase and compose Group 1, and encompass the following activities: Step 1 - map the literature, define the propositions and delimit the boundaries and general evolution; Step 2 - select the contact units, choose the means for collecting data, develop the protocol for data collection and define means of research control; Step 3 - test application procedures, check data quality and make the necessary adjustments. Steps 4, 5 and 6 represent the process mining activities that encompass: Step 4 - quote the cases, record cases and limit the effects of the researcher; Step 5 - produce a narrative, reduce data and identify causalities; Step 6 - draw theoretical implications and provide structure for replication.

Besides the methodological orientation provided by the case study method, project management techniques contained in the PMBOK were employed. This additional knowledge supported the creation of a project of process mining of logged project events.

3. Process Mining Project

This chapter discusses the proposed structure for a process mining project. It uses the process mining techniques presented by van der Aalst et al. (2012), van Eck et al. (2015), van der Heijden (2012) and Karla & Medeiros (2008). Process mining is known as the skills, techniques and tools used to extract information from event logs.

In the process mining area, there are two main drivers: original process rebuild and the analysis of the logged data (Aalst et al. 2012). On one hand, the processes are analyzed directly from the mined data. On the other hand, the registered data is evaluated to comprehend how the information is distributed within the processes.

Figure 2 brings the process mining project proposal using an IDEF0 diagram.

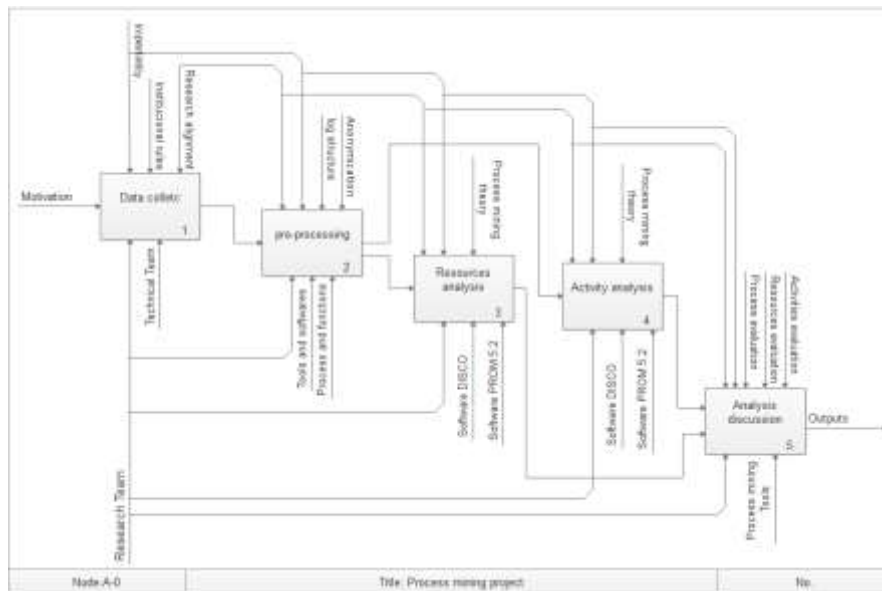


Figure 2. Process mining project proposal – the activities are represented by the numbered boxes 1-5; the horizontal arrows on the left of the boxes are the info inputs; arrows on the right are the outcomes; arrows below are mechanisms, tools or resources used in the activity; arrows above are the control or constraint actions that drive the activity development.

The descriptions about each of the activities shown in Figure 2 follow below:

Data collection – This is a critical activity where the specificities of process mining, technical demands and organizational rules need to find a balance in order not to jeopardize the process mining project.

Pre-processing – This is one of the most important activities of the proposed project. Its objective is to adapt the different data from the log events to a common

event log structure used in the process mining. The proposed structure can be summarized as seen in Table 1.

Table 1 Common event log structure.

Index	Description
Case ID	Case identifier. Key information to identify all activities belonging to the same group. Using the Case ID it is feasible to run analysis between instances of the same process.
Activity	Name of the activity performed by a resource or a group of resources.
TimeStamp - Start	Activity start date including the start hour.
TimeStamp - End	Activity finish date including the finish hour.
Resource	Resource assigned to the activity
Other	Other attributes that can be analyzed independent of the activity
Remove	Attribute to be removed from the analysis

Resources analysis – this activity contains a number of process mining tasks that aim to identify and analyze who performed each activity. It is related to the operational level. The main aspect of this analysis is the handover of activities between resources and volume of activities executed.

Activity analysis – similar activity as resource analysis, but focused on analyzing the different logs from the activities point of view. It considers the macro activities, detailing the information flow and execution sequence, not taking resources into account.

Analysis and discussions – in this step, the processes, resources, activities and their relationships are analyzed with the objective of understanding the originator process.

4 Results

Following the phases defined in the process mining project described in the previous section, it is possible to detail each of the steps taken:

1. Data Collection - the software development company XYZ supplied the logs of the seven projects in the XLSX format. They were divided in two files, one containing six projects and one containing one project.
2. The Pre-Processing process started by analyzing the information in each file and dividing the projects into groups. The first file containing six registered project events was split in two groups and the project event in the second log file was identified as a third group. These groups are shown in Table 2.

Table 2. Projects divided by groups depending on the content of the records of each project.

Group 1 – Two projects	Group 2 – Four projects	Group 3 – One project
Nome da tarefa	Nome da tarefa	Project
Informações WBS	Work	Data
Predecessors	% Work Complete	Usuário
Actual Work	Baseline2 Work	Atividade
Remaining Work	Baseline3 Work	Tarefa
Baseline2 Work	Actual Work	Comentário
% Complete	Actual Start	Horas
% Física Completa	Actual Finish	Baseline
Physical % Complete	Actual Work	Origem da Melhoria
SPI	Start	Primeiro Desenvolvedor
CPI	Finish	Receitável
Início Previsto	Actual Work	Faturado?
Termino Previsto	% Work Complete	Horas Faturadas
Work	Physical % Complete	
Duration	% Complete	
Prazo Restante	Duration	
Desvio Prazo Inicial	Resource Names	

To preserve the identity of the resources available in the records, a conversion table with anonymous resource names was created, linking the real resource names to a generic reference.

The standardization of the records is also a key step before proceeding to the process mining. Standardization transforms all records into an equivalent format making it possible to analyze the data sets in a homogenous way because all logs will have the same format. An example of standardization is provided in Table 3.

Table 3.Log structure after standardization

Index	Description
Case ID	Project identifier
TimeStamp - Start	Activity start date
TimeStamp - End	Activity finish date
Activity	Name of the activity
Resource	Resource assigned to the activity
Other	Other attributes that can be analyzed independent of the activity
Remove	Attribute to be removed from the analysis

After the pre-processing, the log files are ready to be treated by process mining tools. In this paper, PROM 5.2⁶ and DISCO 1.9.8⁷ were used to mine the log files.

⁶ ProM 5.2 Process Mining Workbench. Available at: www.promtools.org/doku.php?id=prom52

3. Resource Analysis - Among some of the resource analysis performed using PROM5.2, the Social Network Analysis is one of the most important because it shows the handover of activities between the different resources. This is shown in Figure 3. Using DISCO, it is noted that a total of 451 activities are performed in all projects. 27,6% of the activities was done by Resources 2 and 6, Resources 1 and 19 did app. 7% of the activities, Resources 13 and 35 app. 6%. Resources 42, 37, 41, 18 executed only one activity with respective duration: 121, 39, 31, 29 days.

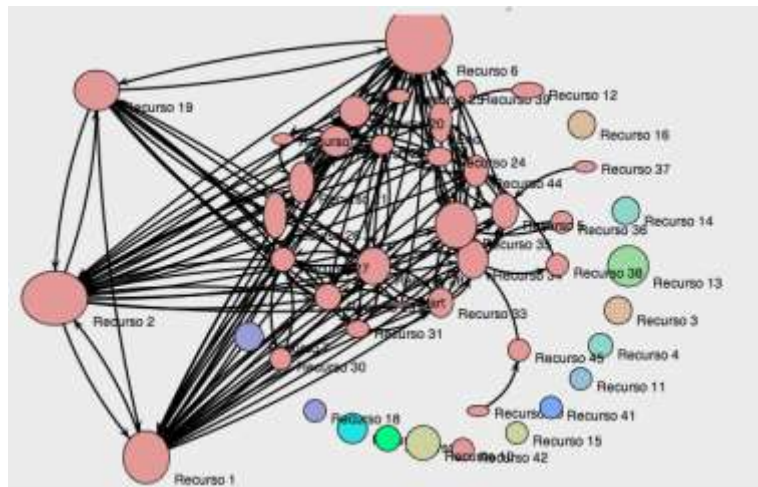


Figure 3. Social Network Analysis showing the handover of activities between all resources considering all projects. The bigger the circle, the bigger the amount of handovers a resource is involved in.

4. Activity Analysis – considering all projects, the most frequent activities are: Development (39,01%); Analysis (15,09%) and Tests and Homologation (13,16%). The mean duration of these activities are respectively: 51, 53 and 24 days. Remaining activities correspond to 135 out of 138 activities.

5. Analysis and discussion – Resource Analysis gives information on what is done and who does the activity in a more operational level. It shows who does what. It can also show the resources performing the similar activities and who is more efficient. Activity Analysis shows the information flow and sequence of activities in a broader perspective without taking resources into account. It is possible to build causal networks, compare them with pre-defined modeled processes and check the adherence between what is modeled and what is effectively done in practice. These comparisons can help identify points for improvement

⁷ Fluxicon Disco - Process Mining and Automated Process Discovery Software for Professionals. v 1.9.8. Available at: <https://fluxicon.com/disco/>

5. Conclusions

Based on the process mining project, it is possible to deepen the analysis of the project management process of software development. It was also possible to identify the main involved resources per project and in a full scope. The main activities executed were also highlighted after the analysis. It is noteworthy that the method proposed in Figure 2, to structure the activities necessary to deliver results within the context of a process mining project are general in nature and useful not only to software development companies. The main contribution of this work was in the systematization of the process mining approach to projects. Although projects are one of a kind initiative, they deliver value through a process that may repeat itself throughout a set of similar projects.

References

- Aalst, W. Van Der et al., 2012. Process Mining Manifesto. , pp.169–194.
- Cauchick Miguel, P.A., 2007. Estudo de caso na engenharia de produção: estruturação e recomendações para sua condução. *Produção*, 17(1), pp.216–229.
- Cauchick Miguel, P.A. & Sousa, R., 2012. O Método de Estudo de Caso na Engenharia de Produção. In *Metodologia de Pesquisa em Engenharia de Produção e Gestão de Operações*. São Paulo - SP: Campus, pp. 131–148.
- FIPS PUBS, C.S.L.N.I. of S. and T., 1993. Integration Definition for Function Modeling (Idef0). *Draft Federal Information Processing Standards Publication 183*, IV(June 1981), pp.1–128.
- Karla, A. & Medeiros, A. De, 2008. *ProM Framework Tutorial*,
- PMI, 2013. *PMBOK - A Guide to the Project Management Body of Knowledge* 5th Edition, Newton Square, PN, USA: Project Management Institute, Inc. Available at: www.pmi.org.
- Van der Aalst, W.M. et al., 2012. Process mining manifesto. *BPM 2011 Workshops Proceedings*, pp.169–194.
- Van der Heijden, T.H.C., 2012. Process Mining Project Methodology : Developing a General Approach to Apply Process Mining in Practice. , (August), pp.1–94.
- Van Eck, M.L. et al., 2015. PM²: A process mining project methodology. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 9097, pp.297–313.
- VOSS, C.A., Tsiriktsis, N. & Frohlich, M., 2002. Case Research in Operations Management. *international Journal of Operations and Production Management*, 22(2), pp.195–219.

Unit of Production Effort Method for Performance Measurement in Production Systems: Conceptualization and Application

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Abstract The Unit of Production Effort Method (UEP) is a costing “equivalence” method that allows the breakdown of production processes into their most important and basic elements (e.g. operations, activities and processes). It is presented as a simple method to calculate relatively accurate costs without spending significant resources. The potential of equivalence methods, in general, and UEP in particular, have been not yet recognized worldwide and rarely presented and discussed in the literature. In this paper, it is presented as a powerful approach for performance measurement and continuous improvement evaluation in production systems. Indeed, it provides a set of useful key performance indicators particularly for capacity optimization and continuous improvement measurement. This article discusses the conceptualization and application of UEP for this purpose and highlights opportunities for future developments in this domain.

Keywords: Equivalence Costing Methods; Unit of Production Effort Method; *Unidade de Esforço de Produção* (UEP), Performance Measurement, Continuous Improvement Evaluation.

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1. Introduction

Cost management systems should be analysed from the trade-off accuracy *versus* cost of designing and supporting the cost system itself, i.e. typically, more accurate systems are more expensive. Equivalence costing methods have been proposed and used to calculate relatively accurate costs without spending significant resources (Bornia, 2009). These methods are characterized by the breakdown of the processes to their elementary operations and the use of a common unit for all the operations. So, they simplify the cost computation process and subsequently cost analysis. The production mix and resources are presented through a single and standard reference (typically, a product) and therefore the production of multi products or services is converted in a fictitiously mono product or service entity (Gervais and Levant, 2014). There is evidence of applications of such methods in the UK (Rodrigues and Brady, 1992), in France (Gervais and Levant, 2014) under the denomination of *Unité de Valeur Ajoutée* (UVA) and in Brazil (Allora and Allora, 1995) under the denomination of *Unidade de Esforço de Produção* (UEP).

However the UEP method can be seen beyond its costing condition. Most manufacturing companies produce a wide variety of products with distinct technical specifications, in addition to production volumes that change every month. In this scenario, it is difficult to carry out an evaluation of the factory performance as well as to analyze properly the level of use of the production capacity. In this context, UEP appears to be a useful method for measuring performance and supporting the continuous improvement of production systems.

There are not many systems that can simultaneously measure performance and support the assessment of the economic impact of continuous improvement (Folan and Browne, 2005) thus, promoting the integration of both. Although there is an awareness of the usefulness of costing systems to boost performance measurement in the organizations (Fiorioli and Müller, 2013) and despite the increasing use of the UEP method by companies, namely Brazilian ones, the academic literature has not yet devoted sufficient space to this method.

This article intends to make a contribution in this sense, both in theoretical and in practical terms, and arises in the sequence of previous pioneering works carried out by the authors. In fact, on previous research with a specific focus on performance indicators related to the UEP method, it is worth mentioning the studies of (*hidden reference to preserving blind-reviewing*). These studies have examined the applicability of the non-financial indicators of the UEP method to companies of different sizes in different industries. In the following sections, the UEP method is contextualized in terms of performance measurement and continuous improvement in production systems, followed by the conceptualization, application and discussion of the proposed model for capacity optimization and continuous improvement measurement. It ends by highlighting opportunities for future work in this field.

2. State of the Art

The Unit of Production Effort Method (UPE) and similar costing “equivalence” methods are not yet fully presented and discussed in the international literature despite being well known in some specific industries and countries (particularly in Brazil and France). Furthermore, the potential of such methods goes beyond costing purposes namely supporting effective and efficient performance measurement in production systems. These issues, UEP and performance measurement, are briefly explained in the next subsections.

2.1 *Unit of Production Effort Method*

The Unit of Production Effort Method is a costing system that can be included into the group of “equivalence methods”, having in common the use of a single cost driver (e.g. time-related) for the equivalence between operations or between products (Gervais and Levant, 2014). Such methods, characterized by the decomposition of the production processes down to their most elementary operations, are presented as simple and cheap methods to calculate costs in production systems characterized by high levels of complexity and diversity. Equivalence methods can be applied only for a part of the production process or to the whole of a company (Dhavale, 1996a). Gervais and Levant (2014) argue that exists a continuum between approaches that just consider “group of resources” as the TDABC to the equivalence methods which in their latest stage they are defined equivalences between the whole of the products or of the operations of the organisation.

Occasionally presented in the literature, these equivalence methods have been used by several companies in different countries namely, Brazil, France, UK and the US (Rodrigues and Brady, 1992; Dhavale, 1996a; Dhavale, 1996b), but they are not recognized worldwide. The UVA and UEP methods seems to be the most diffused and conceptualised (Levant and de La Villarmois, 2009; Souza and Diehl, 2009).

The UEP method is primarily concerned with the conversion costs, which represent the effort made by the company to convert raw materials into a ready-to-market product. Slavov (2013) reports that the UEP focuses on the cost of converting homogeneous operations to workstations, usually in plants with a high diversified production mix. Wernke et al. (2012) argue that in the UEP method, unit product costs are summarized in terms of raw material costs plus conversion costs.

The UEP method is based on the notion of effort to use the resources that are available to production, for example, the effort made by a working machine, direct labor effort, capital invested effort, the effort of the used energy, etc. One can then conceive the total production effort as resulting from the sum of all production efforts (i.e. consumption of resources) assigned to the different operations. Thus, each product can be measured by the amount of effort required to manufacture it,

i.e. from the perspective of the work done by the production system to transform raw materials into finished products. This conception is closely related to the logic of continuous improvement and lean management which turns the UEP method particularly interesting to be applied in the economic evaluation of continuous improvement and lean management practices.

2.2 Performance Measurement and Continuous Improvement Evaluation

Performance measurement is one of the building blocks of an effective Management Control System (MCS). There is a large literature on MCS that discusses its benefits namely, facilitating the implementation of strategy offering conditions and tools for planning and control, as well as providing means for supporting managers in decision making.

The design and use of MCS for performance evaluation must take into account both the external context and the internal operations. A performance measurement system should include financial and non-financial measures, as well as internal and external measures. The importance of both financial and non-financial measures in performance evaluation processes has been well established in the literature for many years (Kaplan and Norton, 1992, 1996). Performance measures are necessary to translate the strategy into specific objectives in order to guide the organization at its different levels (Lohman et al., 2004; Eccles, 1991).

In practice, performance measurement systems are generally supported by a framework of Key Performance Indicators (KPI) that support a regular measurement of the organization's results, effectiveness and efficiency. Regular measurement is the key feature of a performance measurement process. Most of the known performance measurement systems are based primarily on company best practices and were not originally developed academically (Folan and Browne, 2005). In this way, this research project intended to give both a theoretical and a practical contribution for the design and use of more effective and efficient performance systems in production systems.

Continuous improvement, can be defined "as the culture of sustained improvement with the goal of eliminating waste in all processes and systems of an organization" (Bhuiyan et al., 2005), "improvement initiatives that increase success and reduce failures" (Juergensen, 2000) or "continuous improvement is improving the performance of the organization" (Fryer et al., 2007: 498).

3. UEP Method for Performance Measurement in Production Systems: Conceptualization and Application

In this research project they were defined a set of indicators provided by the UEP method which are presented as relevant to support performance measurement and

continuous improvement. These indicators were applied to a company in the agribusiness production chain (involving producers and industrial units). An extensive report and a UEP model on spreadsheets was developed. Some of the information obtained and results produced will be presented here to explain the core discussion of the paper. Additional or more detailed information about the case study can be obtained from the authors.

3.1 Conceptualization

Souza and Diehl (2009) note that some of the main uses of the UEP method are effectively related to decision making and to the management of production systems. Other authors also mention that this tool provides reports on the available production capacity of the production process, activities and operations (Wernke et al., 2013, Wernke et al., 2012).

In this research project, a performance measurement model was systematized based on the following indicators: 1) Production in equivalent UEP: the base product equals 1 UEP, products that consume less resources have less UEP and vice versa; 2) Production potential of workstations in UEP: allowing the analysis of the balancing of the production capacity; 3) Comparing of the production of different periods in UEP: it allows to compare different periods, independently of the mix of products manufactured; 4) Idle capacity in UEP: it allows to establish a relationship between the performance of workstations and use of resources; 5) Continuous improvement: allowing a better prioritization of improvement or cutting-costs initiatives by optimizing the consumption of the resources; 6) Other: measures of "throughput", "productivity", etc.

3.2 Capacity Management and Continuous Improvement

The measurement of production capacity, the level of idleness and the balance of resources is extremely important in the management and optimization of a production system. The UEP method can be very useful for such objective considering that it allows to compute capacity both in resources and (equivalent) products making it a very interesting method for lean manufacturing environments.

For example, in the case studied, very different production capacities were verified: only two workstations were able to produce more than 200 UEP per hour; four stations had the capacity to produce between 100 and 200 UEP per hour and three stations produced less than 100 UEP per hour of work.

The "bottleneck" of production (workstation 3- Weighing) was identified as a function of the production capacity. On the other hand, assuming that all the products go through all workstations to be completed, it was possible to calculate the production capacity in units of product measured in UEP (in this case 37.89 UEP).

Knowing the production potential per hour of the workstations and the monthly available hours it was possible to estimate the available production capacity in

terms of UEP per month. In this sense, based on the information obtained in the company, it was possible to elaborate Table 1 for one of the months studied.

Table 1 Available, Used and Idle Capacity measured in UEP

Workstation	Capacity (hours)	Prod. Potent. (UEP/h)	Capacity (UEP)	Used Cap. (UEP)	Idle Capacity	
1- Crusher	184.8	74.66	13,797.90	10,629.67	3,168.24	23%
2- Milling	184.8	177.10	32,727.62	25,416.55	7,311.06	22%
3- Weighing	184.8	37.90	7,003.72	4,238.07	2,765.64	39%
4- Mixer	184.8	189.63	35,044.03	27,808.56	7,235.47	21%
5- Filling 1	184.8	289.21	53,445.53	44,603.86	8,841.67	17%
6- Filling 2	184.8	618.97	114,386.24	62,777.56	51,608.67	45%
7- Emulsify	184.8	85.00	15,709.24	10,959.92	4,749.31	30%
8- Prep/Season	184.8	109.94	20,316.01	16,092.22	4,223.80	20%
9- Weight/Pack	184.8	185.52	34,283.39	27,131.70	7,151.69	20%
Total			326,713.67	229,658.12	97,055.55	30%

¹Source: The authors

In the period studied, it would be possible to produce 326,713.67 UEP. However, the production capacity actually used was 229,658.12 UEP, which represents an average idle capacity of 30%. Nevertheless, it should be mentioned that capacity utilization can change from month to month for several reasons: smaller sales, production of different items in each period, unscheduled stops, etc.

From the study of the used capacity, one should start to search for continuous improvement opportunities. In a first approach we could say that workstations with a higher cost per hour could be prioritized. However, the UEP method allows us to analyze the manufacturing process from another perspective.

In fact, it can be seen that not always the most cost-consuming workstations (in BRL) per hour are those that might be priority areas of improvement when the entire manufacturing process is considered. These differences are of most importance and ask for detailed analysis. Table 2 compares these two approaches.

Table 2 Prioritization of Continuous Improvement Initiatives considering Production Effort and Cost per Hour

workstation	Production Effort (UEP)	Priority (UEP)	Cost per Hour	Priority (Cost)
1- Crusher	62.22	8	38.86	8
2- Milling	221.37	3	92.18	5
3- Weighing	23.69	9	19.73	9
4- Mixer	143.66	6	98.70	3
5- Filling 1	289.21	2	150.53	2
6- Filling 2	1289.53	1	322.18	1

7- Emulsify	193.20	4	44.25	7
8- Prep/Season	91.61	7	57.22	6
9- Weight/Pack	185.52	5	95.56	4

¹Considering a batch of 2,500 kg of Product 1. Production Effort are measured in UEP and Cost per hour in Brazilian Real (BRL).

For example, workstation 7 - Emulsify consumes 193.20 UEP in the production situation presented, occupying the fourth position in terms of production effort, among the nine workstations. However, considering the criterion cost per hour it would be in seventh position in terms of relevance. From the comparison of these two criteria they were also observed positioning changes in the workstations: 4-Mixer, 9- Weight/Pack, 2- Milling and 8- Prep/Season.

4. Conclusions, Limitations and Opportunities for Further Research

In this article it was emphasized that the application of the UEP method allows the obtaining of several indicators that can be used to analyze the performance of production systems. Several key performance indicators (KPI) were systematized and particular attention was given to capacity management and continuous improvement. The UEP method was originally designed for production systems management and for this reason it is particularly interesting to integrate financial and operational KPI, as well as cost management and production management. However, it presents some limitations to be taken into account namely, dependence on the accuracy of the processing times per workstation, it requires relatively standardized operations, and the choice of the base product is of some subjectivity. Gervais (2009) points out that a limitation of the equivalence methods is that they need constant updates in order to incorporate the productivity gains that companies are constantly achieving. In this article we point it inversely, arguing that the UEP method can also be a very useful tool for operating continuous improvement in production systems. Thus, opportunities for research and practical application of the UEP method are highlighted in the scope of performance measurement in production systems in general and continuous improvement evaluation in particular. Demonstrating the applicability of performance indicators constructed using the UEP method opens up very relevant research and practical opportunities.

References

Allora, F, Allora V (1995) UP: unidade de medida da produção. São Paulo: Pioneira

- Bhuiyan N, Baghel A (2005) An overview of continuous improvement: from the past to the present. *Management Decision*, vol. 43 issue 5, 761-771
- Bornia, A. (2009) *Análise gerencial de custos: aplicação em empresas modernas*. 2. ed. São Paulo: Atlas
- Dhavalé D (1996a) *Management Accounting Issues in Cellular Manufacturing and Focused-Factory Systems*, Montvale NJ, IMA Foundation for Applied Research
- Dhavalé D (1996b) Problems with existing manufacturing performances measures. *Journal of Cost Management*, Winter, pp 50-55
- Eccles R (1991) The Performance Measurement Manifesto. *Harvard Business Review* 69 (January February), 131-137
- Fiorioli C, Müller C (2013) Desenvolvimento de um sistema de custeio para uma pequena empresa do setor de serviços. *Iberoamerican Journal of Industrial Engineering*, vol. 5, issue 9, 113-135
- Folan P, Browne J (2005) A review of performance measurement: Towards performance management. *Computers in Industry*, vol. 56, 663-680
- Fryer K, Antony J, Douglas A (2007) Critical success factors of continuous improvement in the public sector. *The TQM Magazine*, vol. 19, issue 5, 497-517
- Gervais M (2009) *Contrôle de gestion*, 9e éd., Paris, Économica
- Juergensen T (2000) *Continuous Improvement: Mindset, Capability, Process, Tools and Results*. Indianapolis: The Juergensen Consulting Group, Inc
- Kaplan R, Norton D (1992) The balanced scorecard - Measures that drive performance. *Harvard Business Review*, 72-79
- Kaplan R, Norton D (1996) *The Balanced Scorecard—Translating Strategy into Action*. Boston: Harvard Business School Press
- Levant Y, de la Villarmois O (2009) Simplified Customer Profitability Evaluation: The Equivalence-Based Method, *Cost Management*, Jul/Aug, vol. 24, issue 4, 28-34
- Lohman C, Fortuin L, Wouters M (2004) Designing a performance measurement system: A case study. *European Journal of Operational Research*, vol. 156, 267-286
- Michel G, Levant Y (2014) A New Way to Improve Measurement in Product Costing. *Sciences de Gestion*, issue 65, 309-340
- Rodrigues L, Brady G (1992) Cost Accounting Control in a Multiproduct Environment— The Unit of Production Effort Method, *Journal of Operations and Management*, vol.12, 66-80
- Slavov T (2013) *Gestão estratégica de custos: uma contribuição para a construção de sua estrutura conceitual*. PhD Thesis. Faculdade de Economia, Administração e Contabilidade da Universidade de São Paulo - FEA/USP, São Paulo
- Souza M, Diehl C (2009) *Gestão de custos: uma abordagem integrada entre contabilidade, engenharia e administração*. São Paulo: Atlas
- Wernke R, Junges I, Cláudio, D (2012) Indicadores não-financeiros do método UEP aplicáveis à gestão de pequena indústria. *Iberoamerican Journal of Industrial Engineering*, vol.4, 125-145

Wernke R, Lembeck M, Junges I, Ritta C (2013) Método UEP: estudo de caso sobre a aplicabilidade em pequena fábrica de confecções femininas. *Iberoamerican Journal of Industrial Engineering*, vol. 5, issue 9, 296-319

**Logistics,
Production and
Information
Systems**

Application of Fuzzy Sets in the Selection of Industrial Valves Suppliers

Santos M¹, Souza N², Tenório F³, Lopes R⁴, Dias F⁵

Abstract This paper aims to propose a mathematical model, from the Fuzzy Logic, capable of qualifying a group of valve suppliers for a given company. These suppliers were pre-selected, based on common attributes, in order to meet the supply of control valves, which will be used in the industrial gas production process. In view of the ability of nebulous mathematics to model the vagueness of human thought and, therefore, to be part of what is known as "fuzzy expert systems", such modeling was developed from a questionnaire applied to the Suppliers group and all persons involved in the classification of suppliers. Because of the risks and the criticality of the systems where such valves are employed, the analytical model presented here aims at better qualifying suppliers through their respective degrees of pertinence.

Keywords: fuzzy logic, control valves, supplier selection

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1. Introduction

In the process of industrial development, the valves have a prominent position, because this device provides the safety of all process. They are devices to control and block the flow of fluids, fundamental in the control of the separation process of gases, subjected to high pressures and cryogenic temperatures in the order of -200°C.

The mathematical modeling was performed with data from a multinational company that has operations in more than 50 countries, being the largest industrial gases company in the Americas and one of the largest in the world. It should be noted that, in Brazil alone, the company has more than 5,000 employees.

According to the consumption profile of each client, an exclusive supply procedure is established according to the needs of each case. Figure 1 shows the main sectors served by the company under study, which, due to the confidentiality of the data, will be called by fictitious name of "GASOSA".

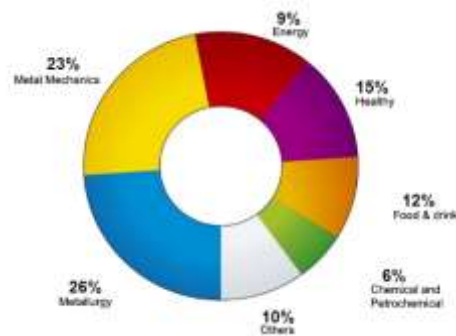


Figure 1 Productive sectors served by the company "GASOSA"
Source: Authors (2016)

2 Theoretical Foundation

Wood Jr and Zuffo (1998) argue that supply chain management is the synchronization of all activities in the production chain and not only the activities that make up the supply chain. This composition makes these activities closer to each other and tend to reduce costs, maximizing the value added of the final product.

Ballou (2006) points out that a supply chain is a set of functional activities that are repeated many times along the channel by which the raw materials are converted into finished products, to which value is added to the consumer.

Santos (2015) et al states that Operational Research uses mathematical and/or logical models to solve real problems, presenting a highly multidisciplinary.

According to Silva (2010), valves represent, on average, about 8% of the total cost of an industrial plant and, depending on the sector, such as the oil and gas industry, they amount to 20% to 30% of pipe costs. It is relevant to emphasize the importance of this equipment in industrial plants, since, on many occasions, one valve fails is enough to compromise an entire production chain. For example, an oil platform producing 180,000 barrels per day has approximately 12,000 valves. Medium-capacity oil refineries have between 80,000 and 95,000 valves. These represent the relevance of the research carried out here.

Santos (2016) et al argue that the Fuzzy Logic provides a method of translating verbal, vague, imprecise and qualitative expressions (common in human communication) into numeric values.

According to Tanscheit (2003), the membership functions can be defined from the experience and perspective of the user, but it is common to use standard membership functions, such as triangular, trapezoidal and Gaussian. In practical applications, the initially selected forms can be adjusted according to the observed results. The degree of pertinence is defined by means of a generalized characteristic function, called a membership function.

3. Problem

There is a wide variety of valve models for different types of applications, which can confuse professionals when specifying the most suitable model for each purpose, creating conditions for possible loss of productivity or even a fatal accident.

The control valves act on the flow, pressure and temperature, without manual intervention. Its control characteristics are pre-established according to NBR 10285: 2003 - Industrial Valves - Terminology. The main accessories that make up a control valve are: positioner, actuator (pneumatic, hydraulic or electric), I/P converter, pressure regulator filter, valve body, electric motor, seals and position switches etc.

The process begins with the taking of prices, in which usually those who have the lowest price guarantees their sale. In addition, the proposal is divided into two: technical and commercial. The valve is not always technically approved, even at the lowest price. Therefore, it is necessary to establish a method of classification and choice of the main manufacturers of control valves.

4. Methodology.

A bibliographic research, exploratory and field research, was carried out in this study. Since Fuzzy Logic is a widespread subject in the Academy, publications were selected from 1965 to 2016, narrowing the reading of references in the period from 2002 to 2016.

According to Lakatos and Marconi (2007), the bibliographic research covers all bibliographies already made public in relation to the topic of study, such as individual publications, bulletins, newspapers, magazines, books, monographs, etc.

Santos et al (2016) states that in Operational Research, the data collection phase plays a critical role. This is because of the influence in the choice of the model to be applied by the availability, quantity and quality of the data available.

Data were collected from the distribution of 100 questionnaires in the period from September to October, 2016. Of the total, eighty-four questionnaires were answered, all related to the contracting of industrial valves suppliers. After data collection, the software called InFuzzy was used, which is easy to use and free of charge, available at <http://www.posselt.com.br>.

5. Mathematical Modeling

The following variables were listed: price, deadline, technical assistance, quality, number of certifications, production capacity and reputation. From these variables, the fuzzy modeling was done with the variables: price, deadline and quality. From these definitions, a performance indicator related to the qualification of suppliers was elaborated. Entries were compiled into InFuzzy software to make it easier to obtain the result.

5.1 Fuzzy Price Variable

Figure 2 shows the Fuzzy price variable that is formed by the Cheap, Ideal and Expensive linguistic labels, with discourse universe between 0 and 10, besides the degree of pertinence [0,1]. Price is the cost of manufacturing plus profit on the supply of the product.



Figure 2 Fuzzy Variable Pertinence Functions – Price
Source: Authors (2016)

Equation of the Straight-Line of the Label Cheap:

$y = ax + b$, defined by the points (0,1) and (5,0)

$$a = \frac{0-1}{5-0} \equiv -0,2 \quad -0,2 = \frac{y-1}{x-0} \quad -0,2x = y-1$$

$$y = -0,2x + 1$$

$$\int_{0-1}^{5-0} (-0,2x + 1) dx$$

Equation of the Straight-Line of the Label Ideal:

By the Rule of the Triangle: $\left\{ \begin{array}{l} \mu(x) = (x - Sl)/(C - Sl) \\ \mu(x) = (x - Sr)/(C - Sr) \end{array} \right\}$

$$I = \int_{2-0}^{5-1} \left(\frac{(x-2)}{3} \right) dx + \int_{5-1}^{8-0} \left(\frac{(x-8)}{-3} \right) dx$$

Equation of the Straight-Line Label Expensive:

$y = ax + b$, defined by the points (5,0) and (10,1)

$$a = \frac{1-0}{10-5} \equiv 0,2 \quad 0,2 = \frac{y-0}{x-5} \quad y = 0,2x - 1$$

$$\int_{5-0}^{10-1} \left(\frac{(0,2x - 1)}{-1} \right) dx$$

Integral Fuzzy of Variable Price:

$$\int_{0-1}^{5-0} (-0,2x + 1)dx + \int_{2-0}^{5-1} \left(\frac{(x-2)}{3} \right) dx + \int_{5-1}^{8-0} \left(\frac{(x-8)}{-3} \right) dx + \int_{5-0}^{10-1} \left(\frac{(0,2x-1)}{-1} \right) dx$$

5.2 Fuzzy Deadline Variable

Figure 3 below presents the Fuzzy deadline variable that is formed by Short, Tolerable and Long linguistic labels, with discourse universe between 0 and 6, besides the degree of pertinence [0,1]. Deadline is the time it takes, from the issuing of the purchase order to the receipt and installation of the valve.



Figure 3 Fuzzy Variable Pertinence Functions – Deadline
Source: Authors (2016)

5.3 Fuzzy Quality Variable

Figure 4 below shows the Fuzzy quality variable that is formed by Bad, Good and Great linguistic labels and discourse universe between 0 and 100, in addition to the degree of pertinence [0,1]. The quality is referenced by its production process, its facilities, and its final product delivered.

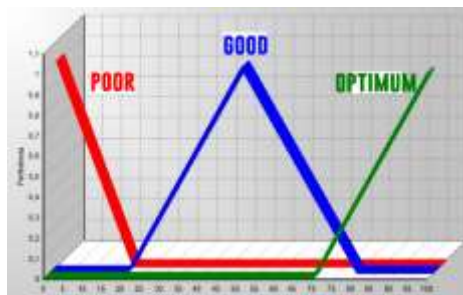


Figure 4 Fuzzy Variable Pertinence Functions – Quality
Source: Authors (2016)

Performing all calculations of items 5.2 and 5.3 in a manner analogous to sub-item 5.1.

6. Results Achieved

A priori, a model more adherent to the supplier selection process should take into account the following input variables: price, deadline, technical assistance, quality, certifications, production capacity and reputation. However, from these input variables, we would arrive at a large number of possible combinations from the rules of fuzzy inference. Thus, only three input variables that most impact the selection process were listed: price, deadline and quality.

After insertion of the inputs, the inference rules were established, as shown in Figure 5.

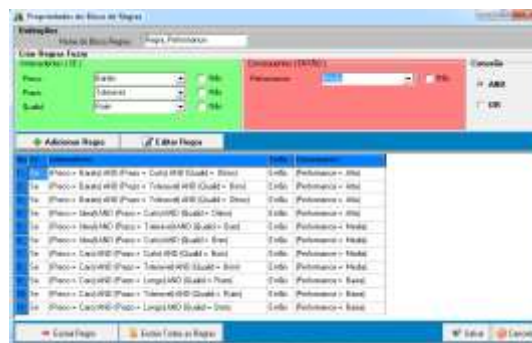


Figure 5 Rule Block Property
Source: Authors (2016)

Numerous scenarios were established from the actual data of ten suppliers. The values of each input variable were computed from the questionnaire that was answered by professionals related to the contracting of industrial valves.

The analysis, for example, of supplier 1 in relation to price shows that it has the note 8. Thus, it has degree of pertinence C, which means "expensive". This analysis was done for all 10 suppliers. As a result, we have the InFuzzy software screen shown in Figure 6, with the entries in green and the result in red color.

Therefore, the best performance is that of the supplier number 7, which has a score of 82.30. A possible second best supplier would be the supplier number 5, with the note of 62.70. This supplier will serve as a substitute when the best supplier may have any type of problem.



Figure 6 Fuzzy logic simulation
Source: Authors (2016)

7. Final Considerations

In this research, based on intangible factors that are not normally considered in the decision-making process, the nebulous mathematics in the modeling and proposed solution of the problem was used. The dual nature of the method used in this work is emphasized, and it can be adapted and applied to several other situations where decision-making approaches imprecise variables. The initial stimulus for the development of this research was due to the difficulty in the selection of suppliers regarding the complexity and detail of the equipment, being often used the price as the only decision parameter.

The survey was conducted with 10 manufacturing companies of industrial valves, with data acquired in the history of the department of supplies. In the evaluation of the scenarios, a 6" globe valve was considered in the class of 150 #, aiming to list a list of suppliers in order of priority. After processing the model, it was concluded that the supplier number 7 obtained the best performance.

References

- Ballou, R. H. (2006) Gerenciamento da cadeia de suprimentos/logística empresarial. 5.ed. Porto Alegre: Bookman.
- Lakatos, E. M. & Marconi, M. A. (2007) Metodologia do trabalho científico. 7ª ed. São Paulo: Atlas.
- Santos, Marcos dos *et al.* (2016) Fuzzy Logic application in the evaluation of performance of a prototype vehicle powered from solar energy and water electrolysis process. *International Journal of Applied Mathematical Research*. Vol. 5, issue 4, p. 176-81, 2016. doi: 10.14419/ijamr.v5i4.6720

- Santos, Marcos dos *et al.* (2015) Simulation of Operation of an Integrated Information for Emergency Pre-Hospital Care in Rio de Janeiro Municipality. *Elsevier – Procedia Computer Science*. Vol. 55, p. 931 – 938, 2015. doi: 10.1016/j.procs.2015.07.111
- Santos, Marcos dos *et al.* (2016) Application of AHP Method in the formation of a performance indicator for operational level professionals. *International Journal of Development Research*. Vol. 06, issue 12, pp. 10610-10615, 2016.
- Silva, Osmar José Leite (2010) Válvulas Industriais. Qualitymark, 2ª ed.
- Tanscheit, R. (2003) Sistemas Fuzzy. VI Simpósio Brasileiro de Automação Inteligente, Bauru, SP.
- Wood JR, T.; Zuffo, P. K. (1998) Supply chain management. *Revista de Administração de Empresas*. São Paulo: FGV, vol. 38, 1998.

Contributions of packaging improvements as logistic costs reducing on electronic commerce

Stankevix M¹, Neves JMS², Ramos TBS³, Langhi C⁴, Akabane GK⁵

Abstract: Packaging is significant part of the process of shipping products to e-commerce customers. This study aims to verify if the exchange of air cushions for fragmented cardboard to final packaging reduces costs of logistics operations in a Brazilian trading company. In conclusion, there was reduction of costs without customer complaints.

Keywords: Packaging; Logistic Costs; Electronic Commerce.

1. Introduction

The last decades have been marked by greater access to IT and new possibilities for activities such as social interactions, banking transactions, learning, research, entertainment and electronic commerce (Albertin, 2004).

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Due to these factors, e-commerce, mainly in the form of retail, has shown growth all over the world, with a trend of continuous growth until 2020 (Emarketer, 2016).

Therefore, packaging is recognized as having significant importance in the efficiency of logistic activities, impacting on company costs (Hellström & Saghir, 2007).

In the company, object of the study, the goal of the indicator of costs with packaging inputs was not being reached over several months.

Considering these aspects, the research question is: "can substitution of packaging inputs reduces logistics operations costs of an electronic commerce company without customer complaints?".

2. Objectives

This paper aims, as main objective verify if the substitution of packaging inputs is a suitable way to reduce the costs of the logistics operations of an electronic commerce company without customer complaints, with the specific objectives of identifying the main steps and actions to reduce costs.

3. Methods

This is characterized as a qualitative exploratory research, using a case study in a company that operates in electronic commerce, having as main market the resale of products directly to final consumers (B2C) of the entire territory of Brazil.

The Average Unit Cost indicator (AUC) is used to measure the cost with packaging inputs. A cost analysis showed the inputs with higher impact on costs. A Priorization Matrix was adopted and an Action Plan was implemented.

The main action was substitute air and paper cushion on final packaging by fragmented cardboard. This cardboard generally was discarded.

Information on customer complaints was registered by the customer service.

4. Results

The action plan was executed and completed in accordance with its deadlines, being finalized three months after the start of implementation, on July 2016.

After implantation, the AUC was reduced from 0.443 \$/order to 0.366 \$/order, having an improvement of 17.4% in the indicator, reaching the goal of 0.400 \$/order. No customer's complaints about packaging inputs were registered.

5. Conclusion

The results showed that the substitution of inputs by fragmented cardboard was an effective way to reduce costs on logistics operations of an electronic commerce company. For future research, it is recommended to evaluate the application of the method in other segments and evaluate the environmental impacts of the actions.

References

- Albertin, A.L. (2004) *Comércio Eletrônico: Modelo, Aspectos e Contribuições de sua Aplicação*. Atlas, São Paulo
- Emarketer (2016) "Worldwide Retail Ecommerce Sales Will Reach \$1.915 Trillion This Year", Available at: www.emarketer.com/Article/Worldwide-Retail-Ecommerce-Sales-Will-Reach-1915-Trillion-This-Year/1014369 (accessed 7 March 2017)
- Hellström, D. & Saghir, M. (2007) Packaging and logistics interactions in retail supply chains. *Packaging technology and science*, doi: 10.1002/pts.754

Proposed model for risk assessment

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Abstract Most risk management models assess risks as independent events, disregarding the interrelationships between chain links and between risks. This was identified in the theoretical survey as being an important limitation. Therefore, the purpose of this article is to present a critical analysis of risk management models for supply chains, presenting at the end a proposal of a theoretical model that incorporates the dependence and the interrelationships between risks in risk assessment. This proposal is based on the available literature on SCRM, where the combined use of three different techniques for risk assessment was identified, notably for the calculation of probability of risk, ANP, Monte Carlo Simulation and Bayesian Networks. The combined use of these tools may allow us to insert the risk in-teractions between the risks in the risk assessment phase and to map the dependencies and connections in the supply chain in the calculation of the probability of occurrence of the risk.

Keywords: Risk assessment. ANP. Monte Carlo Simulation, Bayesian Networks

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1. Introduction

Risks rarely act independently in the supply chains (Badurdeen *et al.*, 2014) Govindan and Chaudhuri (2016) point out that the relationships between risks must be identified because "hidden influences" of one risk or connections with another risk can cause substantial damage to the chain. Despite this observation, Mogre, Talluri and D'Amico (2016) point out that most of the studies on risks in the supply chain still assume that the risks, their impact and their probability are independent even if it is verified that this assumption is rarely verified in practice. Kayis and Karningsih (2012) affirm that the number of works that incorporate the interdependence between risks is very small in relation to the amount of existing works in the SCRM. This is considered a simplified and reductionist view.

From the above reasons, it can be concluded that it is important to propose risk management models that permit risk management considering the dependencies between risks and how they propagate throughout the supply chain. Assuming that this premise is relevant, the objective of this article is to present a critical analysis of risk management models for supply chains, presenting a model proposal that incorporates the dependence between risks in the evaluation of risks.

A theoretical research was adopted as a method, based on a theoretical survey carried out on 88 articles that present risk management models in the supply chain available at the Web of Science and Scopus databases from 2000 to 2016. From the reading of these articles it was possible to do analysis on how these assess the dependent risks. Based on the reviews and criticisms identified, a proposal for a risk management model is presented, incorporating the interdependencies between the risks in the supply chain.

2. Risk management model in supply chains

Punniyamoorthy *et al* (2013) explain that in supply chain risk management, companies should not only concentrate on the risks arising from their own operations, but also the risks that are caused by other members of the supply chain. Due to the high dependency on supply chains, supply chain risks can be connected within themselves. That is why the identification of interdependencies is of crucial importance (Pfohl, Gallus and Thomas, 2011).

Kayis and Karningsih (2012) affirm that risks should not be identified as an isolated event, but their interrelationships must be observed. Ghadge, Dani, and Kalawsky (2011) have shown that failure at a single point in the supply chain can cause collapse to the entire supply chain. Heckmann, Comes, and Nickel (2015) affirm that risk has a cumulative effect, in a way that they spread along the supply chain. Punniyamoorthy *et al* (2013) affirm that risks are often interconnected. Thus, risk management in the supply chain needs to be a more global approach,

seeing the interconnections between risks in the chain. Cagliano *et al.* (2012) points out that most approaches to supply chain risk management are limited to the identification of risk areas or risk analysis independently, without considering the related risks and impacts. Kayis and Karningsih (2012) affirm that the number of works that consider the interdependence between risks is very small in relation to the amount of works developed in the SCRM theme. Aqlan and Lam (2015) are emphatic in affirming that traditional risk management models may fail because they do not consider the interconnections between risks and therefore are limited because they do not have a broader view of risk and its propagation in the chain. Several authors such as Yang and Yang (2010), Pfohl, Gallus and Thomas (2011), Ghadge, Dani and Kalawsky (2011), Kayis and Karningsih (2012), Cagliano *et al.* (2012), Punniyamoorthy, Thamaraiselvan and Manikandan (2013), Heckmann, Comes and Nickel (2015), Habermann, Blackhurst and Metcalf (2015) also highlight the need to assess the risks, their dependencies and risk-spreading effect in the supply chain. By identifying these limitations, it is considered important that a risk management model should observe the dependency relationships between risks, incorporating a broader view of the network map of chain risks. From the theoretical survey carried out on 88 articles, the main techniques and tools that are used for risk assessment were identified.

These are presented in Table 1. In this Table 1 it can be verified that the main tools used for risk assessment considering the dependence between the risks are: ANP (Analytic Network Process), Bayesian Networks, failure trees, cause and effect analysis and ISM. Despite this, it is observed that the AHP (Analytic Hierarchy Process), Fuzzy Logic, FMEA (Failure Mode and Effect Analysis), and probability and impact matrices are widely used tools for risk assessment, apart from not being capable of observing the interrelationships between risks. This denotes that many models of risk management still disregard the interdependencies that may exist between risks.

Thus it is verified that the number of risk management models that do not incorporate risk dependency in the evaluation phase is not yet significant. For this reason a risk management model that allows the identification of interrelationships and connections between risks in risk management in the supply chain is proposed, considering that in this manner the management model is more real.

Hallikas *et al.* (2004), Cohen and Kunreuther (2007), Giannakis and Louis (2011) and Tummala and Schoenherr (2011) identify four generic steps for risk management in supply chains: 1- risk identification; 2- risk assessment; 3- proposition of strategies; and finally, 4- monitoring of their impacts.

However, it is observed that many of the risk management models in supply chains see risks as independent events, disregarding the interrelationships and connections between risks and between the supply chain. Thus, a risk management model that uses a combination of tools that are meant to be applied in the risk assessment in such a way that it incorporates the interconnections and interdependence between the risks is suggested. This model is based on ANP, Monte Carlo Simulation and Bayesian Networks as illustrated in Figure 1.

Table 1. Tools used for risk assessment in the portfolio of articles

Risk assessment tools	Researches
Matrix of Impact and Probability	Hallikas <i>et al.</i> (2004); Ritchie and Brindley (2007a); Blackhurst, Scheibe and Johnson (2008); Blome and Schoenherr (2011); Tummala and Schoenherr (2011); Thun e Hoenig (2011); Ouabouch and Amri (2013)
ANP	Xia and Chen (2011); Muchfirodin, Guritno and Yuliando (2015); Fazli, Mavi and Vosooghidizaji (2015); Cao and Song (2016)
AHP	Gaudenzi and Borghesi (2006); Wu, Blackhurst and Chidambaram (2006); Schoenherr, Tummala and Harrison (2008);Funo <i>et al.</i> (2011); Lee and Ulferts (2011);Chen and Wu (2013);Ganguly and Guin (2013); Samvedi, Jain and Chan (2013); Prakash <i>et al.</i> (2014)
AHP + FUZZY	Ganguly and Guin (2013); Samvedi, Jain and Chan (2013); Sofyalioglu and Kartal (2012); Radivojević and Gajović (2013)
Cause and effect analysis	Li e Yu (2010); Lin e Zhou (2011); Kumar e Havey (2013)
Fault tree	Cigolini and Rossi (2010); Kumar and Havey (2013); Aqlam and Lam (2015a); Sherwin, Medal and Lapp (2016); Mogre, Talluri and D'Amico (2016)
BAYESIAN NETWORKS	Pai <i>et al.</i> (2003), McCormack (2007), Han and Chen (2007); Lockamy and McCormack (2010); Lockamy and McCormack (2012); Lockamy (2014); Amundson <i>et al.</i> (2014); Badurdeen <i>et al.</i> (2014), Garvey, Carnovale and Yenyurt (2015), Nepal and Yadav (2015); Mogre, Talluri and D'Amico (2016)
Structural interpretive modeling (ISM)	Faisal and Shankar (2007); Pfohl, Gallus and Thomas (2011); Diabat, Govindan and Panicker (2012)
FMEA	Pujawan and Geraldin (2009); Tuncel and Alpan (2010); Chen and Wu (2013); Kumar and Havey (2013); Pradhan and Routroy (2014); Bradley (2014); Lavastre, Gunasekaran and Spalanzani (2014); Bradley (2014); Nepal and Yadav (2015)

According to this proposition (Fig. 1), it is perceived that the risk management system in the supply chain adopts four phases, beginning with the identification, evaluation, mitigation and monitoring of risks. From these phases, it is suggested to adopt a set of tools for risk assessment, with emphasis on probability calculation, which should consider the concept of conditional probability.

Risk assessment consists of understanding the criticality of risk. This should be done observing the parameters severity and probability of occurrence (Tang and Musa, 2011, Tummala and Schoenherr, 2011 and Wieland, 2013).

Thus, the existing interdependence relationships between risks are inserted when doing the probability of occurrence of risks survey, in an attempt to consider not only the probability of the isolated risks but the conditional probability between the dependent risks, which are connected and propagated along the whole chain generating unfolding beyond the origin of the risks.

The first stage of the proposed model is the identification of risks which is the first step in the risk management process (Pfohl; Gallus; Thomas, 2011; Ho *et al.*, 2015). The identification of risks has the objective of obtaining maximum relevant

information's about the risks (Kern *et al.*, 2012). Tummala and Schoenherr (2011) affirm that the risk identification phase aims at the complete and structured determination of the risks that occur in the supply chain.

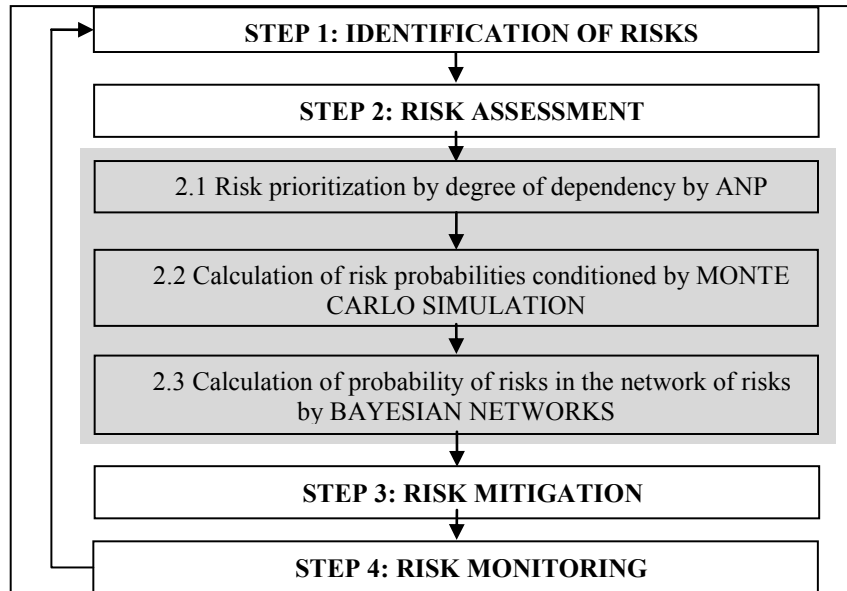


Figure 1. Phases of the risk management model in the supply chain with emphasis on risk dependence.

The second stage consists of the risk assessment stage. Cao and Song (2016) emphasize that risk assessment involves determining the importance of risks and their prioritization, which is the critical step in risk management. The assessment process is an important tool for estimating the consequences of risk. That is why measuring the probability of occurrence is an essential activity to quantify the risk (Bandaly *et al.*, 2012). If this risk criticality assessment is carried out, the most critical risks, that is, those that have a higher probability of occurrence and greater impact in a combined manner, should be pointed out. Ahmed *et al.* (2007) clarified that risk assessment is the stage where risk events need to be prioritized in a way that risk mitigation plans are directed. Mogre, Talluri and D'Amico (2016) indicate that risk mitigation strategies correspond to measures taken to reduce the probability of the occurrence of risks or their impact, as well as to seek means to transfer/eliminate the risks completely. Fazli, Mavi and Vosooghizaji (2015) suggest as strategies for risk mitigation: to accept, to avoid, to share and to transfer risks. Aqlan and Lam (2015b) suggest some strategies for risk mitigation such as: prevention, reduction, transfer, acceptance, ignoring and exploiting risk. Kern *et al.* (2012) indicate that continuous monitoring is necessary for risk control, as well as for the analysis of the effectiveness of the adopted strategies, and adjustment of measures when necessary. Thus, risk monitoring helps predict potential areas for improvement and recognizes the contribution of effective measures taken, as well

as lessons learned from past incidents, enabling new forms of risk to be perceived more quickly and easily.

It can be perceived that the most critical stage of the risk management models is the risk assessment, because at this stage they should be raised on the probability of occurrence and the impact associated with the risk. It is also in this phase that the use of several tools such as those listed in Table 1 is made. In view of the above, the proposed risk management model suggests the use of ANP to prioritize risk in the risk assessment phase, to incorporate risk dependence according to the dependency relationships identified between the risks. After prioritization, the use of the Monte Carlo Simulation to calculate the probabilities of the priority risks is suggested, adopting the conditioned relations between pairs of dependent risks. Finally, in order to calculate the probability of the final risks, the application of the Bayesian Networks is suggested in order to incorporate all the relations between the risks, and not only the relations between pairs. Through the Bayesian Networks it is possible to calculate and simulate the final probabilities of the risks that are generated, seeing the relations of dependence between the risks in the supply chain. After risk assessment, the most critical risk mitigation strategies should be adopted, i.e. those most likely to occur. Finally, a risk monitoring plan should be developed, where risks are controlled, and among other things, the effectiveness of the mitigation actions adopted. As it is a model proposal it is suggested that future works can apply this model in real cases in order to verify the obtained results, so that the cases of success can be analyzed and the difficulties found in these applications.

References

- Ahmed, A. *et al.* (2007). A review of techniques for risk management in projects. Benchmarking: An Int Journal. DOI 10.1108/14635770710730919
- Amundson, J. *et al.* (2014) Life-Cycle Risk Modelling: Alternate Methods Using Bayesian Belief Networks. Proc of the 47th CIRP Conf on Manuf Systems. DOI 10.1016/j.procir.2014.02.029
- Aqlan, F. e Lam, S. (2015a) A fuzzy based integrated framework for supply chain risk assessment. Int Journal Prod Econom. DOI 10.1016/j.ijpe.2014.11.013
- Aqlan, F. e Lam, S. (2015b).Supply chain risk modelling and mitigation. International Journal of Production Research, DOI 10.1016/j.eswa.2015.08.028
- Badurdeen, F. *et al.* (2014) Quantitative modelling and analysis of supply chain risks using Bayesian theory. Jou of Manuf Tech Manag, DOI 10.1108/JMTM-10-2012-0097
- Bandaly, D. *et al.* (2012) Supply chain risk management – I: Conceptualization, framework and planning process. Risk Management. DOI 10.1057/rm.2012.7
- Blackhurst, J. *et al.* (2011) An Empirically Derived Framework of Global Supply Resiliency. Jou of Business Log, DOI 10.1111/j.0000-0000.2011.01032.x

- Blome, C. e Schoenherr, T. (2011) Supply chain risk management in financial crises-A multiple case-study approach. *Int. J. Prod Econ.* DOI 10.1016/j.ijpe.2011.01.002
- Bradley, J. R. (2014) An improved method for managing catastrophic supply chain disruptions. *Business Horizons*, DOI 10.1016/j.bushor.2014.03.003
- Cagliano, A. et al. (2012) An integrated approach to supply chain risk analysis. *Journal of Risk Research*, vol. 15, n. 7, 817-840. DOI 10.1080/13669877.2012.666757
- Cao, J.;Song, W. (2016). Risk assessment of co-creating value with customers: A rough *Expert Systems With Applications*, DOI 10.1016/j.eswa.2016.02.012
- Chen, P., Wu, M. (2013) A modified failure mode and effects analysis method for *Computers & Industrial Engineering*. DOI 10.1016/j.cie.2013.09.018
- Cigolini, R. e Rossi, T. (2010) Managing operational risks along the oil supply chain. *Production Planning & Control tfe Management of Operations*. DOI 10.1080/09537280903453695
- Cohen, M. A e Kunreuther, H. (2007) *Operations Risk Management: Overview of Paul...Prod and Operations Management Society*. DOI 10.1111/j.1937-5956.2007.tb00278.x
- Diabat , A.; Govindan, K.; Panicker, V.(2012) Supply chain risk management and its mitigation in a food industry. *Int Jou of Prod Research*. DOI 10.1080/00207543.2011.588619
- Faisal, M.;Shankar, D.K. (2007) Information risks management in supply chains: an assessment and mitigation framework. *Joul of Ent Inf Manag*, DOI 10.1108/17410390710830727
- Fazli, S, Mavi, R.; Vosooghidizaji, M. (2015) Crude oil supply chain risk management with DEMATEL–ANP. *Oper R Int J*. DOI 10.1016/j.eswa.2015.10.041
- Funo, K. et al.(2011)Supply chain risk management: an exploratory research in Brazilian aerospace industry. *Int Journal Value Chain Management*. DOI 10.1504/IJVC.2011.043230
- Ganguly. K.; Guin,K (2013) A fuzzy AHP approach for inbound supply risk assessment. *Benchmarking: An International Journal*. DOI 10.1108/14635771311299524
- Garvey, M.;Carnovale, S.;Yeniyurt, S. (2015) An analytical framework for supply network... *European Journal of Oper Research*. DOI 10.1016/j.ejor.2014.10.034
- Gaudenzi, B.;Borghesi, A. (2006) Managing risks in the supply chain using the AHP method. *The International Journal of Logistics Management*. DOI 10.1108/09574090610663464
- Ghadge, A. et al (2011) Systems Thinking for Modeling Risk Propagation in Supply ...5th Int Conf on Ind Engineering and Eng Manag, IEEE, DOI 10.1109/IEEM.2011.6118203
- Giannakis, M.;Louis, M. (2011) A multi-agent based framework for supply chain risk management. *J of Purch e Supply Managt*, DOI10.1016/j.pursup.2010.05.001
- Govindan, K.; Chaudhuri, A. (2016) Interrelationships of risks faced by third party .. *Transp Research Part e Logistics and Transp Review*, DOI 10.1016/j.tre.2015.11.010
- Habermann, M., Blackhurst, J.; Metcalf, A. (2015) Keep Your Friends Close? Supply Chain Design and Disruption Risk. *Decision Sciences*. DOI 10.1111/deci.12138
- Hallikas, J.; et al. (2004) Risk management processes in supplier networks. *International Journal of Production Economics*, DOI 10.1016/j.ijpe.2004.02.007
- Han,M.;Chen, J. (2007) Managing operational risk in supply chain. *IEEE Int Conference on Wirelessand Mobile Computing*. DOI 10.1109/WICOM.2007.1205

- Heckmann, I; Comes, T.; Nickel, S. (2015) A critical review on supply chain risk –Definition, measure and modelling. *Omega*. DOI 10.1016/j.omega.2014.10.004
- Ho, W. et al. (2015) Supply chain risk management: a literature review. *International Journal of Production Research*, DOI 10.1080/00207543.2015.1030467
- Jereb, B., Ivanusa, T.; Rosi, B. (2013) Systemic Thinking and Requisite Holism in Mastering Logistics Risks: the Model for Identifying Risks in Organizations and Supply Chain
- Kayis, B.;Karningsih, P.(2012) A knowledge-based system tool for assisting *Journal of Manuf Technology Management*. DOI 10.1108/17410381211267682
- Kern, D. *et al.* (2012) Supply risk management: model development and empirical analysis. *Int Jou of Physical Distrib e Log Managt*. DOI 10.1108/09600031211202472
- Kumar, S. e Havey, T. (2013) Before and after disaster strikes: A relief supply chain decision support framework. *Int Jof Prod Economics*. DOI 10.1016/j.ijpe.2013.05.016
- Lavastre, O.; Gunasekaran, A. e Spalanzani, A. (2014) Effect of firm characteristics, supplier relationships and techniques... *Int J of Prod Research*. DOI 10.1080/00207543.2013.878057
- Lee, C.; Ulferts, G. (2011) Managing Supply.. *NK Review*. Fall. DOI 10.3172/NKR.7.2.34
- Li, S;Yu, J. (2010) Identification and evaluation of supply .. *Application Research of Computers*.
- Lockamy, III A. (2014) Assessing disaster... *Ind M & D S*. DOI 10.1108/IMDS-11-2013-0477
- Lockamy, III A.;McCormack, K. (2010)Analyzing risks in supply networks to facilitate outsourcing decisions, *Int Journal of Prod Research*.DOI 10.1080/00207540903175152
- Lockamy, III A.;McCormack, K. (2012)Modeling .. *Ind Management & Data Systems*. DOI 10.1108/02635571211204317
- McCormack, K. (2007) *Measuring and Managing Risk. Supply Chain Risk Management: ...ed. Handfield andMcCormack*. Auerbach Publications: New York. DOI 10.1201/9781420013306
- Mogre, R.; Talluri, T.; D’Amico, F. (2016) A Decision Framework to Mitigate Supply *IEEE Transactions on Engineering Management*.DOI 10.1109/TEM.2016.2567539
- Muchfirodin, M. et al (2015) Supply Chain Risk Management on Tobacco Commodity in Temanggung, *Agriculture and Agricultural Science* DOI 10.1016/j.aaspro.2015.01.046
- Nepal, B.;Yadav, O. (2015) Bayesian belief network based framework for sourcing risk analysis during supplier selection. *Int J of Prod Research*. DOI 10.1080/00207543.2015.1027011
- Ouabouch, L.; Amri, M. (2013) Analyzing Supply Chain Risk Factors: A Probability-Impact Matrix Applied to Pharma Industry. *Jof Logist Manag*, DOI 10.5923/j.logistics.20130202.01
- Pai, R. et al. (2003) Methods toward Supply Chain Risk Analysis. *Proc. IEEE Int. Conf. Syst. Man Cybern*. DOI 10.1109/ICSMC.2003.1245702
- Pfohl, H.; Gallus, P;Thomas,D(2011) Interpretive structural modelling of supply chain risks. *Int J of Physical Distrib & Logs Manag*. DOI 10.1108/09600031111175816
- Pradhan, K. e Srikanta, S. R. (2014) Analyzing the supply chain risk issues for an Indian *Journal of Advances in Management Research*. DOI 10.1108/JAMR-11-2012-0047
- Prakash, S.et al. (2014) Information Risks Modeling in e-business Supply Chain using AHP. *Proceedings of 2014 RA ECS UIET*. DOI 10.1109/RAECS.2014.6799634

- Punniyamorthy, M.; et al (2013) Assessment of supply chain risk: scale development and validation. *Benchmarking: An Int Journal*, DOI 10.1108/14635771311299506
- Pujawan, I.; Geraldin, L. (2009) House of risk: a model for proactive supply chain risk management. *Business Process Management Journal*. DOI 10.1108/14637150911003801
- Radivojević, G.; Gajović, V. (2013) Supply chain risk modeling by AHP and Fuzzy AHP methods. *Journal of Risk Research*. DOI 10.1080/13669877.2013.808689
- Ritchie, B.; Brindley, C. (2007) Supply chain risk... *Int J of Oper & Prod M.* DOI 10.1108/01443570710725563
- Samvedi, A.; Jain, V.; Chan, F. (2013) Quantifying risks in a supply chain through integration of fuzzy AHP and fuzzy TOPSIS. *Int J of Prod Res.* DOI 10.1080/00207543.2012.741330
- Schoenherr, T.; Tummala, V.; Harrison, T. (2008) Assessing supply chain risks with the *Journal of Purch & Supply Management*. DOI 10.1016/j.pursup.2008.01.008
- Sherwin, M et al (2016) Proactive Cost-.... *Int. Jo of Prod Econ.* DOI 10.1016/j.ijpe.2016.02.001
- Sofyalioğlu, C.; Kartal, B. (2012) The selection of global supply chain risk.... 8th International Strategic Management Conference. DOI 10.1016/j.sbspro.2012.09.1131
- Tang, O.; Musa, S. (2011) Identifying risk ... *Int Jou Prod Econ*, DOI 10.1016/j.ijpe.2010.06.013
- Thun, J.; Hoening, D. (2011) An empirical *IntJ Prod Econ.* DOI 10.1016/j.ijpe.2009.10.010
- Tummala, R.; Schoenherr, T. (2011) Assessing and managing risks using the Supply Chain Risk Management Process. *Supply Chain Management: An Int J* DOI 10.1016/j.ijpe.2010.06.013
- Tuncel, G.; Alpan, G. (2010) Risk assessment. *Comp Ind.* DOI 10.1016/j.compind.2009.09.008
- Wieland, A.; Wallenburg, C. (2013) The influence of relational competencies... *Int J of Physical Distn & Log Manag*, DOI 10.1108/IJPDLM-08-2012-0243
- Wu, T.; Blackhurst, J.; Chidambaram, V. (2006) A model for inbound supply risk analysis. *Computers in Industry*. DOI 10.1016/j.compind.2005.11.001
- Xia, D.; Chen, B. (2011) A comprehensive decision-...Exp systems with app. DOI 10.1016/j.eswa.2010.09.156
- Yang, B.; Yang, Y. (2010) Postponement in supply chain risk management: a complexity perspective. *Int Journal of Production Research*. DOI 10.1080/00207540902791850

Using of Performance Indicators to evidence improvement of the competitive dimensions of an electronic commerce company (B2C)

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Abstract: This paper aims to verify, using a case study, what performance indicators of the logistics operations of an electronic commerce company can be used to evidence the improvement of its competitive dimensions. It is characterized as a qualitative research, using the contextualization of the company, the definition of indicators and the link with the competitive dimensions. The results showed what performance indicators were able to evidence the improvements of the competitive dimensions in the logistics operations of an electronic commerce company.

Keywords: Performance Indicators; Competitive Dimensions; Logistics Operations; Electronic Commerce.

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1. Introduction

In the 1980s the fourth era of quality, Strategic Management of Quality, begins (Garvin, 1992). One of the approaches to Strategic Quality Management is one based on performance indicators.

In this way, the competitive dimensions are highlighted, which are operational priorities of differentiation that a process or supply chain needs to meet to satisfy its internal and external customers (Jitpaiboon, 2014).

The e-commerce, mainly in the form of retail, has shown growth all over the world, with a trend of continuous growth until 2020 (Emarketer, 2016).

The research question is: "what performance indicators can be used to evidence the improvement of the competitive dimensions of logistics operations of an electronic commerce company?".

2. Objectives

This paper aims, as main objective to verify what performance indicators can be used to evidence the improvement of the competitive dimensions of logistics operations of an electronic commerce company, with the specific objectives of identifying the improved competitive dimensions.

3. Methods

This is characterized as a qualitative exploratory research, using a case study in a company that operates in electronic commerce, having as main market the resale of products directly to final consumers (B2C) of the entire territory of Brazil.

The company was characterized through its field of action and internal processes. Based on the literature, the competitive dimensions and the indicators used in its logistics operations were selected, establishing links between the competitive dimensions and the performance indicators.

The study was performed using data provided by the company itself.

4. Results

The competitive dimensions adopted were Cost, Quality, Delivery, Flexibility and Innovation, and the Indicators were Operational Lost, Unity Cost, General Costs,

Absenteeism, Stock Damage, Cancelled Orders, Customer Complaints, On-Time Effective Exit of Delivery, Productivity per Attributed Order, Saving with Quality Circle, and Number of suggestions for improvement. Improvements were identified on the indicators related to Cost and Quality dimensions.

5. Conclusion

The results showed that was possible to evidence improvement of competitive dimensions of logistics operations of an electronic commerce company using performance indicators. Improvements on Cost and Quality dimensions were evidenced. For future research, it is recommended to evaluate the actions when the goals of the indicators are not reached.

References

- Emarketer (2016) Worldwide Retail Ecommerce Sales Will Reach \$1.915 Trillion This Year, Available at: <https://www.emarketer.com/Article/Worldwide-Retail-Ecommerce-Sales-Will-Reach-1915-Trillion-This-Year/1014369> (accessed 7 March 2017)
- Garvin, D.A. (1992) Gerenciando a Qualidade: A Visão Estratégica e Competitiva. Qualitymark, Rio de Janeiro
- Jitpaiboon, T. (2014) The study of competitive priorities and information technology selection: exploring buyer and supplier performance. Journal of international technology and information management, Vol. 23 Iss. 3 Article 6, Available at: <http://scholarworks.lib.csusb.edu/jitim/vol23/iss3/6> (accessed 7 March 2017)

Analysis, Categorization and Comparison of Planning Methods for Order Picking Systems

Martini A¹, Mauksch T², Stache U³

Abstract The planning of order picking systems is a complex and demanding task. This article provides a comparative observation of the planning procedures developed over the last 40 years in Germany regarding their general functionality, the procedure of decision making as well as the frame conditions, applicabilities and application conditions. Finally, the overarching development path and its potential future continuation are described.

Keywords: Planning Method; Order Picking System; Feasibility; Optimization

1. Introduction

The order picking in companies is of great importance for the production supply as well as the distribution of goods. For the first mentioned case it is a mandatory prerequisite to meet the requirements of a modern production like low stock, high variant diversity and flexibility as well as low order throughput times. Within the distribution logistics, order picking imminently determines the quality of the delivery service and thus the customer's perception of the company. Furthermore, order picking can cause high costs of up to 50 % of the logistics costs due to its

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high personnel intensity or respective degree of automation (Pulverich, Schielinger 2009).

One key difficulty when planning efficient order picking systems is the lack of a comprehensive overview of existing design alternatives of components, structures and processes. Another difficulty is that the design alternatives cannot be combined arbitrarily (see Fig. 1) and numerous dependencies exist. In some cases the alternatives mutually exclude or require themselves. Findings on the combinability are only available for single cases, a comprehensive overview is also missing. The same applies for the effects of design alternatives on the goals: The effect directions can often be estimated but this is not applicable for the effect intensity. Another aggravating factor is the non-linearity of some of the effect function making the effect dependant on the system's operating point (Miebach 1971: 16; Gudehus1973: 48). Therefore, in the same order picking system one design alternative can be highly relevant or, in another operation situation, totally irrelevant.

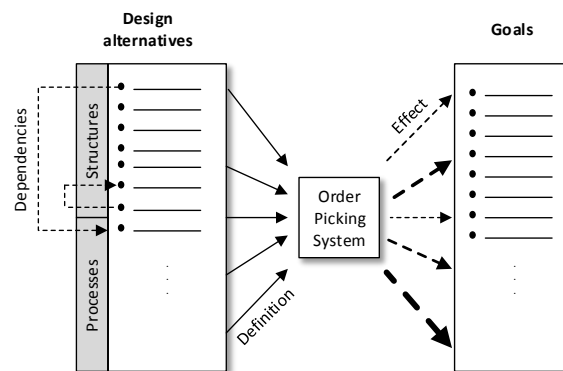


Figure 1. General problems when planning order picking systems

Dependencies between the effects of design alternatives, synergetic or conflicting, further complicate the planning. Hereinafter, the available approaches for planning of order picking systems are described in regards of their functionalities, categorized into the classes of morphological, IT-based and simulation-based approaches as well as compared to each other.

2. Description of planning approaches

2.1. Morphological planning approaches

The approaches by the authors Miebach (1971), Gudehus (1973) and von Borries & Fürwentsches (1975) firstly classify order picking systems by means of their basic material handling functions of provision, movement, removal and collection.

By combining the technical design alternatives of these basic functions morphologies arise which can be depicted in structure trees. A first limitation during the system selection is made by evaluating the technical feasibility of these combinations. Furthermore, performance data and indicators achieved from observations (e. g. order picking factor), simple calculations (e. g. travel and handling time calculations) and simulations help to limit the number of potential systems. Performance profiles of individual system configurations are compared with the requirement profile and lead to an exclusion of inappropriate configurations. Whereas Miebach systematically excludes system variant by means of a decision tree approach, Gudehus and von Borries & Fürwentsches rely on detailed calculations of picking times. Besides economic efficiency calculations, Miebach and Gudehus apply the cost-benefit analysis for being able to consider qualitative decision criteria such as flexibility or extensibility for the system finding process.

2.2. IT-based planning approaches

The basis of decision making of the IT-based planning approaches are – in contrast to the performance data and indicators in the morphological approaches - computer-based calculation methods as well as data bases which contain observation data achieved from investigations in companies.

The approach by Pieper (1982) rests upon empiric researches of the operational application of order picking systems in 35 companies in different sectors. Referring to the above mentioned basic functions of order picking systems, item and order related data from the technical and organisational areas is recorded. Pieper derives nine characteristic performance profiles from the applications by means of cluster and correlation analyses. These profiles are compared with the requirement profile of the present planning case in order to develop design recommendations for the system structure to be chosen by means of requirement parameters.

In her approach Staiger (1992) firstly creates a catalogue of potential designs of order picking systems basing on a classification of technical design options of individual system components (incoming goods, conveyor system, stock of units, order picking system, outgoing goods) and the characteristics of the basic functions (here: admission into warehouse, provision, removal, movement, delivery). 191 technically feasible system variants result from a complete enumeration. The first step in the course of the three-step selection procedure is the preplanning with its limitation of the number of system variants by determining appropriate load carriers and the warehouse structure. During the second step, the preselection, the consideration of technical and organisational mandatory criteria leads to a further reduction of the number of permissible system variants. During the final evaluation step, performance profiles of the remaining system variants are generated and their qualitative features evaluated by a cost-benefit analysis.

Töpper (1995) generates numerous, theoretically feasible order picking systems by means of a configuration system consisting of material flow, information, strategy and system organisation modules. Using a so-called inference algorithm, the data to be entered by the planner (e. g. scope of product range, number of order lines, required order throughput times) is linked to a knowledge base by determining affiliation degrees - and thus the configuration of system variants. In this process, performance relevant features of order picking systems are associated to fuzzy cause-effect-correlations (affiliation degree to specific groups) between feature and system performance by applying the fuzzy set theory. This shall avoid the early discard of design options. By re-transforming fuzzy values into exact values, a ranking of design alternatives for each feature can be established. The summary of the respective best features manifests the planning result.

Table 1 provides an overview of the processing order of the individual basic functions of the material flow system (subproblems). It can be noted that the authors consider different basic functions and process them in a different order.

Table 1. Comparison of considered planning elements and sequence of application

Author(s)	Miebach (1971)	Gudehus (1973)	von Borries / Fürwentsches (1975)	Pieper (1982)	Staiger (1992)	Töpper (1995)
Admission into warehouse	1				1	
Provision		1	1	1	2	2
Storage	2					
Movement		2	2		4	1+3+5+7
Removal	3	3	3		3	4
Picking				3		
Collecting				4		
Warehouse structure				5		
Delivery		4	4	2	5	6
Order collection	4					
Superordinate organisation	5					

2.3. Simulation-based approaches

These planning approaches use computer-based simulation models for the determination and optimization of case-specific performance indicators. Due to the high processing power of modern computers, dynamic interrelations like bottlenecks and deadlocks can be considered and visualized by simulation. By means of optimization of the performance indicators - especially in regards of performance, investments and operating costs - a system selection is made.

Potyka (1995) defines a knowledge-based modular system which consists of four functional levels: sector, system, component and basic function level. Preliminarily, the individual functions of order picking are associated to the functional levels and for this purpose structure, productivity, cost and quality performance indicators are respectively defined. The comparison with the

knowledge base determines the further procedure on the respective system levels. Six typical functional models which can be adapted and optimized to the requirements are the starting point from which the optimized system is created. This optimization is made by means of parameter sets regarding system load data, organization data as well as technical data generated by simulation.

The particularity of Ulbrich's approach (2010) is the use of the process simulation already at an early planning stage. Thus, dynamic interrelations and interdependencies between design alternatives shall be considered as well as solutions close to the overall optimum shall be found. The analysis of existing systems is made among others by means of Methods-Time-Measurement (MTM). Additionally, the approach allows to define sales-related future scenarios. Standardized simulation modules are developed from the possibilities of merging the key elements provision unit, order storage (e. g. container, pallets, cartons for shipment) and order picker. These elements have to be chosen and parameterized by the user depending on the applicability to the present problem. A comparative system selection is made by means of performance and cost indicators.

Like Ulbrich, Venn (2011) also uses the process simulation at an early planning stage. Furthermore, both approaches are suitable for heterogeneous order picking systems (i. e. consisting of different techniques or use different strategies). Contrary to the approach by Ulbrich, at first a peak day (in performance) for dimensioning the technology and resources and then a standard day (in performance) for calculating the cost indicators is simulated for comparative evaluation. Additionally, there is a comprehensive visualization of the result data.

3. Analysis and comparison of the planning approaches

The nine described planning approaches have been developed within a time frame of 40 years. It is apparent that the procedures build on each other methodologically and always represent continued developments. Furthermore, the increased use of improved technical possibilities of data processing can be stated.

For the *morphological planning approaches* (1971-1975) manually applicable methods like morphological boxes, structure and decision trees, static performance indicators as well as cost-benefit analyses are used. The selection decisions regarding the respective individual, technical basic functions are made with regard to performance indicators and rules on the basis of universal statements. There is no observation of the overall system. The handling of the procedures is simple and can be executed by non-experts with manageable effort. These approaches show a low level of details and only provide a rough orientation on the design of the order picking system to be planned (see Table 2). An example of such a directive selection decision is the choice between a goods-to-person or a person-to-goods system. The fundamental understanding of the procedure is to find a working

solution for a given task. An optimization in the sense of finding the most appropriate solution is not made.

The progress in technical development of *IT-based planning approaches* (1982-1995) is apparent by the use of knowledge data bases and computer-intensive methods like complete enumeration or fuzzy sets. For these approaches, the decision making is mostly supported by using observation data of existing systems. Compared with the class of the first-mentioned procedures, these applications are more laborious and require experts with logistics as well as IT skills. The level of details as well as the degree of support are also significantly higher than of the first-mentioned class. However, an important point of criticism is that it is normally not clear how close to the optimal design the reference systems stored in the knowledge data bases really are and, if they perform well, why they do so. Thus, those systems are also only for securing the operability of the planned order picking system. The number of reference systems to be classified as low (35 (Pieper 1982) up to 191 (Staiger 1992)) is an additional point of criticism (Töpper 1995, 122) as well as the circumstance that not all data bases are completely open for public access. With regards to the use case, different solutions can result from the different processing sequences of the subproblems (refer to Table 1), which bears the risk of early elimination of the global optimum from the solution space. It can be assumed that the authors have divergent views regarding the importance of the subproblems for the planning of order picking systems. This can also be concluded from the selection of the subproblems considered by the planning approaches. It also can be stated that none of the planning approaches consider all subproblems.

The application of *simulation-based planning approaches* (1995-2011) allows an holistic view on the order picking systems to be planned. Furthermore, these approaches not only support the consideration of the structures but also the processes in a dynamic view and thus allow an interpretation of the system behavior.

Table 2. Qualitative comparison of the planning approaches

Criteria	Morphological approaches			IT-based approaches			Simulation-based approaches		
	Miebach (1971)	Gudehus (1973)	v. Borries & Fürwentsches (1975)	Pieper (1982)	Staiger (1992)	Töpper (1995)	Potyka (1995)	Ulbrich (2010)	Venn (2011)
Planning effort	medium	low	medium	low	high	medium	very high	very high	very high
Level of details	low	low	low	low	high	medium	high	very high	very high
Required knowledge of the planner	low	low	low	high	medium	high	very high	very high	very high
Planning of the organisation	yes	yes	no	yes	yes	yes	yes	yes	yes
Consideration of quantitative evaluation criteria	yes	yes	yes	yes	yes	yes	yes	yes	yes
Consideration of qualitative evaluation criteria	no	yes	yes	yes	yes	yes	yes	yes	yes
Planning of heterogeneous order picking systems	no	no	no	no	no	no	no	yes	yes
Scope of required input data	low	low	low	medium	medium	medium	high	very high	very high
Volatility of the result data in dependence of the input data	low	low	low	low	high	medium	medium	very high	very high

Graduation: low - medium - high - very high

Furthermore, for the first time heterogeneously structured order picking systems can be analytically observed. Visualizations support the gain of knowledge as well as the user's system understanding and increase the transparency of the system evaluation. The application of these procedures mandatorily requires one or more experts in the field of simulation as well as order picking. The high demand of input data allows a high level of details and thus an extensive support during the planning, however, restricts the feasibility on the other hand. There is also no general and complete access to the algorithms and databases for these planning procedures so that application restrictions for third parties are existent. The simulation-based analysis of system variants facilitates the determination and assessment of the quality of alternative order picking systems already at an early planning stage and allows a comparative evaluation. Basing on preset target variables, a ranking of the systems can be derived. An optimization is only made by proceeding the planning until a result of sufficient quality is achieved.

4. Conclusion and outlook

When comparing the planning procedures directly a consistent development path towards a higher level of detail is clearly recognisable. This leads to an improved planning quality and significance of the procedure regarding the achievability of the preset planning goals on the one hand. On the other hand the effort for the application rises along with the complexity; manageability diminishes. In the light of the currently achieved level of detail it can be assumed that there will be no

further grow. All relevant aspects are considered and the high efforts of a further increase are opposed by an increasingly lower benefit.

While the procedures of the 1970s are seen as tools for creating feasible solutions, the optimization as a new aspect is gaining more and more importance in the course of the years. First efforts towards this direction can be recognized by creating rankings of planning alternatives, but this is still far from optimization procedures in the sense of operations research. However, a change in the basic pattern is clearly visible.

A central task for the future is the systematic and comprehensive recording and documentation of design alternatives in regards of technology, structures and processes. First structurings are already available (ten Hompel et al. 2011, 65) and can be used as a basis. Besides the documentation task there is the necessity to determine the compatibility of the design alternatives. This can be made deductively or by observation. Ideally it will be possible to create a modular system of design alternatives for all functions of order picking systems. The next research task is to gain universal statements regarding the effects of the selection of design alternatives on the target variables of the systems to be planned. It is uncertain whether it will be possible to gain such statements in terms of generality and quantity. Nevertheless qualitative information as e.g. the determination of the effect direction would already be of great value and would provide the possibility to consider target variables of the order picking systems already at an early planning stage.

There are also research needs regarding the development of methods for implementing the optimization aspect into the planning procedure. It seems expedient and necessary to firstly develop a procedure that supports the planner in designing a permissible system configuration as a first step. The next step should be to quantify the valid effects of the design alternatives for the individual case. Finally an approach should be developed with which the planning results can be improved in iterative steps along a search path towards the optimum.

Some of the required methods already exist and have to be further developed to an overall procedure under the headline of simulation-based optimization (SBO). The following and of course more further ahead development step is the automation of the planning and optimization of order picking systems. For this the subproblems of the automated system configuration and optimization have to be distinguished. Due to the structure of the problem and the complexity of the interrelations, genetic algorithms and agent systems seem to be promising approaches. Ellinger's work (Ellinger 2015) provides a promising basis. The author examines the applicability of agent system for the concept development for planning order picking systems. Although the optimization aspect is explicitly not considered, substantial problems of automated planning are eliminated.

References

- Borries R, Fürwentsches W (1975) Kommissioniersysteme im Leistungsvergleich. verlag moderne industrie, Munich, Germany
- Ellinger M (2015) and also Diss. University Dortmund 2015 Beitrag zur agentenbasierten Konzeptplanung von Kommissioniersystemen Verlag Praxiswissen, Dortmund, Germany
- Gudehus T (1973) Grundlagen der Kommissioniertechnik – Dynamik der Warenverteil- und Lagersysteme. Verlag W. Girardet, Essen, Germany
- Miebach J (1971) Die Grundlagen einer systembezogenen Planung von Stückgutlagern, dargestellt am Beispiel des Kommissionierlagers. DEMAG Fördertechnik, Wetter (Ruhr), Germany
- Pieper R (1992) Auswahl und Bewertung von Kommissioniersystemen. Beuth-Verlag, Berlin Köln, Germany
- Potyka S (1995) and also Diss. University Dortmund 1994 Systematik zur Selektion von Kommissioniersystemen in der Planung. Verlag Praxiswissen, Dortmund, Germany.
- Pulverich M, Schietinger J (2009) Handbuch der Kommissionierung. Vogel Verlag, Munich, Germany
- Staiger S (1992) Entwicklung eines rechnergestützten Verfahrens zur technisch-wirtschaftlichen Bewertung von Lager- und Kommissioniersystemen. Diss. Universität Karlsruhe.
- ten Hompel M (2011) Kommissionierung. Springer-Verlag, Berlin, Germany
- Töpfer H H (1995) Entwicklung eines Verfahrens zur Auswahl und technischen Gestaltung von Kommissioniersystemen. Diss. Universität Dortmund, Germany.
- Ulbrich A (2011) and also Diss. UE Munich 2010 Simulationsgestützte Grobplanung von Kommissioniersystemen. fml – Lehrstuhl für Fördertechnik Materialfluss Logistik, Munich, Germany
- Venn E (2011) and also Diss. University Duisburg-Essen 2011 Beitrag zur simulationsgestützten Konzeptplanung von heterogen strukturierten Kommissioniersystemen. Verlag Praxiswissen, Dortmund, Germany

Study of fruit pulp chain from the perspective of Supply Chain Management (SCM)

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Abstract Globalization and the advent of Information and Communication Technologies had influenced Substantial changes in forms of management. The global competitive landscape intensified, which generated new forms of competition for the various players in this scenario. Faced with the unstable and complex environment, organizations need to focus their efforts on shared strategies. In the ambit of agribusiness, which is formed by a set of specifics that give greater complexity to the activity. Regarding the agroindustrial chain of fruit pulp, this dynamic becomes even more tenuous, considering the peculiarities of the sector. Therefore, this paper aims to describe the fruit pulp chain from the perspective of the business processes of Supply Chain Management (SCM). To do so, eight business processes were considered for the qualitative analysis supported by the bibliographical research on a well-known scientific basis such as Web of Science, Scopus and Ebsco. The results describe the business processes and the activities that compose it in the fruit pulp sector, allowing understanding the synchronous and dependent relationship between the processes, as well as the importance of information sharing in the dynamics among all activities.

Keywords: Supply Chain Management, SCM, Fruit Pulp, Business Process

1. Introduction

The different economic changes, such as the phenomenon of globalization, have created the need for adaptations in the markets, making them more competitive and increasing their unpredictability and uncertainty (Shukla and Jharkharia, 2013; Fernandes and Berton, 2012). Local businesses have become global, giving new forms of competition to the various agents of this complex (Costa, 2009).

The intense competition between companies has led companies to take different actions to achieve competitive advantage. Often, these actions prioritize continuous processes of innovation that confer benefits such as better levels of

quality and differentiation of products and services (Stevens and Johnson, 2016; Melo and Alcantra, 2014).

Supply Chain Management (SCM) emerges with the objective of promoting the alignment between the links of supply chain in times which corporate autonomy gives place to the collaborative work. In this way, companies act in a systemic and integrated manner, facilitating the bidirectional flow of business and information, causing feasible gains in the network (Simon et al., 2015).

SCM can be considered as an expanded approach to traditional materials management as it requires a more competitive positioning of its agents. This breakdown of competitive paradigm clarifies that competition occurs between productive chains and not between isolated business units. Thus, organizations cannot be considered closed systems, but open systems and dependent on the other agents that compose this complex network (Pires, 1998).

In view of such assumptions, as well as the unstable and dynamic nature of the productive arrangements currently in place, this paper presents the general objective of describing the fruit pulp chain from the perspective of SCM's business processes.

2. Methodology

The methodological contribution of the work was carried out through a bibliographical review, with an exploratory-descriptive approach. The bibliographic review provided an understanding of the current configuration of literature on industrial engineering area, which includes SCM and Business Processes. The bibliographic review also provided an understanding of the specificities that permeate agribusiness and the fruit industry, allowing the construction of the results from the supply chain management perspective. This step was supported by the research of scientific materials in the search bases Web of Science, Scopus and Ebsco.

For that, the steps were used through the model defined by Gil (2014): (i) Problem formulation, (ii) Elaboration of the work plan; (iii) Identification of sources; (iv) Location of sources and obtainment of material; (v) Reading of material; (vi) Registration; (vii) Logical construction of work, and (viii) Writing the text.

It is necessary to state that by proposing a theoretical approach on Supply Chain Management and Business Processes, this study was based on the theory coined by Lambert Cooper and Pagh (1998).

The originality of this article can be based on the small character of researches that contemplate the analysis of the fruit pulp sector from the perspective of the business processes. Regarding the area of knowledge of the fruit pulp chain the presence of many studies on the physical-chemical composition of the pulp was identified, but little related to the management of the supply chain.

3. Results

3.1. The Fruit Pulp Sector Supply Chain

Figure 1 demonstrates the Fruit Pulp Sector Supply Chain with all possible agents interacting in this complex.

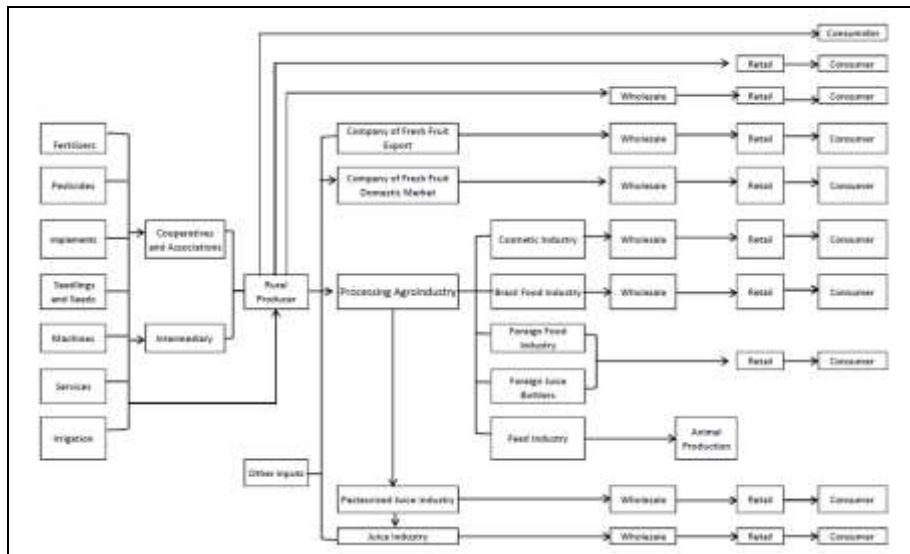


Figure 1. Fruit Pulp Sector Supply Chain
Source. Prepared by the authors based on Fava Neves (2004)

The first link is composed by inputs needed for planting and dealing with crops. The commercial relations between these companies and the rural producers can be realized directly or through associations, cooperatives or other intermediaries, depending on the size and degree of organization of the agents.

The rural producer can relate to both, the industrial sector and the domestic market. In industry, there is the possibility of commercialization with the processing agribusiness, companies of pasteurized juices and ready juices. In domestic market, it is possible to sell the fruit in natura to supermarkets or acting in the direct sale, such as free trade shows, for example. Some rural producers invest in the sale to the foreign market, with the export of the fruit to countries of Europe and North America. However, phytosanitary requirements may pose barriers to small producers, since not all have the financial structure to afford drastic adaptations (Coronado et al., 2014).

3.2. Customer Relationship Management

This relationship allows identifying the profile of the client and direct measures to make them loyal. Among the tools used to facilitate this communication are web sites, e-mails, social networks, call centers, sales points and other strategies that facilitate marketing management, sales, pricing and production planning (Chen and Popovich, 2003).

As an example, an agroindustry that exports fruit pulp perceives a demand to access a specific market, thus adopting a certain certification (such as Kosher certification) or good practice procedures, such as HACCP (Hazard Analysis & Critical Control Points), to broaden its capillarity of action at international level. In this sense, the importance of the flow of information in the supply chain, whether for the management of short-term resources or for the expansion of the market, is corroborated.

3.3. Customer Service Management

This business process refers to the development of actions to manage customer orders, being supported by the administration of products and services. The responsible team should establish strategies to optimize this relationship, determine communication channels and write a plan of action to measure management alternatives and their impact on company activities (Simon et al., 2014).

Regarding the post-sale service in the fruit pulp industry, agribusiness must provide the essential information to its customers, such as the manufacturing lot, expiration date, payment situation, delivery methods, quantity sold, type of transportation used and other relevant logistical information. In addition, the team should inform customers about any potential problems.

3.4. Demand Management

Demand management in the fruit pulp chain must align the needs of the customers with the production capacity of the company. Dollar variations should be monitored if much of the production is destined for export, as it may directly influence the quantity demanded by the countries that import pulp.

Fruit Pulp, besides being sold to the domestic market and destined for consumption as natural juice, is also widely used as raw material in the production of sweets, pasta, jellies, ice cream and nectars. Thus, there is the advantage of producing during the harvest period and marketing in more favorable periods per the demand of the consumer market. Therefore, the team in charge of demand management should prepare contingency plans to synchronize supply and demand, periodically review plans, conduct inspection of production capacity, and interact with other business processes.

3.5. Order Fulfillment

This business process can directly influence manufacturing flow management, since it is the information derived from this process that will initiate production operations, whether in the purchase of the raw material (fruits), packaging or in the production and delivery planning of the final product.

The personnel responsible for this management should determine the specific steps from the time of order entry to delivery of the final product and verify the customers' credit and, thereby, direct the possible forms of payment. They should also identify the productive capacity to meet high demand, communicate the management team of customer service when the order is delivered, and share information to those in charge of demand management (Matta et al., 2005).

3.6. Manufacturing Flow Management

Production consists of the following steps: (i) Reception and weighing, depending on the period it is necessary to store them in temperatures between 5° C to 12° C; (ii) Selection, washing and rinse. The fruits are separated per their physical state, discarding those spoiled, attacked by parasites or with some other sign, which demonstrates non-conformity with quality. The first wash aims to clean the most superficial impurities, whereas in the second wash they are immersed in chlorinated water for about 20 to 30 minutes; (iii) Peeling and Cutting, the stage at which fruits must be weighed to control productive income. The cutting may be manual or mechanical, and unused debris should be placed in closed containers to avoid attracting insects; (iv) Pulping consists of separating the pulp from the fibrous material. Crusher, disintegrator or industrial blender carries out the crushing; (v) Packaging and filling can be performed by means of automatic dispenser, semi-automatic or manually; (vi) Freezing and Storage.

The bags used in the packaging are polyethylene plastic, the size varies per the type of marketing (home market are small portions and in drums for export). The aforementioned productive steps, such as peeling and filling will vary according to the type of fruit processed, since they differ in their physical structure, fiberiness, consistency and bark stiffness. It is up to the responsible team for the productive process to direct the best way, as well as the processing sequence to achieve time saving (Matta et al., 2005).

3.7. Supplier Relationship Management

In the agribusiness chain of fruit pulp, rural producers are mainly responsible for supplying the raw material necessary for the progress of the company's production process.

Because these are sensitive products with high perishability, agribusiness must pay attention to some aspects such as the location of suppliers, deadlines and transportation conditions to not jeopardize the quality of the product and generate losses. Rural producers should be located close to the productive units in a way that facilitates transportation and reduces transportation waste. The deadlines for

delivery must be established in advance among those involved, as well as the requirements such as quality and maturation of the fruit. In addition to the main suppliers, there are the suppliers of secondary products as spare parts suppliers of the machinery, which although they operate with less periodicity are important in this business process (Lambert and Schwieterman, 2012).

3.8. Product Development and Commercialization

Fruit pulp is a natural product without the addition of chemicals and preservatives that alter the original composition of the food. This characteristic attributes to it nutritional advantages not provided by industrial juices. Per Evangelista and Vieites (2006), the sector associated with conditions such as seasonality and high perishability drives the technological development that guarantees the commercialization and consumption during an extended period. That is, allowing the extension of the useful life and adding quality and value to the product, besides acting in the reduction of wastes in the transport and storage of the fruit in natura.

This business process is challenging for the managers of the fruit pulp chain, as it is a natural product. Innovation and development should focus on aspects related to the mixing of more than one fruit in a single package, such as orange with acerola and addition of other ingredients such as mint in the pineapple pulp. In this scenario, the trade in fruit pulp for detox juices, directed to a specific target public, is glimpsed. This type of drink consists of adding vegetables and other ingredients such as cabbage, ginger, tomato, carrot, flaxseed, among others. This process is not necessarily related to the creation of an innovative product. The adoption of partnerships with suppliers to encourage the production of more exotic fruits or typical of the northeast region as açai and cupuaçu is also considered an inherent practice in this business process.

The commercialization of frozen fruit pulp is facilitated by the transportation to long distances, fact that is not provided by the commercialization of fruit in natura. In addition, it is possible to export fruit during the off-season. Sale is carried out by the company itself or through intermediary agents, such as commissioned dealers or representatives. When the commercialization is done directly by the agribusiness, it is generally responsible for the costs of delivery, which requires own investment or outsourcing of the logistics activity (Lambert and Schwieterman, 2012).

3.9. Returns Management

Among other quality service procedures, it is highlighted the inventory control, since the fruits cannot be stored for an extended period. Thus, the fruits should be stored in sanitized plastic containers and identified by date, lot, quantity and time. The stock of the finished product must remain under adequate refrigeration, with cross contamination control that refers to the possibility of contact of the raw material with the finished product, so that there is no contamination of microorganisms present in the fruits. The cleaning of environments should be

carried out daily, emphasizing the control of pests with door, window and drain sealing, being strictly prohibited the presence of any animal within the agribusiness. Finally, there should be records and controls performed for each stage of the production process, as well as any interruptions that may occur (Matta et al., 2005).

Sub products resulting from fruit processing such as peels and seeds can be reused in the manufacture of other products such as animal feed and cosmetics, as shown in Figure 1. Ferrari *et al.* (2004) highlight the high concentration of fatty acids in passion fruit seeds having nutritional importance in human and animal food, besides being present in the manufacture of cosmetics, paints and soap. The practice of reverse logistics represents the reuse of materials with the correct and sustainable destination, in addition to providing economic value to products previously discarded.

In addition to the aforementioned practices, it is possible to consider the machinery maintenance processes, in which there is a need for replacement of specific parts and equipment. This maintenance can generate returns to suppliers of these materials or service providers for possible repairs, which is a task that is part of the return management process.

4. Conclusions

Although the eight business processes have been analyzed here individually, it is possible to conclude that they have a strong synchrony relationship. In addition, sharing information among the teams responsible for each business process is critical to the efficiency of its execution. Customer Relationship Management and Customer Service Management brings together a set of important data that can generate execution and planning orders in the process responsible for managing demand, manufacturing flow management and order fulfillment.

Managing the manufacturing flow, besides contributing to the organization and optimization of the production process, also guides the quality control procedures that must be strictly followed per obligatory technical procedures and good manufacturing practices. Efficient management of this business process will reduce the potential for failures and bottlenecks in the return management process. In addition, consideration should be given to the use of fruit residues, such as seeds and bark, which are resold to agroindustries of other segments, for the manufacture of animal feed, cosmetics and soap.

The uncertainties and unpredictability that affect production chains, coupled with the specificities of agribusiness, imply greater complexity in the sector's performance. In addition, there are often agents marked by a disorganized configuration and information asymmetries, which makes more difficult to manage activities efficiently along the chain. Based on such clarifications, it is corroborated the importance of the practice of business processes in the supply

chain management in the fruit pulp sector to avoid losses and to create competitive advantage.

References

- Chen, I. J. and Popovich, K. (2003) “Understanding customer relationship management (CRM)”, *Business Process Management Journal*, Vol. 9 No. 5, pp. 672 – 688.
- Coronado, J. A., Bijman, J., Onno, O. and Lansink, A. O. (2015) “A case study of the Mexican avocado industry based on transaction costs and supply chain management practices”, *Economía: Teoría e Práctica. Nueva Época*, No.42, pp. 137-165.
- Costa, C. C. (2009), *Estratégia de negócios*. 1ed., São Paulo, Saraiva.
- Evangelista, R.M. and Vieites, R.L. (2006) “Avaliação da Qualidade de Polpa de Goiaba Congelada, Comercializada na Cidade de São Paulo”, *Segurança Alimentar e Nutricional*, Vol. 13 No.2, pp. 76-81.
- Fava Neves, M., Lopes, F. F., Rossi, R. M. and Melo, P. A. O. (2004) “Metodologias de análise de cadeias agroindustriais: aplicação para citros”, *Revista Brasileira de Fruticultura*, Vol.26 No. 3, pp. 468-473.
- Fernandes, B. H. R. and Berton, L. H. (2012) “Administração Estratégica: da competência empreendedora à avaliação de desempenho” 2ed., São Paulo, Saraiva.
- Ferrari, R. A.; Colussi, F. and Ayub, R. A. (2004) “*Caracterização de subprodutos da industrialização do maracujá aproveitamento das sementes*” available at: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-29452004000100027 (accessed 10 January 2017).
- Gil, A. C. (2014) “*Métodos e técnicas de pesquisa social*.” 6 ed., São Paulo, Atlas.
- Lambert, D. and Schwieterman, M. A. (2012) “Supplier Relationship Management as a macro business process”, *Supply Chain Management: An International Journal*, Vol.17 No 3, pp.337-352.
- Pires, S.R.I. (1998) “Gestão da cadeia de suprimentos e o modelo de consórcio modular” *Revista de Administração*, Vol. 33, No 3.
- Simon, A. T.; Satolo, E. G.; Scheidl, H. A. and Di Sério, L. C. (2014) “Business process in supply chain integration in sugar and ethanol industry” *Business Process Management Journal*. Vol. 20, No. 2, pp. 272-289.
- Simon, A. T.; Di Sério, L. C.; Pires, S. R. I. and Martins, G. S. (2015) “Evaluating Supply Chain Management: A Methodology Based on a Theoretical Model”, *Associação Nacional de Pós Graduação e Pesquisa em Administração*, Vol.19, No 1, pp. 26-44.
- Shukla, M. and Jharkharia, S. (2013) “Agri-fresh produce supply chain management: a state-of-the-art literature review”, *International Journal of Operations & Production Management*, Vol. 33, No 2, pp.114–158.
- Matta, V. M., Freite Junior, M., Cabral, L. M. C. and Furtado, A. A. L. (2005) “Polpa de Fruta Congelada” Brasília Informação Tecnológica, 2005.

- Melo, D. C.; Alcântara, R. L. C. (2016) “O que torna a gestão da demanda na cadeia de suprimentos possível? Um estudo multicascos dos fatores críticos de sucesso”, *Gestão da Produção*, Vol. 23 No 3, pp. 570-587.
- Stevens, G. C. and Johnson, M. (2016) “Integrating the Supply Chain. 25 years on. International” *Journal of Physical Distribution and Logistic Management*, Vol. 46 No.1, pp. 19-42.

Using PERT / CPM in Choosing the Shortest Path

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Abstract This article reports a case study where the PERT / CPM techniques were applied in the choice of the best route from one of the tourist points in Belém to the Estácio de Belém educational institution (IESAM), focusing on analyzing the critical and shortest path. The study is based on the sequencing of the sections and verification of the time of signals, the definition of critical activities and the construction of the critical path network. The work presents results emphasizing the total time of the routes and checking the shortest route.

Keywords: Shortest path; Pert / CPM; Routes

1. Introduction

Expenses and an attempt to optimize are common factors in the daily lives of individuals and companies. Which company has never changed a route of their vehicles trying to find the shortest or most economical way to reach or finish a certain goal or made a mistake in order to delay the delivery of the order? . Well,

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today with new technologies (like GPS) these kinds of problems have become easier to get around.

In order to meet demands effectively, in an environment characterized by the speed of change, a management or project management model based on the focus on priorities and objectives becomes indispensable.

Today as much as we have evolved technically, we are faced with an environment that evolves many times faster, that is, today we are much more capable than in the past, but this increase of capacity is less and less compared with the increase in the dynamics of the environment. Therefore it is necessary to develop mechanisms that reduce this difference between man and the environment.

In order to help the organizational environment, in the last years two research-related trends have emerged related to the project management area: (i) current management science with PERT / CPM, a technique to identify the shortest completion time of a project; (ii) current project management, technical to verify human problems such as lack of technical skills and project execution and lack of teamwork (Cox III; Schleier, 2013).

With the help of the PERT / CPM, the objective of this work was to conduct a study of predetermined points routes in order to obtain the best route, that is, the one that will reach the shortest route time with the exemplification of the network model. In addition to making a comparison per kilometer traveled and amount spent fuel.

2. Literature review

2.1. PERT / CPM

The PERT and CPM methods were created in the late 1950s, both techniques emerged as a breakthrough in project management. According to Cox III and Schleier (2013), the CPM (Critical Path Method) was developed for use in the reconstruction of manufacturing facilities by DuPont and the PERT (Program Evaluation and Review Technique) to be used with the Polaris submarine nuclear program by the Office of Special Projects of the Navy Department and consulting firm Booz Allen Hamilton.

For Peinado and Graeml (2007) in the PERT system the deadlines for accomplishment and completion of the tasks are treated probabilistically whereas in the CPM system the deadlines for accomplishment of the tasks are treated deterministically.

According to the same author, the difference between the two methods is currently irrelevant, since the characteristics that previously differentiated them were incorporated from one technique to another so that there were no practical

advantages to consider as two different systems. Due to this integration it is currently referred to by the PERT / CPM system indistinctly.

2.2. PERT / CPM network model

The PERT / CPM method is a technique used for the planning and control of projects, where the use of this method in the production scheduling is applied to the study of unique products, with the purpose of determining how long it is possible to finish the project (Martins; Laugeni, 2005).

According to Cox III and Schleier (2013), a project is defined by a series of activities, once all the activities are identified, it is possible to represent them through a project network. The project network organizes the tasks so as to be clear logical precedence, which shows whether the activity should be preceded or followed by one or more activities (Cox III; Schleier, 2013).

For Martins and Laugeni (2005, p. 420) the main phases for the elaboration of the project network are: Define the project (beginning and end); Divide the project into activities; Identify the sequence logic that exists between the activities (which depend on another (s) and which does not show dependence on each other); Build the project network; Determine the duration of each activity; Determine the amount and type of resource needed to develop the activity; Determine the cost of each resource; Determine the critical path; And Elaborate the schedule for project programming.

For Cox III and Schleier (2013), designing a project network is simple, but all the activities and dependencies (legal requirements, finances, sales, human resources) needed to complete the project objectives should be included. The steps are: First, ask yourself: "What are the activities of the project?". Subsequently, one wonders: "Which one comes first? Which one comes next? What can be done simultaneously if sufficient resources are available?" (Cox III and Schleier, 2013).

According to Tubino (2007), a network is formed by an interconnected set of arrows and nodes, the arrows represent the activities of the project that consume time / resource, and the nodes represent the start and end time of the activities which are called event.

There are two methods for describing the PERT / CPM technique, the French method, and the American method. The American method is recommended for manually elaborated networks, since its use is easier, in this method the times and the slots linked to each event are calculated and their representation is by means of arrows, where the arrows indicate the sequence of activities (Ávila, 2010).

In the French or Roy network, nodes are represented by blocks, which specify the name of the activity, time and total slack, the arrows indicate only the priority among activities, in this format, it is recommended to characterize the initial event And final by means of an initial and an end block (Ávila, 2010).

2.3. Development of a PERT / CPM network

Any planning network is constituted according to its activities, its dates, its duration, regardless of the adopted time of each activity (minutes, days, weeks, months), it is important to maintain the compatibility between the units of the same network Of planning (Avila, 2010).

In the use of the CPM method, a single duration is determined for each activity, where in the sequence the critical path algorithm is applied. In both models, American and French, the methods of representation are quite similar, the rules and observations are practically the same, but in the French method the activities in the network diagram are represented by us, and in the American the activities are represented in Arrows

The rules for assembly of PERT / CPM networks are as follows (Peinado, Graeml 2007, pp. 497-500):

- Each activity will be symbolized by an arrow, with direction and direction for the next activity;
- Each activity happens between two nodes, being the start node and the end node, the nodes are represented by circles and each node has a number, in the arrows are described the activity and duration of each task;
- The arrow indicates that its start has one or more previous activities and its end indicates that there is one or several tasks following it. A task can not be started unless its precedent is completed. The arrows representing the activities constituting the project must always follow the direction and direction from left to right;
- There can not be two or more distinct tasks beginning and ending in the same step, in this case in order to maintain the individuality of each of the tasks, one must use an artifice called ghost activity, which is represented in the graph through A dotted arrow, this arrow has no duration value.

2.4. Scripting

The routing methods continue to expand in number of researches and applications, proving the importance of routing methods in organizations that seek to minimize costs and optimize the delivery times of their products, consolidating their logistics practices.

The routing process can be described as the decision that refers to the group of clients to be visited and later the schedule of visits sequencing and the restriction, where it is necessary to complete the routes with the available resources (Novaes, 2007).

The objective is to determine vehicle routes that minimize transport costs, so that the demands of all customers are met, and vehicle capacity constraints are respected (Belfordi et al., 2006). According to Cunha (2000), routing can be

characterized by n clients (represented in a transport network by us or arcs) that should be served by a fleet of vehicles, without restrictions or the order in which they should be served.

Enomoto and Lima (2007) raise the main restrictions that must be considered when performing a routing, being: size of fleet available; Type of fleet; Vehicle garage; Nature of demand; Location of demand; Characteristics of the network; Restrictions on vehicle capacity; Personnel requirements; Maximum route times; Operations involved; Costs and objectives.

3. Methodology

The research strategy adopted was the case study, where according to Freitas and Jabbour (2011) such strategy aims to gather detailed and systematic information about the facts. According to Andrade (2010) in this type of strategy, the facts are observed, recorded, analyzed, classified and interpreted without the influence of the researcher.

The present article is considered descriptive and the approach to the problem can be considered qualitative, since it has the purpose of describing a situation and its main objective is the interpretation of events (Freitas Jabbour, 2011).

The team chose the mode of road transport, using a popular vehicle to carry out the chosen routes and then the assembly of the network graphics applying the calculations necessary to highlight the routes with the smallest and longest time.

4. Results

4.1 Routes

In order to identify the routes, we used the google maps software to allow a better view of the routes to be traversed from the starting point, the Ver-o-Peso Market, to the end point of the Estácio Belem institution. In images 1 we can see routes Chosen. Seeking accuracy in the results, the team performed the data collection on Monday (11/23/2015) from 14:00 to 15:00.



Figure 1 First route chosen. Source: Authors (2015).

By collecting the time of the signs and time of each section of the routes, we can assemble the network of routes to perform the calculations and thus reach the objective of this work.

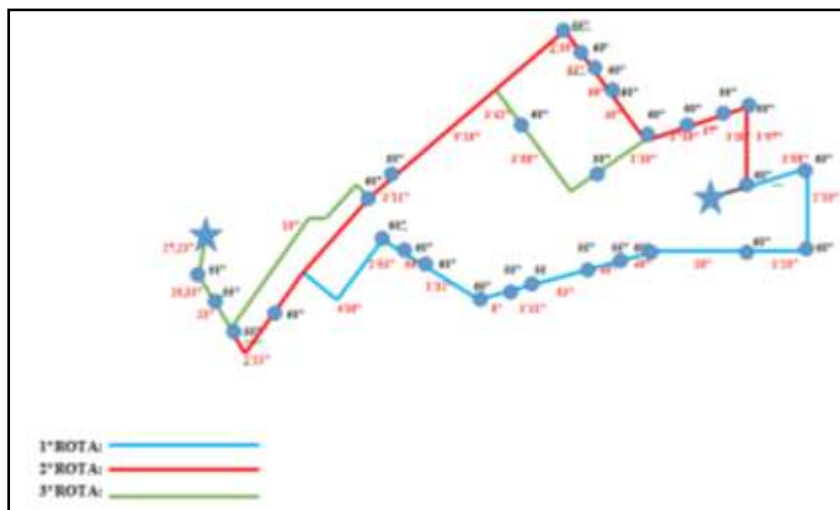


Figure 2 Network with route signs. Source: Authors (2015).

4.2 Shortest Path

Table 1. Time taken by route 1

Route 1	
Stretch ' "	50% Signal Time "
00:25	00:27,5
00:17	00:27,5
00:18	00:25

02:20	00:30
04:35	00:30
02:53	00:30
00:56	00:30
01:32	00:30
00:08	00:27,5
01:31	00:27,5
00:58	00:27,5
00:45	00:27,5
00:49	00:27,5
00:38	00:30
01:20	00:30
02:10	00:30
01:08	00:27,5
01:50	00:30
0:05	00:00
TOTAL:	25',37''

Source: Authors (2015).

Table 2. Time taken by route 2

Route 2	
Stretch ' "	50% Signal Time ' "
00:30	00:27,5
00:22	00:27,5
00:18	00:25
02:03	00:30
05:06	00:30
03:11	00:25
05:25	00:27,5
02:35	00:30
00:53	00:30
00:59	00: 30
00:45	00: 30
01:01	00: 30
00:12	00:27,5
01:30	00:27,5
00:40	00:30
00:50	00:30
00:07	00:00
TOTAL:	28':05''

Source: Authors (2015).

Table 3. Time taken by route 3

Route 3	
Stretch '	50% Signal Time''
00:27	00:27,5
00:22	00:27,5
00:33	00:25
00:18	00:25
05:24	00:30
03:42	00:25
03:58	00:27,5
01:30	00:30
00:40	00:30
01:12	00: 30
01:20	00: 27,5
01:37	00: 30
01:24	00:30
00:06	00:00
TOTAL:	23':60''

Source: Authors (2015).

5. Conclusion

The study through the assembly and calculations of the PERT / CPM network, found that route 03 is faster. Being able to help the driver to arrive faster in the final destination, which in this case was Estácio de Belém college.

The PERT / CPM technique facilitates the production management, since through the application it is possible to carry out the planning and monitoring of the project, in order to allocate the available resources in order to guarantee the completion date of the project.

References

- Andrade, Maria Margarida de. Introdução à metodologia do trabalho científico. 10. ed. São Paulo: Atlas, 2010.
- Avila, Antônio Victorino. O método PERT/CPM. Santa Catarina, 2010. Disponível em <http://pet.ecv.ufsc.br/arquivos/apoio-didatico/ECV5318%20-%20Planejamento_cap06.pdf>. Acesso: 22 nov.2015.
- Cox III, James F.; Schleier, John G. Handbook da teoria das restrições. Tradução Beth Honorato. Porto Alegre: Bookman, 2013. 1206 p.

- Cunha, C. B. Aspectos Práticos da Aplicação de Modelos de Roteirização de Veículos a Problemas Reais. *Transportes*, v. 8, n.2, 2000. pp. 51-74.
- Enomoto, L. M. Análise da distribuição física e roteirização em um atacadista do Sul de Minas Gerais. 2005. 141 p. Dissertação (Mestrado) – Programa de Pós-Graduação em Engenharia de Produção, Universidade Federal de Itajubá – UNIFEI, Itajubá. 2005.
- Freitas, Weley R. S.; Jabbour, Charbel J. C. Utilizando estudo de caso(s) como estratégia de pesquisa qualitativa: boas práticas e sugestões. *Estudos e debates*. Lajeado, v. 18, n. 2, p. 07-22, 2011.
- Martins, Petrônio Garcia; Laugeni, Fernando P. *Administração da produção*. 2. ed. São Paulo: Saraiva, 2005. 562 p.
- Novaes, A. G. *Logística e gerenciamento da cadeia de distribuição: estratégia, Operação e avaliação*. 3. ed. Rio de Janeiro: Elsevier, 2007.
- Peinado, Jurandir; graeml, Alexandre Reis. *Administração da produção: operações industriais e de serviço*. Curitiba: Unicenp, 2007. 750 p.
- Tubino, Dalvio Ferrari. *Planejamento e controle da produção: teoria e prática*. São Paulo: Atlas, 2007. 190p.

Lean Manufacturing and Lean Accounting Cost: An analysis of performance in Open Capital Companies on Bovespa

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Abstract: Lean accounting is not simply applying lean principles to accounting function. It is to use accounting methods and practices that can support lean thinking. The target of this paper is an analysis of Lean Accounting through of the companies that implemented the Lean manufacturing. The following companies were analyzed: Embraer, Whirlpool, BR Foods and Braskem. The data was gathered from the Balance Sheet of the companies and a questionnaire was used in the companies Whirlpool and Braskem to identify how deep the companies implemented lean production. After the adoption of the "Lean", improvements in the control and reduction of waste were evidenced, however, raised inventory levels.

Keywords: Lean Production; Lean Cost; Bovespa.

1. Introduction

With the publication of the bestsellers "The Machine That Changed the World" and "Lean Thinking" (James Womack, Daniel Jones and Daniel Roos in the 1990s) there was a real "treasure hunt" for popularizing these foundations, where the North American companies began to spread this culture and the implementation of this system. In the late 1990s, Brazilian companies agreed to this trend of

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productivity and productive control. Jusko (2007) understands that lean accounting is not simply applying lean principles to accounting function. It is to use accounting methods and practices that can support lean thinking and show clearly and simply how lean changes affect operational and financial performance and add value to the customer.

2. Objectives

This paper has targeted a field much explored nowadays, Lean Accounting through of the companies that implemented the philosophy of the Lean manufacturing. The Companies inside this dynamic environment, adopted strategies targeting their own survival and being efficient.

3. Methods

The following companies were analyzed: Embraer, Whirlpool, BRFoods and Braskem, leaders in their segment from 2005 to 2015 and that had implemented Lean Manufacturing in this period. In this model of management were gathered data from the Balance Sheet of the companies that adopted Lean Thinking and in this case were placed in focus these companies for the analysis of the proposed objective. A questionnaire was used in the companies Whirlpool and Braskem to identify how deep the companies implemented lean production, the influence on available stocks after adoption of the system, financial influence on results, complication factors and a view of the accounting system adopted.

4. Results

Data captured at the Securities and Exchange Commission indicate that at Embraer net income rose from 7% to 8%, while in Whirlpool it rose from 8% to 9%, BRFoods jumped from 3% to 7% and Braskem's net income rose From 1% to 3%. Regarding the level of inventories, all companies registered an increase between 144 to 252%. The questionnaires applied at Whirlpool indicates the presence of 80% of the necessary conditions for the Lean Inclusive Culture, however, it was found difficult to keep inventory levels low due to machine set-up and over-regulation. At Braskem, the problems encountered are similar and there was an unbalance between customer orders and production supplies, causing excessive returns.

5. Conclusion

After the adoption of the "Lean", improvements in the control and reduction of waste were evidenced, however, the Brazilian labor legislation makes it difficult to adopt the "Lean" culture, since there is no flexibility for the demand seasonality, making the labor costs offset by high production rates, which raise inventory levels.

References

Jusko, J (2007) Accounting for lean tastes. Industry Week.
<http://www.industryweek.com/software-amp-systems/accounting-lean-tastes>

Systematic literature review and a technology mapping of Industrie 4.0

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Abstract: A new conception proposes a rapid transformation of industries through the Internet of Things, resulting in a worldwide trend in advanced manufacturing countries called Industrie 4.0. However, there is no generally accepted definition of design principles, technological aspects and scenarios in the context of Industrie 4.0. Therefore, based on a systematic literature review, this work aimed to describe the concept of Industrie 4.0 and to develop a technological mapping of the sector, identifying the main challenges to be overcome especially in Brazil. The results have shown that the basis for Industrie 4.0 is the Cyber-Physical-System and Big Data, IoT, Cyber Security and Intelligent Robotics are the main technologies. Therefore, a clear definition of Industrie 4.0 have to englobe technologies and principles in the value chain of the organization.

Keywords: Industrie 4.0; Design Principles; Technology Mapping.

1 Introduction

The Internet of Things (IoT), in which people, processes and products are part of the same system, led to the emergence of Industrie 4.0, where similarly supply, manufacturing, delivery and customer are connected in real time. The term Industrie 4.0 emerged from the report of the Industry-Science Research Alliance group that was presented to the German Chancellor and launched at the Hannover Messe in 2013. Although there are new solutions arising from the fields of the IoT

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and Industrie 4.0, a clear definition of the multiple aspects and perspectives of Industrie 4.0 is not observed, especially in scientific literature. Therefore, systematic reviews are important tools in providing evidence for decision making in Industrie 4.0 practices and to enable further investigation on the topic by academic community.

2. Objectives

This work aimed to describe the concept and principles of Industrie 4.0 and to develop a technology mapping, identifying the main challenges to be overcome, especially in Brazil, in the context of the fourth industrial revolution.

3. Methods

A systematic literature review was conducted to identify the principles and concept of Industrie 4.0, in order to be able to develop a technology mapping and to analyze potential challenges of implementation, especially in Brazil. The following academic databases were used: Web of Knowledge, Scopus and SAGE Journals and main research fields included Engineering, Advanced Manufacturing, Production Technology, Cyber-Physical-Systems and Cloud Computing.

4. Results

Findings have shown that the basis for Industrie 4.0 is the Cyber-Physical-System and the main technologies: Big Data, IoT, Cyber Security, Intelligent Robotics, Industrial Automation, Visual Computing and Product Life Cycle Management. The requirements demanded indicate that the integrated systems being developed should meet six main principles: Interoperability, Virtualization, Decentralization, Real-time capacity, Service orientation, and Modularity. Therefore, a potential clear definition of Industrie 4.0 have to englobe technologies and principles in the value chain of the organization. A challenge for Brazil is that in addition to seeking the incorporation and development of technology, it needs agility to avoid a productive delay in relation to other countries.

5. Conclusion

Studies geared toward the grouping and analysis of information about Industrie 4.0 are becoming a facilitating factor to guide organizations to optimize many aspects of a industrial successful business. Furthermore, academic community may be empowered to investigate further on the topic because the term is still used in different contexts and lacks an explicit definition. This study suggest a potential clear definition of Industrie 4.0 considering it's technologies and principles.

References

- Shafiq SI, Sanin C, Szczerbicki E, Toro C (2015) Virtual Engineering Object/Virtual Engineering Process: Aspecialized form of Cyber Physical System for Industrie 4.0. *Procedia Computer Science*
- Herman M, Pentek T, Otto B (2015) Design principles for Industrie 4.0 scenarios. Technical University of Dortmund, Faculty of Engineering, Audi Endowment Chair Supply Net Order Mana

A Fuzzy AHP Approach to Support Decision Taking for Selecting Wheat Suppliers in the State of Paraná

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Abstract This paper aims to create an approach to support decision taking in the wheat trading's department of an agribusiness company located in Brazil. The main problem faced by the firm is selecting the suppliers. In order to solve it, the Fuzzy AHP method, an evolution of the AHP, was used. After the implementation of the method, it was possible to notice that the criterion with greatest weight was access to modes of transportation (31.21%) and the new supplier partner, located in the north-central region of Paraná, received the main priority, 27.86%.

Keywords: Supply Chain; Facility Location; Warehouse; Fuzzy AHP

1. Introduction

Once established in Brazil, the company being analysed decided to adopt a strategy called blitzscaling to become bigger and acquire a greater slice of the agricultural commodities trading market share. According to Sullivan (2016), such strategy is used by companies that wish to accelerate their growth by offering better services than their competitors. On the other hand, when a firm adopts blitzscaling, it may face several inefficiencies due to the high volume of operations. One problem of this approach is that the strategic planning may be deficient, causing loss of sales opportunities and problematic relationship with suppliers and clients.

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The company does not count with its own warehouse network in the state of Paraná, it owns only one located in Ponta Grossa, metropolitan region of Curitiba. Therefore, it depends exclusively of public and private warehouses distributed all over the state. Also, a well-structured process to make decisions does not exist in the department responsible for wheat trading regarding what suppliers to select in the next harvest season. Such decision is strategic, which may guarantee a competitive advantage over its competitors, and help to reduce transportation and storage costs.

Thus, the advantages of using a multi-criteria method to support decision making in this context are clearly seen. The approach proposed in this paper uses the Analytic Hierarchy Process (AHP) adding the fuzzy logic in the pairwise comparisons. It is believed that the Fuzzy AHP method minimizes the subjectivity inherent in decision takers (Kahraman *et al.*, 2008).

This paper aims to create an approach, through the implementation of the Fuzzy AHP method, to support the decision-making process to select wheat suppliers in the firm studied. Microsoft Excel software was used for the pairwise comparisons and to calculate all parameters needed.

2. Literature Review

In this literature review, three concepts that are important to provide an overview about the topics covered in this paper are mentioned: supply chain, warehousing and storage, and decision analysis.

According to Novaes (2015), supply chain is an evolution of logistics that adds value of place – when the product arrives to its consumer -, time – the product is delivered on the correct schedule -, quality – the product is free of flaws - and information – traceability of the product. Chopra and Meindl (2011) cite that a supply chain is, usually, composed of five actors: clients, retailers, wholesalers or distributors, manufacturers and suppliers of raw material. Companies, frequently, have several products on their portfolio that are sold to different clients, and each one requiring different suppliers. Therefore, one can notice a supply net instead of a single chain. Although each company has its own network configuration, they are organized to achieve two goals, to meet consumer demand and, consequently, its satisfaction. As concepts evolve, Ballou (2010) started to discuss the supply chain management, in which activities of this field interact with other functional departments. The author mentions that an effective supply chain management is a competitive advantage over competitors. It may also reduce logistics costs, and increase the company market share and profits.

Warehousing is associated with the activities of storing goods, which can be raw material in suppliers and finished products in manufacturers, wholesalers or retailers. Years ago, warehouses were mainly used for keeping products stored for

a period of time. Nowadays, they are used strategically, because activities performed in them add value to manufactured goods (Bowersox *et al.*, 2014). They can be divided in four categories: company owned, independent or public, leased or network distributed – when firms use warehouses of different categories to create their network. Regarding the storage functions, Ballou (2012) describes four of them: product shelter, consolidation, transference and transshipment, and grouping.

As stated before, the supply chain management aims to optimize operations. Therefore, one can make use of Operations Research (OR) to define, observe, model complex problems and implement the results obtained to support decision making and guarantee optimal processes. Taking those steps into account, it is possible to find the best result in the context of the problem regarding its constraints, goals and parameters.

Decision analysis is a subarea of the OR field, in which authors study the aspects of the decision-making process, in which, choices are rarely done in environments where one is absolutely sure of its constituents (Hillier and Lieberman, 2013). As these uncertainties exist, problem-solving tools were developed to support companies on their everyday evaluations. They are commonly called multi-criteria decision-making methods (MCDM), which are used to solve problems with conflicting criteria and subjective judgements. Gomes and Gomes (2012) affirm that such methods aims to establish a preference scale or ranking among alternatives being evaluated/prioritized/sorted under the influence of multiple criteria. For Kahraman *et al.* (2008) some methods to solve problems with such characteristics are the AHP, ANP, TOPSIS, ELECTRE, PROMETHEE and Fuzzy AHP.

The Analytic Hierarchy Process (AHP) method was created in the 1970s by Thomas L. Saaty and has been extensively used to solve multicriteria problems since that decade. Taha (2003) points out that the goal of such method is to prioritize alternatives ranked from subjective judgements. It consists basically of five steps: problem definition; analytical hierarchy tree or diagram creation; criteria and alternatives pairwise comparisons using the numerical scale proposed by Saaty; consistence index and relation calculation to verify if the judgments can be used; and weighted vector calculation to learn the alternative with greatest priority among the options (SAATY, 2008).

According to Kahraman *et al.* (2008), the Fuzzy AHP method is an evolution of the AHP itself, in which the subjectivity and imprecision of the pairwise comparison are minimized by adding the fuzzy logic along the process. The steps are the same as the ones from AHP, the only difference is that the numerical scale is changed to a fuzzy number, which is a vector of more than one position. It can vary in format because each researcher can adapt it for many reasons (make it easier for the specialists to execute the pairwise comparisons is an example).

3. Implementing the FAHP to Select Wheat Suppliers

The methodology followed in this paper was proposed by Samed, Gonçalves and Cursi (2014). The emphasis is given in the problem adaptation to the FAHP steps presented in the previous chapter.

The problem encountered in the company was that it did not have a well-defined process or procedure to select their suppliers, making it difficult to draw strategies in the long term. Therefore, the goal was to evaluate and analyze the current situation regarding its suppliers in order to classify the most apt among them.

As the problem has been defined, the next step is to choose the criteria and the candidates or choices, in this case, the suppliers. For this analysis, it was chosen 7 criteria and 6 suppliers (all located in the state of Paraná). Table 1 and 2 describe them.

Table 1. Chosen criteria and their descriptions

Criteria Number	Description
C1	Access to transportation modes
C2	Warehouse's condition
C3	Commercial partnership
C4	Storage fee
C5	Storage capacity
C6	Proximity to wheat crops
C7	Proximity to clients

Table 2. Chosen suppliers and their descriptions

Supplier Number	Description
S1	Public warehouse
S2	Public warehouse
S3	Supplier located in the Central-West region
S4	New supplying partner
S5	Supplier located in the North region
S6	Warehouse owned by the company

The analytic hierarchy diagram is the representation of the decision that is going to be taken (upper level), taking in consideration the selection criteria (intermediate level) through the pairwise comparisons of a list of candidates or

choices, in this case, the suppliers (lower level). The diagram can be visualized in Figure 1.

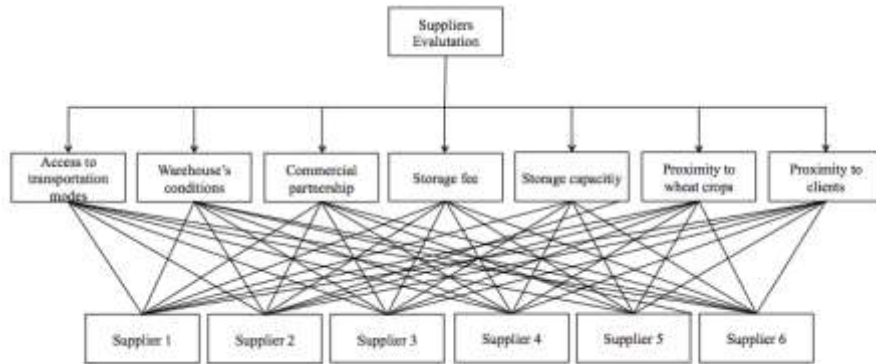


Figure 1. Analytic Hierarchy Diagram

Following the method, its next step is to define the linguistic variable and the numeric scale that it is to be used in the pairwise comparisons. In this research it was used the scale proposed by Saaty (2008), but an arrangement was made in the structure of the comparison matrices to avoid misunderstanding and minimize errors. Table 3 shows how the scale was organized.

Table 3. Linguistic variable and numeric scale

Numeric Scale	Abbreviation	Linguistic Variable
1	I	Same importance
3	IM	A has moderate importance over B
5	IF	A has strong importance over B
7	IMF	A has a very strong importance over B
9	IE	A has extreme importance over B

The FAHP method establishes that the pairwise comparisons must be made for the criteria under the main focus, and for the candidates under each criterion. In this paper, it was not possible to collect the answers from the company's specialists. Therefore, 4 complete simulations of the responses were made. Each one has 1 pairwise comparison for the criteria, and 7 candidate's evaluation under each criterion.

The matrices were built so that the specialists could fill with an X the best comparison between two criteria or candidates. After that, it was used the numeric scale shown in Table 3 to transform the X to a number. Table 4 shows the matrix layout with an evaluation completed.

Table 4. Pairwise comparison for the criteria under the main goal – First simulation

Simulation 1										
Criterion	IE	IMF	IF	IM	I	I/IM	I/IF	I/IMF	I/IE	Criterion
Access to transportation modes				3						Warehouse's condition
Access to transportation modes			5							Commercial partnership
Access to transportation modes					1					Storage fee
Access to transportation modes			5							Storage capacity
Access to transportation modes					1					Proximity to wheat crops
Access to transportation modes					1					Proximity to clientes
Warehouse's condition			5							Commercial partnership
Warehouse's condition					1					Storage fee
Warehouse's condition					1					Storage capacity
Warehouse's condition				3						Proximity to wheat crops
Warehouse's condition				3						Proximity to clientes
Commercial partnership						0.3				Storage fee
Commercial partnership					1					Storage capacity
Commercial partnership						0.3				Proximity to wheat crops
Commercial partnership						0.3				Proximity to clientes
Storage fee				3						Storage capacity
Storage fee					1					Proximity to wheat crops
Storage fee					1					Proximity to clientes
Storage capacity				3						Proximity to wheat crops
Storage capacity						0.3				Proximity to clientes
Proximity to wheat crops					1					Proximity to clientes

Using the equations found in Taha (2003), it was possible to calculate the consistence index (IC) and the consistence relation (RC). To do so, firstly, the comparisons with the same characteristics (4 simulations for the criteria, 4 simulations for the candidates under the first criterion and so on) were arranged in a single table and the average number of each pairwise evaluation was found. Taha (2003) specifies that the RC must be less than 10% or 0.1. In this study, it was found that all evaluations have an RC smaller than 10%, so, it is possible to start the next step, which is the fuzzification.

The fuzzification consists of transforming the pairwise comparisons in a fuzzy number. In this case, it was created a fuzzy triangular number. The first position of such vector was the minimum value, the second position was the average and the third one was the maximum value of the comparisons. It was elaborated eight fuzzy matrices, the first one for the criteria, shown in Table 5, and the other ones for the candidates evaluated under each criterion.

Above the (1, 1, 1) diagonal, the fuzzy number originates from the minimum, average and maximum value from the pairwise comparisons. Under the (1, 1, 1) diagonal, it is necessary to use the number from the transposed cell with the following format:

$$(1/\text{maximum}, 1/\text{average}, 1/\text{minimum}) \quad (1)$$

Table 5. Fuzzy matrix for the criteria evaluation

	C1	C2	C3	C4	C5	C6	C7
C1	(1, 1, 1)	(3, 4, 5)	(3, 4, 5)	(1, 1.5, 3)	(5, 5.5, 7)	(1, 3, 5)	(1, 1.5, 3)
C2	(0.2, 0.25, 0.33)	(1, 1, 1)	(0.33, 2.83, 5)	(0.33, 0.5, 1)	(1, 2, 3)	(3, 4, 5)	(1, 2.5, 3)
C3	(0.2, 0.25, 0.33)	(0.2, 0.35, 3)	(1, 1, 1)	(0.33, 0.67, 1)	(0.2, 1.63, 5)	(0.33, 1.17, 3)	(0.2, 0.63, 1)
C4	(0.33, 0.67, 1)	(1, 2, 3)	(1, 1.5, 3)	(1, 1, 1)	(3, 3.5, 5)	(1, 1, 1)	(0.2, 0.47, 1)
C5	(0.14, 0.18, 0.2)	(0.33, 0.5, 1)	(0.2, 0.61, 5)	(0.2, 0.29, 0.33)	(1, 1, 1)	(1, 1.5, 3)	(0.2, 0.47, 1)
C6	(0.2, 0.33, 1)	(0.2, 0.25, 0.33)	(0.33, 0.86, 3)	(1, 1, 1)	(0.33, 0.67, 1)	(1, 1, 1)	(0.2, 0.63, 1)
C7	(0.33, 0.67, 1)	(0.33, 0.4, 1)	(1, 1.58, 5)	(1, 2.14, 5)	(1, 2.14, 5)	(1, 1.58, 5)	(1, 1, 1)

The next step was to find the aggregation vector, which has three positions as the fuzzy triangular number and is calculated by the geometric average of each position from the fuzzy matrices. After that, it was possible to start the defuzzification process, which consists of producing a crisp number from the fuzzy number. The column called “Weights – Fuzzy” was obtained by the division of each cell by the total sum of the correspondent vector position from the “Aggregation” column. The calculation to find the crisp number is the average of the rows from the column “Weights – Fuzzy”. In this case, the most important criterion is the first one (access to transportation modes) with 31.21% of the preference. Table 6 presents the results obtained from the steps explained.

Table 6. Aggregation and defuzzification of the fuzzy matrix for the criteria evaluation

	Aggregation			Weights - Fuzzy			Weight - Crisp
	<i>l</i>	<i>m</i>	<i>u</i>	<i>l</i>	<i>m</i>	<i>u</i>	
C1	1.72	2.49	3.60	0.35	0.31	0.27	0.3121
C2	0.68	1.32	1.85	0.14	0.17	0.14	0.1482
C3	0.29	0.69	1.47	0.06	0.09	0.11	0.0857
C4	0.79	1.18	1.72	0.16	0.15	0.13	0.1470
C5	0.32	0.53	1.00	0.07	0.07	0.08	0.0693
C6	0.37	0.61	1.00	0.07	0.08	0.08	0.0755
C7	0.73	1.17	2.51	0.15	0.15	0.19	0.1621
Soma	4.91	7.99	13.16	1.00	1.00	1.00	1.00

It is important to mention that the step stated before is also made for all suppliers' evaluations. To find the weight for each supplier, the calculation consists of the sum of products from the suppliers weight under each criterion by the correspondent criterion. The results of the suppliers' weight can be visualized in Table 7.

Table 7. Aggregation and defuzzification of the fuzzy matrix for the criteria evaluation

Ranking	Supplier	Weight
1	S4	27.86%
2	S6	27.71%
3	S2	20.78%
4	S5	11.00%
5	S1	7.34%
6	S3	5.31%

5. Conclusions

The AHP method has been extensively used in helping the decision-making process in many companies. An evolution of this method came up after researchers notice that the evaluations may be very subjective and biased, so the fuzzy logic was added to the AHP, creating then the FAHP method. The main advantage of it is that it minimizes the bias inherit in decision takers (managers, specialists).

The FAHP method was adapted to the problem being analyzed and arrangements in the way that the pairwise comparisons happen were made, in order to make it easier for the specialists to answer them. As it was not possible to collect the responses from the company's specialists, the plan was to create four complete simulations of the evaluations. This is the first step to make sensitivity analysis, in which the responses are changed to check the system's behavior.

It is possible to say that the results from the implementation are satisfactory in the company's context. The criterion with greatest weight was access to modes of transportation (31.21%) and the best supplier was the new supplying partner (27.86%). It is recommended for future work, to add new criteria or suppliers to check the system's behavior and make the analysis more faithful to reality.

References

- Ballou, R.H. (2010) Gerenciamento da cadeia de suprimentos/logística empresarial. 5th edn. São Paulo: Bookman.
- Ballou, R.H. (2012) Logística empresarial: Transportes, administração de materiais e distribuição física. São Paulo: Atlas.
- Bowersox, D.J. et al. (2014) Gestão logística da cadeia de suprimentos. 4th edn. Porto Alegre: AMGH.
- Chopra, S. and Meindl, P. (2011) Gestão da cadeia de suprimentos: estratégia, planejamento e operações. 2011th edn. São Paulo: Pearson Prentice Hall.
- Gomes, L.F.A.M. and Gomes, C.F.S. (2012) Tomada de decisão gerencial: enfoque multicritério. 4th edn. São Paulo: Atlas.
- Hillier, F.S. and Lierberman, G.J. (2013) Introdução à pesquisa operacional. 9th edn. Porto Alegre: AMGH.
- Kahraman, C. et al. (2008) Fuzzy multi-criteria decision making. New York: Springer.
- Novaes, A.G. (2015) Logística e Gerenciamento da cadeia de suprimentos. 4th edn. Rio de Janeiro: Elsevier.
- Saaty, T.L. (2008) 'Decision making with the analytic hierarchy process', International Journal Of Services Sciences, 1(1), pp. 83–98.

- Samed, M.M.A., Gonçalves, M.B. and Cursi, J.E. de S. (2014) 'Logística humanitária: uma abordagem AHP-FUZZY para a localização de centrais temporárias', Santander: PANAM.
- Sullivan, T. (2016) 'Blitzscaling', Harvard Business Review.
- Taha, H.A. (2003) Operations research: An introduction. 6th edn. Upper Saddle River: Prentice Hall.

Approach of Information Systems Applied to Reverse Logistics

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Abstract Reverse logistics is a term that has been taking a great interest in recent years due to the need introduced by the government and society to have companies more responsible with waste and environment impact. At the same time, technologies and computer applications are a key issue for the supply chain management, therefore this work addresses the research of both matters, to determine the trend of these subjects up to now.

Keywords: Computer technologies, reverse logistic, software system, return management, reverse supply chain management.

1. Introduction

One of the first descriptions of Reverse Logistic (RL) was given by Lambert and Stock in 1981. They described the reverse logistic as “going the wrong way on a one-way street”. Murphy and Poist defined reverse logistic as “the movement of goods from a customer towards a producer in a channel of distribution” (Murphy and Poist 1989). Dekker defines reverse logistic as the integration of used and obsolete products again to the supply chain as valuable resources (Dekker et al 2004). A more recent concept by Srivastava, defines RL as “the process of planning, implementing, and controlling the efficient, effective inbound flow,

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inspection and disposition of returned products and related information for recovering value” (Srivastava 2008). Fleischmann et al. (1997), includes all the logistic activities starting from the used products no longer required to products again usable in the market, involving the physical transportation of used products from the end user back to the producer’s facility where the transformation process is carried out. Based on the definitions mentioned before, the different authors agreed that RL is an inverse flow that includes the movement of goods from the customer back to the manufacturer, where through different activities the goods are made valuable again or disposed.

Reverse logistic plays an important role in the current supply chains. According to Rogers and Lembke (2001), reverse logistic can help reduce costs and also increase revenue, and in some cases can even be strategic, making a firm more competitive by reducing the customer’s risk when buying a product, because the product can be returned easily. Yoo and Park (2008) state the activities involved in reverse logistic, those activities are represented in figure 1:

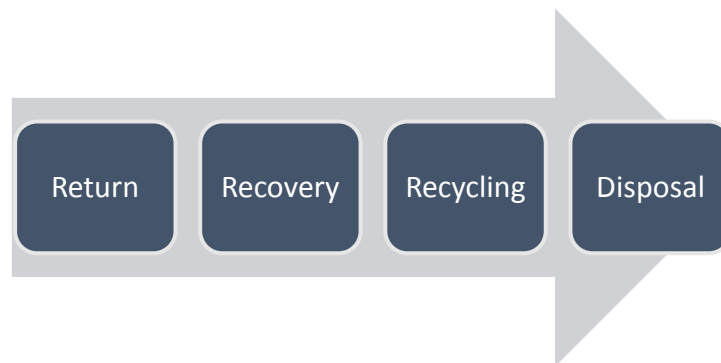


Figure 1. Reverse Logistic Process

Furthermore, new technologies are being used to improve operational, tactical and strategical aspects in reverse logistic. The main goal of this work is to make a scientific investigation in different databases and analyze the results of the different technologies and computer systems applied to reverse logistics, as well as, trends, methodologies and challenges identified due to these new technologies.

2. Methodology

The terms used to find the articles related to the research topic were: “Computer technologies and applications”, “reverse logistic”, “software system”, “return management”, “reverse supply chain management”. The search was made in Spanish and English to expand the results and the databases used were: Google Scholar, Science Direct, IEEE Xplore, Polibuscador, Scopus and Web of Science.

3. Search Results

Table 1 shows the results of the general search. The results have been classified by source (database) and publication year. IEEE Xplore was the source where more results were obtained related to the keywords.

Table 1. Search results by term and source

Search terms	Google	Science	IEEE	Polibusca	Scopus	Web of
	Scholar	Direct	Xplore	dor	T/KW/A	Science
	All fields	T/KW/A	T/KW/A	All fields	T/KW/A	Topic
"computer technology" and "reverse logistic"	39	0	45	7	1	14
"software system" and "reverse logistic"	38	0	39	5	3	39
"computer technologies and applications" and "reverse logistic"	0	0	9	0	0	3
"computer application" and "reverse logistic"	10	0	16	20	3	15
"reverse logistic software"	0	0	61	0	0	77
"data processing system" and "reverse logistic"	1	0	50	1	0	62
"software system" and "return management"	41	56	372	4	37	307
"computer technology" and "reverse supply chain management"	14	4	17	2	1	5
"computer applications" and "reverse supply chain management"	14	0	3	2	1	6
"computer technologies and applications" and "logistic"	1	8	761	10	0	140

Notes: T=Title / KW=Keywords / A=Abstract

In order to have a graphical vision of this information figure 2 shows a map of these relationships with the total number of articles found.

Figure 3 shows the year of publication of these papers. The interest for this topic rose significantly from 2007 and today the interest is maintained. The highest number of publications was in 2010.

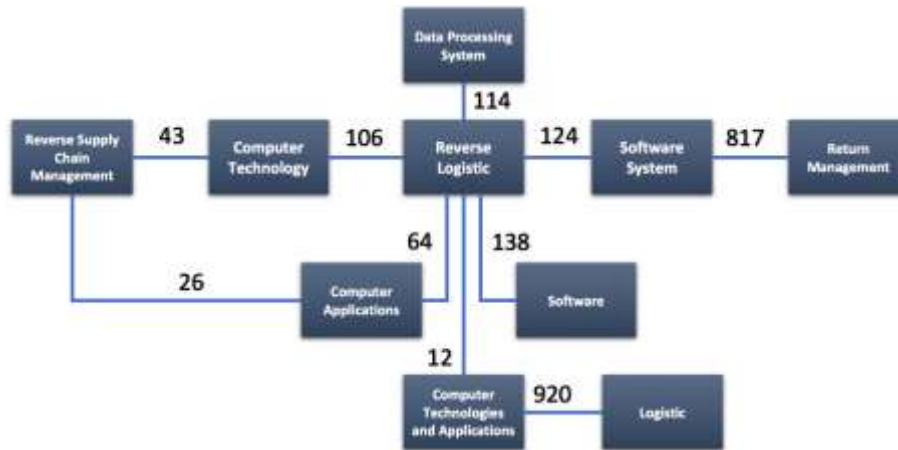


Figure 2. Map of term relationships.

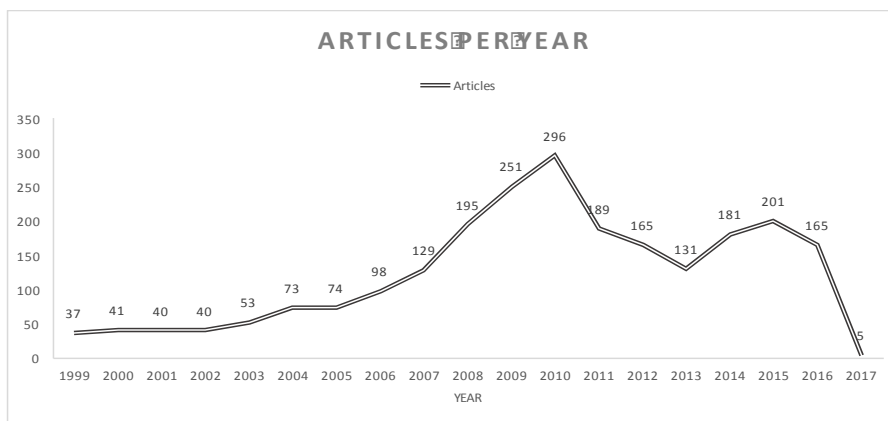


Figure 3. Articles grouped per year.

4. Classification and Analysis

To go deeper into the topic, the papers include in the Table 2 were analysed. The criteria considered for their inclusion were: abstract of the article (highly related to the topic), number of citations, and year of publication. The articles have been classified by author, year, type of technology used and phases of reverse logistic.

Table 2. Type of technology and phases of reverse logistic by Author

Author	Year	Type of technology / tools	Phases of RL
Daniel, V., Guide Jr, R., & Jayaraman, V.	2000	ERP	Return, Recovery
Kokkinaki, A., Zuidwijk, R., van Nunen, J., & Dekker, R.	2004	ICT, PDM, EDL, Ecotools, ERP	Return, Recovery
Richey, R. G., Chen, H., Genchev, S. E., & Daugherty, P. J.	2005	ND (Outsourcing RL)	Return, Recovery, Recycling, Disposal
Rajiv K. Srivastava & Samir K. Srivastava	2006	MILP model	Return, Recovery
Jihyun Yoo & Yongjin Park	2008	RFID, Middleware	Return, Recovery, Recycling, Disposal
Trappey, A. J., Trappey, C. V., & Wu, C.-R.	2010	Fuzzy cognitive map model, RFID	Return, Recovery, Recycling, Disposal
Oloruniwo, F. O., & Li, X.	2011	ERP, EDI, Internet, Satellite, RFID, WMS, TMS	Return, Recovery, Recycling
Huscroft, J. R., Hazen, B. T., Hall, D. J., & Hanna, J. B.	2013	MILP	Return, Recovery, Recycling, Disposal
Oltra R., Gil, H., Bellver, R., Asensio S.	2013	ERP	Return, Recovery
Cortes,P., Boza, A., Cuenca, L.	2014	Internet of Things RFID	Return, Recovery, Recycling, Disposal
Musa, A., Gunasekaran, A., Yusuf, Y., & Abdelazim, A.	2014	RFID, GPRS, GPS, Middleware	Return, Recovery, Recycling, Disposal
Govindan, K., Soleimani, H., & Kannan, D.	2014	ND (mathematical programming)	Return, Recovery, Recycling, Disposal
Filip, F. G., & Duta, L.	2015	Cloud computing, big data, Cyber physical systems	Return, Recovery, Recycling, Disposal
Wood, L. C., Reiners, T., & Pahl, J.	2015	MLIS, ERP, RFID, WMS, TMS, GPS, APS	Return, Recovery, Recycling, Disposal
Shaharudin, M. R., Govindan, K.,	2015	ERP	Return

Author	Year	Type of technology / tools	Phases of RL
Zailani, S., & Tan, K. C.			
Urbanke, P., Kranz, J., & Kolbe, L.	2015	MILP	Return
Sirisawat, P., Kiatcharoenpol, N., Choomrit, N., & Wangphanich, P.	2015	MILP	Return, Recovery, Recycling, Disposal
Chen, H., Daugherty P. J., Jones L. A.	2016	S-D logic, externally develop customizable software	Return
Heilig, L., Hofer, J., Lessmann, S., Voß, S.	2016	Cloud-based Forecasting support system	Return
Alandi Pajares, A.	2016	Internet of Things	Return, Recovery, Recycling
Hong, I. H., Assavapokee, T., Ammons, J., Boelkins, C., Gilliam, K., Oudit, D., Realf, M.J., Vannicola, J.M., Wongthatsanekorn, W.	2016	MILP Model, CPLEX, MS- Access, Visual Basic	Return, Recovery, Recycling, Disposal

Notes: RL=Reverse logistics / ND=not determined

As can be seen in table 2, many technologies and tools are used to address the processes involved in reverse logistics, there is clearly not a specific software, model or tool used to deal with the different processes within the reverse logistics therefore companies and researchers propose to combine and adapt current technologies and tools to be capable of solve the issues in RL.

As result of the research it is possible to highlight that:

- ERP and RFID technologies appear as important tools used in RL.
- MILP, and as a consequence, the software solver engine.
- New proposals in the last years around Cloud and IoT.

5. Conclusions

The research provides a content analysis of articles related to information systems applied to reverse logistics. An overview of the interest in the topic is presented, as well as the different technologies and mathematical tools that are being implemented nowadays to solve the different processes within Reverse Logistics. Also, it is provided a reference guide that could work as support for other researchers.

A challenge of this research has been that applications and computer technologies are presented in a very different way in the reverse logistics literature. Often, the information found was limited or general about information systems.

Based on the investigation it could be noticed that there is no software exclusively design for reverse logistics management, but there are different tools and systems

to address different processes separately that could be of great use to accomplish a better reverse logistics management.

The biggest challenges facing reverse logistics and some of the reasons why it has not been possible to design a specific software for this area are, the high cost of some of the technologies needed for the implementation, the standardization, and the uncertainty in the different processes involved in reverse logistics.

References

- Alandi Pajares, A. (2016). Internet de las Cosas, en las redes Logísticas de la Cadena de Suministro. UPV.
- Chen, H., Daugherty P. J., Jones L. A. (2016). Ensuring returns management software effectiveness through joint development orientation. *Transportation Journal*, Volume 55, Number 1, pp. 1-30.
- Cortes, P., Boza, A., Cuenca, L.(2014) Internet de las cosas en el ámbito de la Logística Inversa. *Book of Proceedings of the 8th International Conference on Industrial Engineering and Industrial Management – XVIII Congreso de Ingeniería de Organización – XX International Conference on Industrial Engineering and Operations Management – International IIE Conference 2014*.
- Daniel, V., Guide Jr, R., & Jayaraman, V. (2000). Product acquisition management: current industry practice and a proposed framework. *International Journal of Production Research*, 38(16), 3779-3800.
- Dekker, R., Fleischmann, M., Inderfurth, K. and Was- Senhove L.N.V. (2004). *Reverse logistics: Quantitative models for closed-loop supply chains*, Springer.
- Filip, F. G., & Duta, L. (2015). Decision Support Systems in Reverse Supply Chain Management. *Procedia Economics and Finance*, 22, 154-159.
- Fleischmann, M., Bloemhof-Ruwaard, J. M., Dekker, R., van der Laan, E., van Nunen, J. a. E. E., & Van Wassenhove, L. N. (1997). Quantitative models for reverse logistics: A review. *European Journal of Operational Research*, 103(1), 1–17. [https://doi.org/10.1016/S0377-2217\(97\)00230-0](https://doi.org/10.1016/S0377-2217(97)00230-0)
- Govindan, K., Soleimani, H., & Kannan, D. (2014). Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future. *European Journal of Operational Research*, 240(3), 603-626.
- H. Hong et al. (2016, July). Planning the e-Scrap Reverse Production System Under Uncertainty in the State of Georgia: A Case Study in *IEEE Transactions on Electronics Packaging Manufacturing*, vol. 29, no. 3, pp. 150-162.
- Heilig, L., Hofer, J., Lessmann, S., & Voß, S. (2016). Data-driven product returns prediction: a cloud-based ensemble selection approach. *ECIS 2016 Proceedings at AIS Electronic Library*
- Huscroft, J. R., Hazen, B. T., Hall, D. J., & Hanna, J. B. (2013). Task-technology fit for reverse logistics performance. *The International Journal of Logistics Management*, 24(2), 230-246.

- Kokkinaki, A., Zuidwijk, R., van Nunen, J., & Dekker, R. (2004). Information and communication technology enabling reverse logistics. In *Reverse Logistics* (pp. 381-405). Springer Berlin Heidelberg.
- Lambert, Douglas M. and James R. Stock, (1981). *Strategic Physical Distribution Management*. Homewood, IL: Irwin, p.19.
- Laudon, K.C. and Laudon, J.P., (2004). *Management information systems: Managing the digital firm*. *New Jersey*, 8.
- Murphy, Paul R. and Richard P. Poist (1989). "Management of logistical Retromovements: An Empirical Analysis of Literature Suggestions. *Transportation Research Forum*, Vol.29, No. 1, 177-84.
- Musa, A., Gunasekaran, A., Yusuf, Y., & Abdelazim, A. (2014). Embedded devices for supply chain applications: Towards hardware integration of disparate technologies. *Expert Systems with Applications*, 41(1), 137-155.
- Olorunniwo, F. O., & Li, X. (2011, January). An overview of some reverse logistics practices in the United States. In *Supply Chain Forum: An International Journal* (Vol. 12, No. 3, pp. 2-9). Taylor & Francis.
- Oltra-Badenes, R. F., Gil-Gómez, H., Bellver-López, R., & Asensio-Cuesta, S. (2013). Análisis de requerimientos funcionales para el desarrollo de un ERP adaptado a la gestión de la logística inversa. *Dirección y Organización*, (49), 5-16.
- Richey, R. G., Chen, H., Genchev, S. E., & Daugherty, P. J. (2005). Developing effective reverse logistics programs. *Industrial Marketing Management*, 34(8), 830-840.
- Shaharudin, M. R., Govindan, K., Zailani, S., & Tan, K. C. (2015). Managing product returns to achieve supply chain sustainability: an exploratory study and research propositions. *Journal of Cleaner Production*, 101, 1–15. <https://doi.org/10.1016/j.jclepro.2015.03.074>
- Sirisawat, P., Kiatcharoenpol, N., Choomrit, N., & Wangphanich, P. (2015). A Study of Reverse Logistics Practices: A Case Study of the Computer Parts Industry in Thailand. *Proceedings of the 2015 IEEE IEEM*, 382–388.
- Srivastava, S. K., & Srivastava, R. K. (2006). Managing product returns for reverse logistics. *International Journal of Physical Distribution & Logistics Management*, 36(7), 524-546.
- Srivastava, SK., (2008). Network design for reverse logistics. *Omega*, 36(4), pp. 535-548.
- Trappey, A. J., Trappey, C. V., & Wu, C.-R. (2010). Genetic algorithm dynamic performance evaluation for RFID reverse logistic management. *Expert Systems with Applications*, 37(11), 7329–7335. <https://doi.org/10.1016/j.eswa.2010.04.026>
- Urbanke, P., Kranz, J., & Kolbe, L. (2015). Predicting Product Returns in E-Commerce: The Contribution of Mahalanobis Feature Extraction. *Icis*, 1–19. Retrieved from <http://aisel.aisnet.org/icis2015/proceedings/DecisionAnalytics/2>
- Wood, L. C., Reiners, T., & Pahl, J. (2015). Manufacturing and logistics information systems. *Encyclopedia of Information Science and Technology*. Hershey, PA: IGI Global.
- Yoo, J., & Park, Y. (2008). An intelligent middleware platform and framework for RFID reverse logistics. *Int. J. Fut. Gen. Comm. Netw*, 1(1), 75-82.

OR, Modelling and Simulation

Analysis of OR-Based Literature Reviews on Agri-Food Supply Chains

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Abstract The growing concern of society about food issues like food quality, safety or sustainability, has increased the OR publications related to agri-food supply chains (AFSCs). In turn, the associated literature reviews have greatly increased. It is necessary to organize this excess of information, to know where we are and where we want to go. In this context, the aim of this paper is threefold: 1) to analyze the literature reviews and the problems they addressed; 2) to conceptualize the relevant dimensions employed by the reviews to analyze and characterize the AFSCs and, 3) to identify which of their future research lines remain valid.

Keywords: Agri-food Supply Chain; Operational Research; Literature Review

1. Introduction

In recent years, the agri-food supply chain (AFSCs), which comprises the activities from production to distribution that bring agricultural and horticultural products from the farm to the fork (Ahumada & Villalobos, 2009), has gained increasing importance on the OR-based research agenda.

The public is increasingly aware of and concerned about the availability and safety of the foods being consumed (Handayati et al., 2015). Different food crisis have resulted in new legislation and regulations regarding food safety and public health, and environmental issues that make it necessary to change the design and operation of AFSCs (Tsolakis et al., 2014). Characteristics of AFSCs extremely differentiate them from other sectors (Zhang & Wilhelm, 2011) that make

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necessary to develop models including more AFSCs realistic features such as: uncertainty, risk, logistics integration, regulatory environment, quality and security (Ahumada & Villalobos, 2009).

As a starting point, we propose to organize existing knowledge by analyzing the OR literature reviews (LR) of AFSC, food supply chain and perishables, in order to make a first approximation to the state of the art in this field and to identify valid future research lines and gaps. In section 2, a descriptive analysis of the found LR and their characterization is made. Section 3 groups the dimensions employed in each LR to classify reviewed works. In section 4 the future research lines in each LR are reported, analyzing the validity of them.

2. Descriptive analysis of literature reviews

40 relevant LR were identified from 1981 to 2016. Publishing frequency suffers a growth from 2009, making that 65% of LR has been published in the last 7 years (Fig.1). Some possible causes of this increase are: the need for models' revision due to stricter regulations and closer monitoring of agri-food products (Ahumada & Villalobos, 2009), the consumers demand for healthy, fresh and cheap products (Shukla & Jharkharia, 2013) and the need for including more realistic AFSCs characteristics (Soto-Silva et al., 2016). As it can be seen in Fig. 2, ten different SC topics are addressed in the analyzed LR based on OR models.

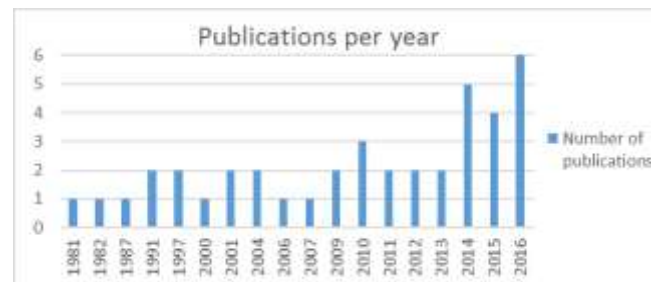


Figure 1. Number of literature reviews published per year

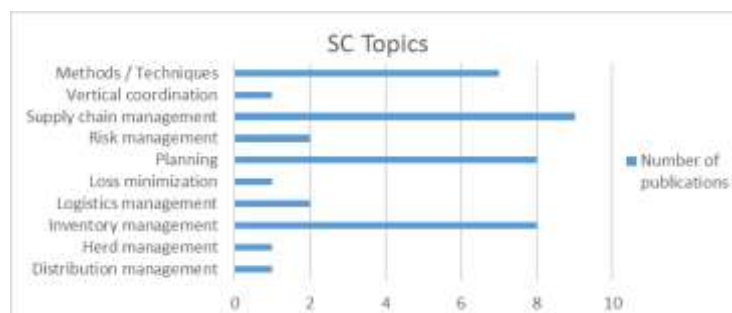


Figure 2. Classification of literatures reviews per SC topics

3. Dimensional analysis

In this section, a collection of the dimensions employed by the 40 LR is made reaching 49 dimensions which have been grouped in 13 dimensional groups that provide us with the relevant attributes to characterize AFSC:

1. *Environment*: it is composed by external factors that can affect the performance of the supply chain such as the country or the government regulations.
2. *Supply chain process*: it includes the number of supply chain stages, the actors involved in them and the different characteristics that define the processes such as the number of items or the setup times, among others.
3. *Products*: it identifies the products for which the models are designed.
4. *Perishability*: it includes the different attributes employed by authors to identify the decay aspect of products in the models analyzed.
5. *Demand*: it defines different attributes related to demand, such as demand functions employed by models (deterministic or stochastic), and the possibility of backlogging or shortages.
6. *Inventory*: it makes reference to the inventory review policy implemented.
7. *Coordination*: it includes the different interdependencies present in the coordinated supply chains such as the problems and actors interdependencies and, the different coordination mechanisms employed.
8. *Food focus areas*: it is concerned with three relevant aspects in today's food industry: food safety, food quality and sustainability.
9. *Decision-making*: it includes the decisional level (strategic, tactical and operative) and their associated decision-maker.
10. *Time horizon*: it represents the length of the time horizon of each model and the consideration about the time horizon is static or dynamic.
11. *Problem*: it is the type of SC problems considered by the OR models.
12. *Uncertainty*: it includes the model's classification in deterministic or uncertain ones and for the last case the nature definition of these uncertainties.
13. *Model*: it includes the model objectives, the modelling technique, the solution method, the validation procedure and the application of the models.

Table 1 shows a classification of the studied papers among the dimension groups defined above which the authors employ in their own categorization of models. The most employed dimension per authors (62.5% of LR) is "Model". Secondly,

there are three dimension groups with the same frequency of utilization (37.5% of LR) which are “Problem”, “Product”, and “Supply Chain Process”.

Table 1. Classification of publications per dimension group employed

Publication	Dimension group												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Kennedy (1981)		X	X							X	X		X
Nahmias (1982)				X	X								
Glen (1987)			X								X		X
Hardaker (1991)													X
Backus et al. (1997)				X	X								
Hayashi (2000)													X
Lowe & Preckel (2004)											X		X
Lucas & Chhajed (2004)	X	X											X
Weintraub & Romero (2006)	X		X										
Pahl et al. (2007)		X		X	X								
Ahumada & Villalobos (2009)													X
Akkerman et al. (2010)			X										X
Li et al. (2010)			X										
Stygar & Makulska (2010)											X		
Karaesmen et al. (2011)		X	X	X					X				X
Zhang & Wilhelm (2011)											X		X
Bakker et al. (2012)		X	X					X	X				X
Soysal et al. (2012)		X			X								
Amorim et al. (2013)													X
Shukla & Jharkharia (2013)						X					X		
Dabbene et al. (2014)	X		X										X
Lemma et al. (2014)		X		X	X								
Pahl & Voss (2014)		X	X										X
Pérez & Torres (2014)	X			X				X			X	X	
Tsolakis et al. (2014)	X		X								X		X
De Keizer et al. (2015)			X										X
Fredriksson & Liljestrand (2015)			X								X		X
Handayati et al. (2015)				X	X					X	X		X
Sel & Bilgen (2015)		X		X	X								
Borodin et al. (2016)									X		X		
Jansen et al. (2016)		X									X		X
Kusumastuti et al. (2016)		X	X					X					
Septiani et al. (2016)							X		X				X
Soto-Silva et al. (2016)		X	X	X							X		X
Tuljak-Suban (2016)												X	X
Total of publications	6	15	15	10	8	1	1	4	5	2	15	2	26

¹Dimension groups legend: 1: Environment; 2: SC process; 3: Product; 4: Perishability; 5:

Demand; 6: Inventory; 7: Coordination; 8: Food focus areas; 9: Decision-making; 10: Time horizon; 11: Problem; 12: Uncertainty; 13: Model.

4. Future Research lines analysis and conclusions

The future research lines in each LR have been assigned to one of the above dimensional groups specifying the publishing year (Table 2). The largest dimensional group is “Model” comprising the 70% of LR. The authors detail in these research lines the need of new models to attach “Problems” (50% of LR) or “SC Process” (45% of LR) that have not been covered properly such as: the AFSC design (Borodin et al., 2016; Kusumastuti et al., 2016; Akkerman et al., 2010; Ahumada & Villalobos, 2009) or holistic approaches for its design and management (Soto-Silva et al., 2016; de Keizer et al., 2015; Tsolakis et al., 2014).

Table 2 Classification of future research lines per year and related dimension group

Dimension group	Year																
	1981	1982	1991	1997	2000	2001	2004	2006	2007	2009	2010	2011	2012	2013	2014	2015	2016
Environment				1			1			1		1			2	1	
SC process	1	1			1		1				2	1	2	2	2	2	3
Product										1	2			2	2	2	2
Perishability	1	1					1	1	1	2	1	1	2	4	3	2	
Demand		1					1							1		1	1
Inventory		1										1					1
Coordination							1			1	1	1			2	3	2
Food focus areas							1			1	1	1	1		2	3	5
Decision-making										1	1	1					1
Time horizon															3		1
Problem	1	1			1		1		1	1	1	2	2	2	2	3	4
Uncertainty				1	1		1	1		1	2	2	1	1		3	5
Model	1		1	1	1	1				1	3	2	2	2	4	3	6

In other “Model” research lines, the authors propose the use of specific modelling approaches or combination of them to address a problem, i.e., Akkerman et al. (2010) proposes combining mathematical programming with simulation when dealing with product safety, Borodin et al. (2016) suggest to combine modeling, optimization and simulation OR approaches when designing integrated AFSC.

Besides, some authors claim that intrinsic characteristics of AFSCs have not yet been addressed properly (Soto-Silva et al., 2016; Amorim et al., 2013; Ahumada & Villalobos, 2009). For this reason, research lines related to “Perishability” (50% of LR) and “Uncertainty” (48% of LR) dimensional groups, which are differentiating characteristics of AFSC, have also been present over the years and

recent authors detail in their LR that more models considering them are necessary for the AFSC especially in its design (de Keizer et al., 2015), in the management of collaborative SC processes (Fredriksson & Liljestrand, 2015; Pahl & Voss, 2014), and in holistic approaches for the AFSC management (Borodin et al., 2016; Janssen et al., 2016; Kusumastuti et al., 2016; Soto-Silva et al., 2016). Other research lines that frequently appear over time are concerning “Demand” and “Inventory”.

The rest of proposed research lines have emerged in the last 12 years and point out the need of modeling new aspects of the SC like the “Environment”, “Coordination”, “Decision-making” or “Time horizon” and some specific characteristics of the AFSC such as the “Product” or “Food focus areas”. In addition, these research lines remain valid, since all of them have been present in publications of the last two years.

The research lines related to “Environment” (18% of LR) show the need of taking into account the changes in the social and/or political environment, including the new food regulations (Fredriksson & Liljestrand, 2015; Lemma et al., 2014; Ahumada & Villalobos, 2009; Lucas & Chhajed, 2004; Backus et al., 1997). In case of “Coordination” (28% of LR), authors say that is evident the need of models for coordinated AFSC as well as the identification of sustainable contractual arrangements between the AFSC actors (Borodin et al., 2016; Kusumastuti et al., 2016; Fredriksson & Liljestrand, 2015; Handayati et al., 2015; Sel & Bilgen, 2015; Pahl & Voss, 2014; Karaesmen et al., 2011; Akkerman et al., 2010; Ahumada & Villalobos, 2009; Love & Preckel, 2004)

On the other hand, research lines related to “Decision-making” (10% of LR) argue that more models are necessary especially for the operational and strategic decision levels (Zhang & Wilhelm, 2011; Akkerman et al., 2010; Ahumada & Villalobos, 2009). The research lines related to “Time horizon” (10% of LR) show the need of models considering the time variable as the major part of existing models considers static approaches (Borodin et al., 2016; Dabbene et al., 2014; Pahl & Voss, 2014; Tsolakis et al., 2014).

Some authors have focused their LR in a specific group of products that share some common features. They expose as research lines related to “Product” (28% of LR) the need of more models to deal with perishable crops, perishable products in general, perishable agri-food products, fresh fruits, among others (Soto-Silva et al., 2016; Handayati et al., 2015; Lemma et al., 2014; Amorim et al., 2013; Shukla & Jharkharia, 2013; Akkerman et al., 2010; Stygar & Makulska, 2010; Ahumada & Villalobos, 2009).

Finally, 38% of LR propose the consideration in models of food quality, food security, traceability and sustainability as crucial research lines related to “Food focus areas” (Borodin et al., 2016; Janssen et al., 2016; Kusumastuti et al., 2016; Soto-Silva et al., 2016; Tuljak-Suban, 2016; Fredriksson & Liljestrand, 2015; Sel & Bilgen, 2015; Dabbene et al., 2014; Tsolakis et al., 2014; Soysal et al., 2012; Akkerman et al., 2010; Ahumada & Villalobos, 2009; Lowe & Preckel, 2004).

This paper gives a first approximation to the state of the art of the use of the OR-models in the agri-food sector by analyzing the existing LR in this field. The dimensions and research lines proposed by each LR are analyzed. After that it is concluded that it would be interesting to develop a new LR analyzing the inherent characteristics of the AFSC considered in the existing OR-models. In addition, the most remarkable research lines are research lines proposed by each LR are analyzed concluding that more OR-models are needed to design and operate the AFSC in an integrated way and, that the characteristics inherent to AFSC should be considered in the proposed models.

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References

- Ahumada, O., Villalobos, J.R., 2009. Application of planning models in the agri-food supply chain: A review. *Eur. J. Oper. Res.* 196, 1-20. doi: 10.1016/j.ejor.2008.02.014
- Akkerman, R., Farahani, P., Grunow, M., 2010. Quality, safety and sustainability in food distribution: a review of quantitative operations management approaches and challenges. *Spectr.* 32, 863-904. doi: 10.1007/s00291-010-0223-2
- Amorim, P., Meyr, H., Almeder, C., Almada-Lobo, B., 2013. Managing perishability in production-distribution planning: a discussion and review. *Flex. Serv. Manuf. J.* 25, 389-413. doi: 10.1007/s10696-011-9122-3
- Audsley, E., Sandars, D.L., 2009. A review of the practice and achievements from 50 years of applying OR to agricultural systems in Britain. *Insight* 22, 2-18. doi: 10.1057/ori.2008.1
- Backus, G.B.C., Eindman, V.R., Dijkhuizen, A.A., 1997. Farm decision making under risk and uncertainty. *Neth. J. Agric. Sci.* 45, 307-328.
- Bakker, M., Riezebos, J., Teunter, R.H., 2012. Review of inventory systems with deterioration since 2001. *Eur. J. Oper. Res.* 221, 275-284. doi: 10.1016/j.ejor.2012.03.004
- Borodin, V., Bourtembourg, J., Hnaien, F., Labadie, N., 2016. Handling uncertainty in agricultural supply chain management: A state of the art. *Eur. J. Oper. Res.* 254, 348-359. doi: 10.1016/j.ejor.2016.03.057
- Cunningham, D.C., 2001. The distribution and extent of agrifood chain management research in the public domain. *Supply Chain Manag. Int. J.* 6, 212-215. doi: 10.1108/EUM0000000006040
- Dabbene, F., Gay, P., Tortia, C., 2014. Traceability issues in food supply chain management: A review. *Biosyst. Eng.* 120, 65-80. doi: 10.1016/j.biosystemseng.2013.09.006

- de Keizer, M., van der Vorst, J.G.A.J., Bloemhof, J.M., Haijema, R., 2015. Floricultural supply chain network design and control: industry needs and modelling challenges. *J. Chain Netw. Sci.* 15, 61-81. doi: 10.3920/JCNS2014.0001
- Fredriksson, A., Liljestrand, K., 2015. Capturing food logistics: a literature review and research agenda. *Int. J. Logist.-Res. Appl.* 18, 16-34. doi: 10.1080/13675567.2014.944887
- Glen, J.J., 1987. Mathematical models in farm planning: A survey. *Oper. Res.* 35, 641-666. doi: 10.1287/opre.35.5.641
- Goyal, S.K., Giri, B.C., 2001. Recent trends in modeling of deteriorating inventory. *Eur. J. Oper. Res.* 134, 1-16. doi: 10.1016/S0377-2217(00)00248-4
- Handayati, Y., Simatupang, T.M., Perdana, T., 2015. Agri-food supply chain coordination: the state-of-the-art and recent developments. *Logist. Res.* 8. doi: 10.1007/s12159-015-0125-4
- Hardaker, J.B., Pandey, S., Patten, L.H., 1991. Farm planning under uncertainty: a review of alternative programming models. *Rev. Mark. Agric. Econ.* 59.
- Hayashi, K., 2000. Multicriteria analysis for agricultural resource management: a critical survey and future perspectives. *Eur. J. Oper. Res.* 122, 486-500. doi: 10.1016/S0377-2217(99)00249-0
- Janssen, L., Claus, T., Sauer, J., 2016. Literature review of deteriorating inventory models by key topics from 2012 to 2015. *Int. J. Prod. Econ.* 182, 86-112. doi: 10.1016/j.ijpe.2016.08.019
- Karaesmen, I.Z., Scheller-Wolf, A., Deniz, B., 2011. Managing Perishable and Aging Inventories: Review and Future Research Directions, in Kempf, K.G., Keskinocak, P., Uzsoy, R. (Eds.), *Planning Production and Inventories in the Extended Enterprise*. Springer US, Boston, MA, pp. 393-436.
- Kennedy, J.O., 1981. Applications of dynamic programming to agriculture, forestry and fisheries: Review and prognosis. La Trobe University.
- Kusumastuti, R.D., van Donk, D.P., Teunter, R., 2016. Crop-related harvesting and processing planning: a review. *Int. J. Prod. Econ.* 174, 76-92. doi: 10.1016/j.ijpe.2016.01.010
- Lemma, Y., Kitaw, D., Gatew, G., 2014. Loss in Perishable Food Supply Chain: An Optimization Approach Literature Review. *Int. J. Sci. Eng. Res.* 5, 302-311.
- Li, R., Lan, H., Mawhinney, J.R., 2010. A Review on Deteriorating Inventory Study. *J. Serv. Sci. Manag.* 03, 117-129. doi: 10.4236/jssm.2010.31015
- Lowe, T.J., Preckel, P.V., 2004. Decision technologies for agribusiness problems: A brief review of selected literature and a call for research. *Manuf. Serv. Oper. Manag.* 6, 201-208. doi: 10.1287/msom.1040.0051
- Lucas, M.T., Chhajed, D., 2004. Applications of location analysis in agriculture: a survey. *J. Oper. Res. Soc.* 55, 561-578. doi: 10.1057/palgrave.jors.2601731
- Nahmias, S., 1982. Perishable Inventory Theory: A Review. *Oper. Res.* 30, 680-708. doi: 10.1287/opre.30.4.680
- Oriade, C.A., Dillon, C.R., 1997. Developments in biophysical and bioeconomic simulation of agricultural systems: a review. *Agric. Econ.* 17, 45-58.
- Pahl, J., Voß, S., 2014. Integrating deterioration and lifetime constraints in production and supply chain planning: A survey. *Eur. J. Oper. Res.* 238, 654-674. doi: 10.1016/j.ejor.2014.01.060

- Pahl, J., Voß, S., Woodruff, D.L., 2007. Production planning with deterioration constraints: a survey, in: *The Development of Collaborative Production and Service Systems in Emergent Economies*, Proceedings of the 19th International Conference on Production Research. pp. 1-6.
- Pérez Mantilla, F.A., Torres Delgado, J.F., 2014. Modelos de inventarios con productos perecederos: revisión de la literatura. *Ingeniería* 19. doi: 10.14483/udistrital.jour.reving.2014.2.a01
- Raafat, F., 1991. Survey of literature on continuously deteriorating inventory models. *J. Oper. Res. Soc.* 42, 27-37. doi: 10.1057/jors.1991.4
- Sel, Ç., Bilgen, B., 2015. Quantitative models for supply chain management within dairy industry: a review and discussion. *Eur. J Ind. Eng.* 9, 561. doi: 10.1504/EJIE.2015.071772
- Septiani, W., Marimin, M., Herdiyeni, Y., Haditjaroko, L., 2016. Method and approach Mapping for Agri-food Supply Chain Risk Management: A literature review. *Int. J. Supply Chain Manag.* 5, 51-64.
- Shukla, M., Jharkharia, S., 2013. Agri-fresh produce supply chain management: a state-of-the-art literature review. *Int. J. Oper. Prod. Manag.* 33, 114-158. doi: 10.1108/01443571311295608
- Soto-Silva, W.E., Nadal-Roig, E., González-Araya, M.C., Pla-Aragones, L.M., 2016. Operational research models applied to the fresh fruit supply chain. *Eur. J. Oper. Res.* 251, 345-355. doi: 10.1016/j.ejor.2015.08.046
- Soysal, M., Bloemhof-Ruwaard, J.M., Meuwissen, M.P.M., van der Vorst, J.G.A.J., 2012. A Review on Quantitative Models for Sustainable Food Logistics Management. *Int. J. Food Syst. Dyn.* 3, 136-155. doi: 10.18461/ijfsd.v3i2.324
- Stygar, A., Makulska, J., 2010. Application of mathematical modelling in beef herd management-a review. *Ann. Anim. Sci.* 10, 333-348.
- Tsolakis, N.K., Keramydas, C.A., Toka, A.K., Aidonis, D.A., Iakovou, E.T., 2014. Agrifood supply chain management: A comprehensive hierarchical decision making framework and a critical taxonomy. *Biosyst. Eng.* 120, 47-64. doi: 10.1016/j.biosystemseng.2013.10.014
- Tuljak-Suban, D., 2016. Food Supply Chain: A Review of Approaches Which Enhance Sustainability with a Focus on Social Responsibility, in Krmac, E. (Ed.), *Sustainable Supply Chain Management*. InTech.
- Weintraub, A., Romero, C., 2006. Operations research models and the management of agricultural and forestry resources: a review and comparison. *Interfaces* 36, 446-457. doi: 10.1287/inte.1060.0222
- Zhang, W., Wilhelm, W.E., 2011. OR/MS decision support models for the specialty crops industry: a literature review. *Ann. Oper. Res.* 190, 131-148. doi: 10.1007/s10479-009-0

Establishing a multi-criteria evaluation model for local development strategies. A case study in Cartagena (Colombia)

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Abstract In this paper we present a methodology based in the multicriteria technique Analytics Network Process for the sustainable evaluation of strategic nautical projects for the urban development of the city of Cartagena de Indias. The aim is to provide answers and guide the decision makers towards the optimal selection of strategies. The model constructed consider political, socio-cultural and environmental aspects. Besides allows local planners to get a consensus between sectors.

Keywords: Analytic Network Process (ANP); Cartagena de Indias; Sustainable Evaluation; Strategies.

1. Introduction

Of all marine activities, the nautical and naval industries are among the most significant and fastest growing industries (Papageorgiou, 2016). The city of Cartagena de Indias (Colombia) has a great development potential in both sectors. Thanks to its morphologic and location conditions, its natural and historical attractions. Much like other coastal cities, several controversies have been generated in Cartagena over the expansion and placement of new nautical facilities. Thus, in terms of local development, planning processes in the nautical and naval sectors are under the pressure of public and private sectors, but mainly, of its citizens. The sustainable evaluation by a multicriteria technique has been widely used (Ginevičius and Podvezko, 2009) and will provide answers and orient

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the decision-maker towards the selection of the facilities of a nautical infrastructure (Kovačić, 2010). The use of the Analytical Network Process (ANP) is proposed, because it allows to better represent the interactions among components of a real system (De Lotto *et al.*, 2016). The model is carried out in collaboration with the private sector in order to present to the public sector a tool to reach a consensus among different stakeholders, the alternatives were preconceived for different local and national plans and programs, and the criteria were selected to seek sustainability and expansion of this sector.

2. Objectives

To verify in practice the relevance and usefulness of the ANP as an appropriate tool to reach a consensus among sectors on territorial development.

To support decision making in order to determine which zone is the most suitable for the location of the new nautical facilities in Cartagena.

3. Methods

The methodological proposal is based on the ANP procedure developed by Saaty (2001). Summarized in the following chart.

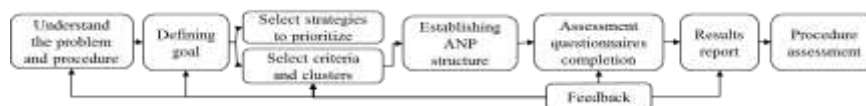


Figure 1. Methodology flow chart

4. Results

The proposed model was defined with 14 criteria which could influence the sustainable evaluation of the proposed alternatives. Four alternatives were selected, oriented to the definition of the most appropriate area to locate nautical and naval development zones in the city. A compliance index of the model objective for each alternative with regard to all considered criteria was determined through a questionnaire designed to allow comparing between pairs of elements.

The obtained priority for each criterion can be considered as its relative importance. Results show that, the most valued were the environmental and sociocultural groups of criteria. The less valued are the economics ones. Priorities

obtained for the alternatives can be considered as their Preference Index, so the higher this index value, the better the proposal prioritization will be. Results indicate that the best strategy to be implemented to improve the nautical and naval sector in the city of Cartagena is the *A4. External Nautical Network* (39%)

5. Conclusions

The results obtained with the model allow concluding that beyond the economic aspects, there is concern over the environmental effects the alternatives could produce, or the way in which they could benefit the current conditions of some water bodies. The better valued alternatives are those that least affect the urban density of certain zones of the city and those which potentially provide higher environmental benefits for the city.

Concerning the use of ANP as a tool for prioritization of strategic plans we can conclude that it allow transparency and participation of the stakeholder. ANP procedure becomes not only interesting in terms of reaching final consensus and prioritization but also in terms of enabling reflection on the subject.

References

- Baser, V. and Biyik, C. (2016) 'The problems and resolution approaches to land management in the coastal and maritime zones of Turkey', *Ocean and Coastal Management*. Elsevier Ltd, 119, pp. 30–37. doi: 10.1016/j.ocecoaman.2015.09.018.
- Ginevičius, R. and Podvezko, V. (2009) 'Evaluating the changes in economic and social development of Lithuanian counties by multiple criteria methods', *Baltic Journal on Sustainability*, 15(3), pp. 418–436. doi: 10.3846/1392-8619.2009.15.418-436.
- Kovačić, M. (2010) 'Selecting the location of a nautical tourism port by applying promethee and gaia methods case study -Croatian northern adriatic', *Promet - Traffic - Traffico*, 22(5), pp. 341–351. doi: 10.7307/ptt.v22i5.199.
- De Lotto, R., Gazzola, V., Gossenberg, S., Morelli di Popolo, C. and Venco, E. M. (2016) 'Proposal to Reduce Natural Risks: Analytic Network Process to Evaluate Efficiency of City Planning Strategies', in: Springer, Cham, pp. 650–664. doi: 10.1007/978-3-319-42089-9_46.
- Papageorgiou, M. (2016) 'Coastal and marine tourism: A challenging factor in Marine Spatial Planning', *Ocean and Coastal Management*. Elsevier Ltd, 129, pp. 44–48. doi: 10.1016/j.ocecoaman.2016.05.006.
- Saaty, T. L. (2001) *The Analytic Network Process: Decision Making with Dependence and Feedback*. RWS Publications. Available at: https://books.google.es/books/about/Decision_Making_with_Dependence_and_Feed.html?id=MGpaAAAAYAAJ&redir_esc=y (Accessed: 15 March 2017).

Environmental performance of a municipal integrated waste management system vs. citizens' behaviour

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Abstract Sustainable Integrated Waste Management Systems (IWMSs) are one of the big challenges faced all over the world having its impact on city' economic, environmental and social performance a prominent role. While economic aspects have been extensively investigated, the environmental and social aspects are gaining more attention. Consistently, the authors propose a Mixed Integer Nonlinear Programming (MINLP) model to plan the Municipal Integrated Waste Management System (MIWMS) shaping both waste collection solutions and treatments options to minimize the green house gases (GHGs) emissions. The MIWMS environmental effectiveness depends on technical and organizational choices as well as on citizens' participation. The analysis of how citizens' behavior affects the Carbon Footprint (CF) of MIWMS is performed too. Consistently, the Marginal Environmental Benefit index is used to investigate the recovery incremental benefit due to the increased attitude of citizens in participating and improving waste separate collection.

Keywords: Waste; carbon footprint; decision-making

1. Introduction

Achieving sustainable development is an ambitious goal for both the extent of required changes and the scope breadth. The European sustainable grand challenges start from the city where the impacts of waste sector on economic, environmental and social performance are widely recognized (IPCC, UNEP). Up to now, economic aspects have been widely investigated and considered the main strategic drivers both for the choice and the evaluation of alternatives decisions. Several effective decision making model based on economic issues are developed (Noche et al., 2010; Costi et al.,2004). In (Gnoni et al., 2008) a mixed integer

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linear programming model economic-oriented is proposed in for designing an Integrated Solid Waste Management System. The increasing focus on the relationship between sustainability and waste management leads to broaden the field of analysis also to environmental aspects. The failure to concurrent assessment of the environmental effects of decisions locally taken led to understate the positive role of an environmentally efficient planning of the waste sector to tackle GHG emissions (Bogner et al., 2007). Several LCA-based models are proposed in scientific literature to assess waste management environmental impacts (den Boer et al., 2007; Tabata et al., 2010; Cherubini et al., 2009; Massaro et al., 2015). The several enabling factors affecting waste management performance are explicitly reported in (Guerrero et al, 2013). The analysis shows that an effective system also depends on socio-cultural factors like citizens' participation and cooperation, education and awareness campaigns. Indeed, one of the most important progresses is the increasing level of awareness among different actors (e.g. decision makers, technicians, citizens) that with different role affect waste management systems' performance. Consistently, the authors propose an optimization model to plan a MWIMS. The model is designed to find out the configuration both for the collection and the treatments phases with the lowest GHGs emissions. In line with the aforementioned issues, the result of a better-designed system suffers from the individual behaviour too. The analysis of how citizens' attitude in participating and improving waste separate collection is carried out. The aim is to highlight potential benefits due to investment increasing social awareness in such a topic. In Section 2, the optimization model and the analysis of environmental performance depending on citizens' behaviour are presented. In Section 3, the results are provided. Finally, in Section 4 conclusions and future developments are shown.

2. Methodology

The optimization model that will be illustrated in the next section is based on a five-level decision model: two strategic and three operative levels. The key factors influencing either individually or jointly, the GHGs emissions of the system have been considered. The three operative levels of the decision model relate the grouping systems (i.e. monomaterial vs. multimaterial), the collection systems (i.e. door to door, aggregate, proximity and street system), and the collection frequency. Readers can find further details in (Caponio et al., 2015; D'Alessandro et al., 2012). The strategic level of decision model relate the primary and the secondary treatments for each fraction collected. Specifically primary treatments are: sorting and selection for dry recycled fraction, anaerobic or aerobic digestion for the organic recycled fraction and mechanical biological treatment (MBT) for un-recycled fraction. Moreover, the alternative secondary treatments are: material recovery, waste to energy (refuse derived fuel 'RDF', gasification) and landfill.

2.1 The optimization model

The optimization model is designed to plan a MWIMS minimizing the net emissions by means of the following objective function (1). The nomenclature adopted in the model is summarized in Table 1.

$$O.F = \text{Min} \left(\sum \text{Direct Emissions} - \sum \text{Avoided Emissions} \right) \quad (1)$$

The direct emissions are:

$$Em_{\text{collection}} = \sum_i \sum_j \sum_k \left(EF_{j,i} H v_j W w_{j,i,k} Y_{i,k} N_{j,i,k} / b_j p_{i,j} \right) \quad (2)$$

$$Em_{\text{dryTreat}} = \sum_{v=1}^2 \sum_{k=2}^4 \left[F_{k,v} X'_k \prod_v^{v-1} e_{k,v-1} AD_v EF_{el} \right] + \sum_{v=1}^2 \sum_{k=2}^4 \left[F_{k,v} X'_k \prod_v^{v-1} e_{k,v-1} AD_v EF_{fuel} \right] \quad (3)$$

$$Em_{\text{an.digestion}} = \sum_{v=3}^4 \left(F_{k,v} X'_k e_{k,v} AD_v EF_{el} \right) \quad (4)$$

$$Em_{\text{compost}} = F_{k,v} X'_k AD_v EF_{el} \quad (5)$$

$$Em_{\text{MBT}} = F_{k,v} X'_k AD_v EF_{el} + F_{k,v} X'_k O_{\text{MBT}} AD_v EF_{el} \quad (6)$$

$$Em_{\text{landfill}} = \sum_{v=1}^2 \sum_{k=2}^4 X'_k (1 - e_{k,v}) EF_l + \sum_{v=3}^6 X'_k (1 - e_{k,v}) EF_l + \quad (7)$$

$$F_{k,v} O_{\text{MBT}} X'_k e_{k,v} EF_l + F_{k,s,v} O_{\text{MBT}} X'_k e_{k,v} EF \quad (8)$$

$$Em_{\text{Rec.mat.sorting}} = F_{k,s,v} (1 - O_{\text{MBT}}) X'_k AD_s EF_{el} \quad (8)$$

$$Em_{\text{RDF}} = F_{k,s,v} (1 - O_{\text{MBT}}) \left(X'_k AD_s EF_{el} + X'_k e_{k,s} EF_{\text{comb.RDF}} \right) \quad (9)$$

$$Em_{\text{flamelesscomb}} = F_{k,s,v} O_{\text{MBT}} AD_s EF_{el} + F_{k,s,v} O_{\text{MBT}} X'_k EF_{\text{flamelesscomb}} \quad (10)$$

The avoided emissions are:

$$Em_{\text{en.recovery}} = E_k EF_{el} \quad (11)$$

$$Em_{\text{mat.recovery}} = \sum_{k=1}^4 \left(X'_k \prod_{s=1}^2 e_{k,s} A_k \right) + F_{k,s,v} (1 - O_{\text{MBT}}) X'_k e_{k,v} A_k \quad (12)$$

being $X_k = g_c M g_k w_{j,i,k} Y_{i,k} N_{j,i,k}$ and $X'_k = X_k + C_k$

Table 1. Notation adopted in the model

<u>Subscripts</u>		<u>Variables</u>	
k	Waste fraction k = 1 organic; k = 2 glass; k=3 paper; k = 4: plastics, metal cans; k=5 cardboard; k=6 wood; k=7 textile; k=8 other	$Y_{i,k}$	boolean variable to infer if the i-th grouping system is adopted for the k-th waste fraction.
i	Grouping systems i =1: mono material; i = 2: multi material'	$N_{j,i,k}$	number of users served by the j-th collection system and the i-th grouping for each k-th fraction.
j	Collection systems j=1door-to-door; j=2 aggregate; j=3 proximity; j=4 street	$w_{j,i,k}$	weekly collection frequency for the j-th collection system according to the i-th grouping system for the k-th waste fraction
v	Primary treatment: s=1sorting; s=2 selection s=3 pre-treatment anaerobic digestion; s=4 anaerobic digestion s=5 post-treatment digestion s=6 composting s=7 MBT s=8 bio-stabilization; s=9 landfill.	$F_{k,v}$	fraction of the k-th waste addressed to the v-th primary treatment
s	Secondary treatment v=1ReMat (recovery material un-recycled), v=2 RDF; v=3 gasification; v=4 pre-treatment flameless; v=5 flameless combustion	$F_{k,s,v}$	fraction of the k-th waste treated in the v-th primary treatment addressed to the s-th econdary treatment
<u>Parameters</u>			
g_c	Production per capita of urban waste [ton/y·ab]	η_{bj}	Collection efficiency
M	Average number of family members	O_{MBT}	Organic not-recycled flow after MBT [%]
G	Total amount waste produced [ton/y]	e_{ks}	Efficiency of s-th stage for the k-th waste fraction.
C_k	Waste produced by commercial users [ton/y]	e_{kv}	Efficiency of v-th stage for the k-th waste fraction.
s_j	Distance travelled [km/day]	AD_s AD_v	Activity Data in the s-th treatment and in the v-treatment [Kwh/ton]
W	Number of weeks in the observation period [#]	EF_{el} EF_{fuel}	Electricity and fuel emission factor [tCO _{2eq} /Kwh], [tCO _{2eq} /t _{fuel}]
g_k	Fraction of the k-th type of G [%]	EF_{ji}	Transport Emission factor [tCO _{2eq} /Km]
b_j	Bin load capacity [#users]	EF_l	Emission factor for disposal waste fraction [tCO _{2eq} /t _{waste}]
p_{ji}	Productivity of collection team [unit/shift]	E_k, A_k	Energy recovery of waste and materials [Kwh/y], [tCO _{2eq} /t _{waste}]
SC_m	Separate Collection level	N_T	Total number of user to be served

Different types of constraints are provided in the model. Technical constraints impose that only one waste stream grouping system is admitted for each waste fraction. In particular, the monomaterial grouping system is the only one allowed for organic and glass fraction. Furthermore, both the same grouping and mix of collection systems are foreseen for paper, plastics, and metal cans streams. Being the collection systems strictly connected to urban fabric constraints, the number of users served by each collection should comply with limits of users identified case

by case for each collection system. According to normative, a minimum level of separate collection (SC_{min}) has to be achieved. Weekly frequency of collection is in a defined set of frequency values according to practical and official waste management guidelines as well as local regulations. Treatments demand constraints ensure that the total amount of waste collected is treated in primary and secondary treatments.

2.2 How citizens' behaviour affect environmental performance

The MIWMS environmental effectiveness depends on technical and organizational choices as well as on citizens' participation. A deeper analysis is carried out to investigate results sensitivity on citizens' behaviors. Both the behavior and the involvement of citizens are modeled by means of collection efficiency' parameter. Indeed, the collection efficiency represents the attitude and responsibility of citizens in leaving separate household waste. The higher the involvement of citizens and the level of monitoring, the higher the efficiency value. The collection efficiencies differ greatly with the collection system. Collection systems with low ratio users per containers (i.e. door to door or aggregate collection systems) are characterized by high efficiencies values allowing higher tight monitoring. The Marginal Environment Benefit (MEB) index is defined as follow:

$$MEB = (\Delta(\text{Emissions})) / (\Delta(\text{Waste Sep. Collected})) \quad [t(\text{CO}_{2eq})/t] \quad (13)$$

where the numerator represents the variation, namely a decrease, of GHGs emissions due to citizens' increased environmental consciousness. The same line of reasoning relates the denominator that represents the variation in the amount of waste separated collected, namely the increase. The MEB index stands for the incremental environmental benefit connected to each separate collected waste ton caused by a moderate (in line with the 'marginal' concept) increase of collection efficiencies. The MEB index is evaluated by considering a stepwise increase in efficiency of $\Delta\eta = 0.05$ for each waste fraction and collection system.

3. Results and discussion

The theoretical model proposed in this paper has been applied to a numerical example based on a real industrial case, Bari, a middle size city in Italy. The city accounts for 147811 families each of them having on the average 2.33 members (M). The overall municipal waste flow (G) amounts to 176677 t/yea. Readers can refer to (Caponio et al., 2015) for case study data.

3.1 Analysis of the optimized solution

On the basis of case study data, the problem (1) is solved by the Generalized Reduced Gradient algorithm. The minimum level of separate collection (SC_{min}) is set to 50%. The dry recyclable fraction has to be collected with the monomaterial

grouping system as well as for the organic and the glass fraction. When such a level of separated collection is pursued, the emission reduction that would be ensured by a multimaterial grouping system, is not balanced by the increase in the emissions due to higher electricity and fuel consumption of treatments. The model suggests for the organic fraction, the door to door and the aggregate collection systems to be kept at the minimum value comparing with the lower limit of these collection systems. Otherwise, the street collection system would be completely glutted. Although the latter is characterized by a higher emission factor, it allows a reduction in collection cycles due to a higher productivity of the collection teams. On the contrary, the adoption of door to door and aggregate collection system is kept low since the number of work-shifts and work cycles tend to increase because of high waste collection distance to be covered. The same line of reasoning is applied for the glass fraction. For the dry recyclable waste, the arguments on door to door collection system are unchanged. Respect to the case of organic fraction, a higher number of users has to be served with the aggregate system. This increase balances the noteworthy reduction of users served by the proximity system and the feeble reduction for the street collection. Although the collection cycles and consequently the distance travelled tend to increase comparing the aggregate with the proximity and the street collection system, the flows of dry recyclable collected increase due to the higher collection efficiency. The increase in collection emissions is more than offset by the increase of the collected and treated waste volumes and consequently by the higher avoided emissions through the recovery of paper, plastics, ferrous and aluminium cans. Indeed, it is worth remembering that the optimized collection solution takes into account the positive and the negative impacts of the treatments and the valorisation downstream. Considering separate collection level constraint as well as greater benefits in terms of emissions related to the recovery of the dry fraction, collection systems with high collection efficiency are preferred. The collection emissions are equal to 1126 tCO_{2eq}/y. Flows treated and relative emissions are listed in Table 2. The main contribution to emissions is the production and combustion of RDF. The high emissions value depends on the burning of fractions such as the plastics one with high fossil origin carbon content. Nevertheless, it is preferred over the gasification alternative process since its net impact exceeds the gasification one.

The flameless combustion of the bio-stabilized organic waste has a great influence too. Likewise, it is preferred on the disposal of such a bio-stabilized fraction. Although the net impact does not represent a 'avoided' emission, the impact is lower than it would be by disposing in landfill. The main contribution to avoided emissions depends on materials recovery of both recycled and unrecycled waste flows. It is followed by the contribution of energy production from RDF.

Table 2. Emissions [tCO_{2eq}/y] and material flows [t/y] for the optimized solution

	Processes	Emissions [tCO _{2eq} /y]	Material Flows [t/y]
POSITIVE EMISSIONS	Sorting,selection dry recyclable fraction	295	53788
	Anaerobic digestion	1388	33914
	MBT	857	88796
	ReMat for unrecycled material	143	10672
	Production and combustion of RDF	17540	42690
	Flameless combustion	9284	28491
	Landfill	5160	38508
AVOIDED EMISSIONS	Recovery of dry recycled fraction	55468	49170
	Energy from biogas and low quality compost	4441	3484
	Recovery of dry unrecycled fraction	14599	13271
	Energy from RDF	24641	13784
	Energy from flameless combustion	7908	4524

3.2 Analysis of citizens' behaviours effects

The analysis of how citizens' behaviour affects the CF of MIWMS is carried out by varying one by one collection system efficiencies. The minimum and the maximum increase are respectively $\Delta\eta=0,05$ and $\Delta\eta=0,20$ with a steady increase equal to 0,05. To better focuses on the effect of citizens' participation in separate collection, the collection system of the optimized solution is unchanged. Results are provided in Fig.1. The vertical axes represent respectively the net emission and the collected flows difference between the scenario with the 'improved' efficiencies and the base scenario with 'standard' efficiencies values. The values are expressed in logarithmic scale to a better results presentation since an huge difference exists between street values and the other collection systems values. For the different collection systems, both the net emissions and the collected flows trends are almost equal but the values differ considerably. It is worth noting that the analysis results are strongly affected by the initial collection solution. The greatest environmental saving and flow increase are obtained in the case of street collection for each $\Delta\eta$ tested.

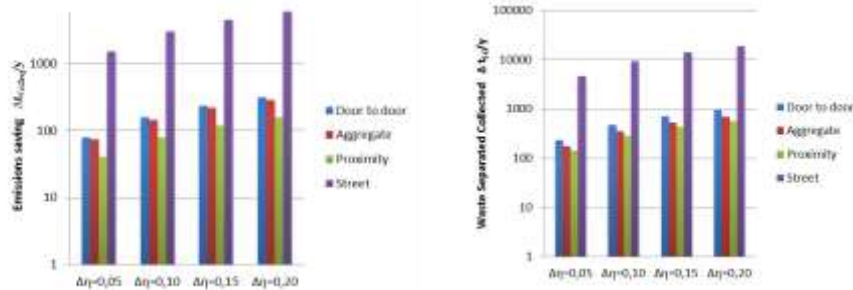


Figure 1. Collection efficiencies effects on both level of separated collection and emissions

The street collection system is the most widespread in the optimal solution. This greatly influences the waste flow collected and in turns the GHGs emissions. The additional savings in emissions is not simply attributable to the increase in dry materials flows recovered and to the increase in biogas production by recycled organic. When the level of separated collection grows, fewer dry materials (paper, cardboard, plastics) are addressed to RDF production. It means a loss of avoided emissions related to energy production from RDF. The MEB trend is shown for each collection system (Fig.2) . MEB represent the environmental benefit related to the additional ton of waste collected ascribable to the improvement in social participation.

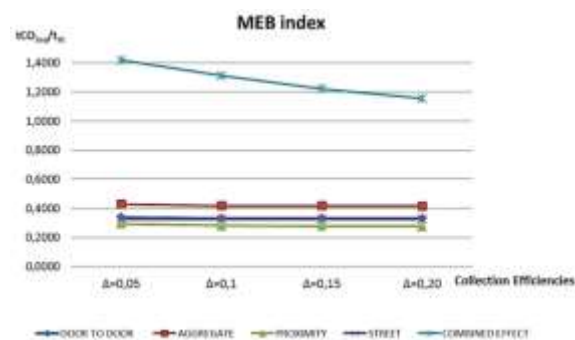


Figure 2. Marginal Environmental Benefit Index

It can be noted, the MEB has a downward trend. It means that the change in the environmental savings caused by progressive improvements in collection efficiencies, is positive, but gradually lower. The combined effect is obtained jointly varying the collection efficiencies with the same steady increase. The results show how positive investment could be to increase social awareness. Combined actions on all collection systems would bring an environmental benefit from 1,18 to 1,4 tCO_{2eq}/ton. To this environmental advantage, it should be added the economic advantage of additional amount recycled.

4. Conclusions

Results obtained stress out the capability of the framework and of the optimization model in supporting public decision-making to optimally set the separate waste collection system with the lowest environmental impact due to GHG emissions while respecting technical and organizational constraints. The analysis carried out shows the great potential to further improvements without changes in organizational or technical choices. With the same collection system, which also means the same costs of the collection service, both the net emissions and the level of separated collection achieved can be greatly improved by acting on the awareness of the individual. It therefore appears that awareness programs as well as increasing levels of monitoring are the perfect enhancement of the technical and organizational aspects to maximize the performance of the MWIMS.

References

- Bogner, J., M. Abdelrafie Ahmed, C. Diaz, A. Faaij, Q. Gao, S. Hashimoto, K. Mareckova, R. Pipatti, T. Zhang, Waste Management, In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B.Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Caponio G., D'alessandro G., Digiesi S., Mossa G., Mummolo, R. Verriello (2015). Minimizing Carbon-Footprint of Municipal Waste Separate Collection Systems. In: *Enhancing Synergies in a Collaborative Environment. Lecture Notes Inmanagement and Industrial Engineering*, p. 351-360 ISBN: 978-3-319-14077-3, ISSN: 2198-0772
- Cherubini F., Bargigli S., Ulgiati S. (2009), Life Cycle Assessment of waste management strategies: landfilling, sorting plant and incineration, *Energy*, 34: 2116-2123.
- Costi P., Minciardi R., Robba M., Rovatti M., R. Sacile R., 2004, An environmentally sustainable decision model for urban solid waste management, *Waste management* 24, 277–295.
- D'alessandro G, Gnoni G, Mummolo G (2012). Sustainable Municipal Solid Waste Management and Recovery. In: Editors: C.N. Madu and C. Kuei. *Handbook of Sustainability Management*, Imperial College Press 2012, London. ISBN: 978-981-4354-81-3
- den Boer J., den Boer E., Jager J., 2007. LCA-IWM: a decision support tool for sustainability assessment of waste management systems. *Waste Management*, 27, 1032–1045.
- Gnoni M., Mummolo G., Ranieri L. , 2008. A mixed integer linear programming model for optimisation of organics management in an integrated solid waste system. *Journal of Environmental Planning and Managemen*, vol. 51, p. 833-845, ISSN: 0964-0568.
- Guerrero L.A., Maas G., Hogland W., 2013, Solid waste management challenges for cities in developing countries, *Waste management* 33, 220-232

- Massaro V., Digiesi S., Mossa G., Ranieri L., 2015, The sustainability of anaerobic digestion plants: a win-win strategy for public and private bodies, *Journal of Cleaner Production*, 104, 445-459.
- Noche B., Chinakupt T., Rhoma F.A., Jawale M., 2010, Optimization Model for Solid Waste Management System Network Design Case Study, Volume 5, 978-1-4244-5586-7/10
- Tabata t., Hishinuma T., Ihara T., Genchi Y., 2010. Life cycle assessment of integrated municipal solid waste management systems, taking into account of climate change and landfill shortage trade-off problems, *Waste management & research*, 29 (4), 423-432

A MILP for mono-machine injection moulding sequencing

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Abstract This paper presents a MILP model to optimise the injection moulding sequencing in a mono-machine case. This MILP, modelled through Julia language, is part of the optimisation repository created in the C2NET European Funded Project.

Keywords: Optimisation Algorithm, Mixed Integer Linear Programming (MILP), Sequencing, Injection, Cloud Collaborative Manufacturing Networks (C2NET).

1. Introduction

The proposed Optimization Algorithm (OA) is developed in response to the identified needs of two industrial partners of the automotive sector within the C2NET European Project that aims at the creation of cloud-enabled tools for supporting SMEs supply network to optimise the manufacturing and logistic assets.

2. A Mixed Integer Linear Programming Model

The Mixed Integer Linear Programming (MILP) model deals with the moulding sequencing of one injection machine. The main index is the mould, and not the product, as it is commonly found in the literature. Table1 shows the nomenclature of the OA.

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The objective function (1) minimises the sum of the cost of setting up the mould j , the inventory and the backorder costs of products i .

Table 1. MILP Model Nomenclature

Index	I : Set of products	J : Set of moulds	T : Set of periods
Parameters	c_{ij}	Production rate of the product i using the mould j	
	d_{it}	Demand of product i during period t	
	$INVMAX_i$	Maximum available inventory capacity for product i	
	$INVMIN_i$	Minimum inventory for product i	
	INV_{i0}	Initial inventory of product i	
	ci_i	Inventory cost of product i	
	cd_i	Delay cost of one unit of product i	
	cs_j	Setup cost of the mould j	
Decision variables	Y_{jt}	1 if the mould j is producing products in the period t , 0 otherwise	
	S_{jt}	1 if the mould j starts producing products in the period t and in period $t-1$ it was another mould j setup, 0 otherwise	
	P_{it}	Amount produced of product i in the period t	
	INV_{it}	Inventory level of product i at the end of period t	
	D_{it}	Delay amount of product i at the end of period t	

$$Minz = \sum_j \sum_t cs_j \cdot S_{jt} + \sum_i \sum_t ci_i \cdot INV_{it} + \sum_i \sum_t cd_i \cdot D_{it} \quad (1)$$

The constrains are presented as follows (1.2-1.8):

$$\sum_j Y_{jt} \leq 1 \quad \forall t \quad (2)$$

$$P_{it} = \sum_j c_{ij} \cdot Y_{jt} \quad \forall i, t \quad (3)$$

$$S_{jt=1} = Y_{jt} \quad \forall j, t = 1 \quad (4)$$

$$S_{jt>1} \geq Y_{jt} - Y_{jt-1} \quad \forall j, t > 1 \quad (5)$$

$$INV_{it} = INV_{i0} + P_{it} - d_{it} + D_{it} \quad \forall i, t = 1 \quad (6)$$

$$INV_{it} = INV_{it-1} + P_{it} - d_{it} + D_{it} - D_{it-1} \quad \forall i, t \neq 1 \quad (7)$$

$$INVMIN_i \leq INV_{it} \leq INVMAX_i \quad \forall i, t \quad (8)$$

This model is validated through 3 different size datasets in order to assess (i) the suitability of the results and (ii) the technical parameters to perform the optimization. The small dataset (2 products, 2 periods and 2 moulds) needs less than 1 second to be optimised; the medium dataset (6 products, 50 periods and 4 moulds) is solved optimally in 60 seconds. Finally, the large dataset (100

products, 50 periods and 100 moulds) is calculated in 60 seconds with a GAP of 0,0067.

3. Conclusion

The MILP is addressed to optimise the sequencing of the injection moulds in a mono-machine case study. This MILP has been modelled through Julia Language and it is open source available in the algorithms repository of C2NET project.

Acknowledgement

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Comparison: Group Model Building workshops of two SMEs from the Basque industrial sector

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Abstract Group Model Building (GMB) is a methodology which involves a target group in the business of model formulation and conceptualization. It is crucial to obtain extended formal models and accelerate group decision support for future model building. In this paper the development of two GMB workshops for two Small and Medium-sized Enterprises (SME) from the Basque Industrial Sector is presented. These workshops focused solely on one problem: the analysis of the commitment of workers to the organization. Each session in each company was of four-hour duration and involved eight workers and two facilitators. This article highlights the importance of involving decision-making agents from each company in the reflection and process of finding solutions for their problem. The results suggest that in spite of the inherent differences and distinct features of each company, both have important similarities when tackling the same problem. These similarities could be translated to a general pattern conceptual model, which could be simulated as a generic (model).

Keywords: Group Model Building, Collaborative Modeling, Industry.

1. Introduction

1.1 Group Model Building (GMB) for managerial decision making

The increasingly competitive nature of the global economy has left many organizations searching for new strategies to build capacity and sustainable competitive advantage. Key to achieving this result is an effective decision making process. Competitive organizations require effective decision making. In this context characterized by dynamic complexity, simulations of social

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phenomena have become a scientific paradigm. This corresponds to a framework that creates events which cannot be observed and understood without this science (Sartori R., Ceschi A., Costantini 2015); (Marijn Janssen, Maria A. Wimmer 2015). Decision-makers, such as policy makers, regulators, infrastructure managers, investors, designers, planners, contractors, service providers and operators should take advantage of opportunities provided by simulation in order to build effective decision making models (Respicio et al. 2006).

Decision making processes are fundamental for organizations as they have direct influence on competitiveness and sustainability (Bearth 2015). Therefore, decisions should be made based on evidence, as they are part of more complex systems which are understood to be a set of interconnected interactions. Such a context requires more effective empirical tools to evaluate and predict the consequences of possible decisions (Diaz et al. 2005); (Sterman 2000).

GMB is a form of causal modelling based on system dynamics. Its main strength is its insistence on feedback loops. The different structures within an organization are defined through variables and causal relationships (Stijn Hoppenbrouwers; Étienne Rouwette 2013). Luna-Reyes et al. (2013) define system dynamics Group Model Building as a tool to underpin interdisciplinary theory-building attempts (Luna-reyes et al. 2013); (Rouwette 2000); (Grobler 2013).

GMB is one approach used for developing and simulating formal models of complex systems. The development of such models is characterized by the challenge of achieving effective collaborations whilst dealing with variables such as lack of transparency and inability to assess the hidden assumptions behind a model. In this context GMB is understood as a form of group decision support that involves stakeholders working with a team to solve a focused problem in a complex system (Andersen & Richardson 1997); (G.P. Richardson; D.F. Andersen 1994). GMB, is the phase in which feedback loops are defined.

Patrick (1995) states that dynamic simulation is useful to obtain a better understanding of verbal theories and any unexpected outcome obtained from them. In addition, it contributes to the creation of a synthetic environment to add to our knowledge about a particular phenomenon. In this way it clarifies understanding of decision making dilemmas and provides clearer focus for further empirical research efforts (Luna-reyes et al. 2013); (Patrick 1995); (Forrester 1994).

2. Objectives

The GMB sessions described in this paper were initiated as a result of a project called BATERATZEN. It began in 2010 with the principal goal of aligning people to the strategic needs of the organization, and thus facilitating the development of more competitive organizations. This initiative is supported by the Regional Government of Gipuzkoa (DFG).

The project aimed to assist two SMEs from the Basque industrial sector in order to make more effective decisions in Human Resource Management. Specifically, the objectives now are as follows:

- Compare two GMB sessions with regard to results, effectiveness of the methodology and finding solutions.
- Clarify the differences in definition of outcomes, and provide guidelines for more standardized assessments and reports.
- Assist managers in making more effective decisions and thus retaining worker commitment to the organisation.
- Construct a System Dynamic model based on the two GMB sessions (oncoming task)

3. Methodology

Prior to the GMB sessions, two important steps were undertaken: (i) Planning for the construction conference. One of the facilitators interviewed a number of key people from each company. In these interviews the existence of the problem (commitment to the company) was confirmed, the goal of the GMB workshops was clarified and causal maps of system feedback were defined. In addition, audience and purpose were selected, diverse profiles that are crucial for the daily activity of the company. (ii) Schedule for the day. The public agenda for each GMB session was set to four hours (8.30-12.30).

3.1 Group model building workshops

Two GMB sessions were arranged, one in each of the selected companies. The organisation of these sessions was as follows:

(i) Problem definition. The workshops addressed the same problem in each organisation, so as to facilitate comparison of results. It is important to note that these workshops were developed in “real” organizations with a “real” problem, worker commitment to their organisations. The selected companies are also cooperatives owned by the workers, a factor that may influence decision making and level of commitment. As system dynamics uses modelling at a high level of abstraction, the workshops were limited to defining the causal loops diagrams. The simulation models will be developed as future work by Mondragon Unibertsitatea, in partnership with the companies. (ii) List of variables. Workshop participants were asked to list variables involved in and related to analysis. Variables could be causes or effects of the problem; the relevance lies in the existence of a relationship with the topic of analysis. Lists were drafted individually, and then compared in an opinion exchange. (iii) Identification of influencers. In this step participants chose the influencers that directly influenced

the problem. (iv) Loop creation. Existing loops in the diagram were identified together with their polarities, and names were assigned.

All phases were developed considering the opinions of all participants, and always in consensus. Such agreement is necessary, before adding any concept to the diagrams or defining any loop.

3.1.1 Company A

The Problem definition phase was almost the same for both companies, and involved a brief reflection on the commitment of workers, development of the analysis and definition of time horizon.

Each participant then produced a list of variables related to commitment and then shared them in the opinion exchange, Figure 1.

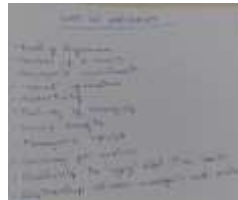


Figure 2. Example of list of variables of one participant in the session

The identification of influencers phase took 1 hour. Most of the influencers were causes (i.e. level or lack of commitment) rather than effects, which required some extra effort on the part of the facilitators to obtain the most accurate and appropriate general diagram, Figure 2.

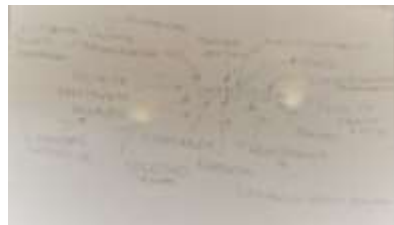


Figure 3. Initial diagram (language chosen for the information phase was Spanish)

The final phase proved the most difficult, due to the abundance of causes rather than effects. A second round review was necessary to obtain two principal loops defining the general structure, main origin of the problem, and its influences.

3.1.2 Company B

Defining the problem and making the individual lists of variables was almost the same for both companies. The most important differences appeared in the process of defining the influences. Company B had fewer variables and thus fewer influencers were identified. The defined variables were causes and also effects of the problem, this situation was really effective in closing the feedback loops, and also identifying the archetypes required for the future task of developing the simulation model, Figure 3.



Figure 4. Initial diagram (Spanish was also chosen for this session)

In the final phase circular feedback loops were identified: five balancing feedback loops (-) and three reinforcing feedback loops (+). All the variables stuck to the wall from the problem definition phase were included in the diagram, indicating that the session was effective enough to include the contributions from all participants.

4. Results

4.1 Company A

The GMB session in Company A was developed with ease due to the commitment to the process from the participants. All participants were volunteers from diverse decision-making roles within the company, but with a shared goal of increasing the competitiveness of their organisation in the context of the highly changeable Basque industrial sector.

Complete agreement is necessary before adding any variable to the general diagram displayed on the whiteboard. The most debatable points for Company A were related to the concept of “reward” and the criteria established for the “evaluation process” of each worker.

The first and principal loop developed in the GMB session referred to responsibility, one of the most notable reasons identified. This has impact on final results, which in turn influences satisfaction (when better results are gained a general atmosphere of satisfaction is created). Finally, the degree of satisfaction

contributes to the overall commitment. Figure 4 shows the loop resulting from this analysis.

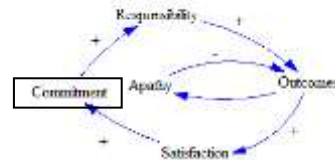


Figure 5. First Loop

The second loop is focused on authority: The type of authority in Company A was linked to management effectiveness (which was negatively evaluated by the group). At the same time, the perceived inexistence of management effectiveness was directly related to a general sensation of “being alone”. Finally, the group identified that workers did not feel supported by their managers (citing the ambiguous answers of managers when requested for help by workers), which leads to a lesser commitment organisation following a specific path that could be seen in Figure 5. The guiding authority in this organisation has demonstrated a tendency to hide problems (directly related to the lack of transparency) which in turn has reinforced a perception of autocratic authority. Participants identified the positive relationship between an effective leadership and the concept of shared goals (the organisation is aligned in respect to strategy and goals). This strategical coherence influences positively commitment.



Figure 6. Second Loop

4.2 Company B

The outstanding feature of the GMB session in Company B was the speed with which the feedback loops were closed. The first part, which focused on finding the causes and effects of the problem, was highly effective as both sides (origin and effects) of all the paths were identified. The key to understanding how commitment could be improved is based on this principal loop in Figure 6.

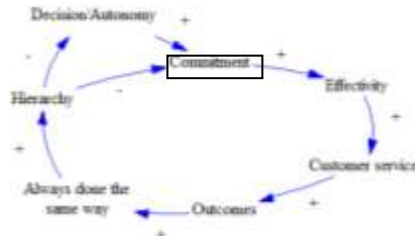


Figure 7. Principal loop

Although different variables are included in the principal loop, the principal factor was identified as “Always done the same way”. Such an approach to managing results in a hierarchical leadership suggests that the decision making of the collective is undermined, leading to a reduction in commitment. At the same time, this philosophy was connected with Taylorism. They stated that this management increases cop-out level of workers. As a result, direction implements some corrective actions such as, order and control. This resolves the problem in the short term however in the expense of the long term.

5. Conclusions

Company A was characterized by the commitment and enthusiasm of the participants, which resulted in the identification of a high volume of “cause” variables for the problem (commitment to the company). This focus on “cause” variables however, resulted in difficulties in defining final closed loops, as the participants did not pay sufficient attention to “consequences”.

In contrast, Company B participants although enthusiastic were more balanced in their approach, and achieved both balancing and reinforcing loops, which will facilitate future work in the construction of a simulation model.

Both sessions analysed in this work have demonstrated the effectiveness of GMB workshops in involving stakeholders in the process of modelling, reflection and seeking solutions. The methodology of this approach implicates the participant in the problem, which effectively captures their attention and increases motivation. In addition, both workshops have proved robust enough to obtain the necessary information to build a reliable simulation model, which is the objective of future work in this project.

Effectiveness of workers has been defined as a direct consequence of feeling committed or not. In both cases type of management has been identified as a crucial influencer for commitment (Authority/Hierarchy). In the line of type of management, Taylorism has been identified as an obstacle for improving commitment for those two companies. Thus, the comparison between the sessions has been extremely useful in identifying similarities between companies from the

same sector. This identification is also the key to creating a standard and transferable template, which will form the basis of the final simulation model, to find solutions for industrial sector companies with the same problem.

Acknowledgements

We would like to thank the Regional Government of Gipuzkoa (GFA) for their support in the development of this project. Special thanks to the Department of Economic, Rural and Territorial Development of GFA in the context of BATERATZEN (OF-267/ 2015).

References

- Andersen, D. & Richardson, G., 1997. Scripts for group model building. *System Dynamics Review*, 13(2), pp.107–129.
- Bearth, M.A., 2015. *Employee Contributions to Organizational Decision-Making Processes and Outcomes*.
- Diaz, R.M., Pichler, F. & Arencibia, A.Q., 2005. Theory Building with System Dynamics, EUROCAST 2005. *10th International Conference on Computer Aided Systems Theory*.
- Forrester, J.W., 1994. System dynamics, systems thinking, and soft OR. *System Dynamics Review*, 10(2), pp.1–14.
- G.P.Richardson; D.F.Andersen, 1994. Teamwork in group model building. *System Dynamics Review*, 11(2), pp.113–137.
- Grobler, J.D., 2013. *Diversity in Decision Making for Competitive Advantage*.
- Luna-reyes, L.F. et al., 2013. Group Model Building to Support Interdisciplinary Theory Building. *International Conference of the System Dynamics Society*, pp.1–17.
- Marijn Janssen, Maria A.Wimmer, A.D., 2015. *Policy practice and digital science: Integrating complex systems, social simulation and public administration in policy research*.
- Patrick, S., 1995. The dynamic simulation of control and compliance processes in material organizations. *Social Perspective*, 38(4), pp.497–518.
- Respicio, A., Antunes, L. & Balsa, J., 2006. Decision Support for Public Tax Policies through Social Simulation.
- Rouwette, D.F.A.J.A.M.V.G.P.R.E.A.J., 2000. Group Model Building: Problem Structuring, Policy Simulation and Decision Support.
- Sartori R., Ceschi A., Costantini, A., 2015. On decision processes in businesses, companies and organizations computed through a generative approach: The case of the agent-based modeling. *International Journal of Business Research*.
- Sterman, 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*.

Stijn Hoppenbrouwers; Étienne Rouwette, 2013. A dialogue game for analysing group model building: framing collaborative modelling and its facilitation. *Radboud Repository*, p.144.

Queuing Theory and Simulation Applied to Arrival Train Process at Port of Ponta da Madeira

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Abstract This paper approaches the application of queuing theory and simulation, in the arrival train process at the Port Terminal of Ponta da Madeira, which aimed to analyze the behavior of the arrival of trains and discuss the impacts of non-linearity of arrival for the productive process of the port. This paper used as technical procedure the case study, to understand the application of theoretical concepts in a practical situation. At the end of the work it was possible to verify the impacts generated in production due to behavior of intervals of the arrival of trains in the port terminal.

Keywords: Queueing theory; Operational research; Port operation.

1. Introduction

Within several techniques used in analysis process, the queuing theory has been emphasized in context of system representation where it can characterize queues by mathematical analysis. Several issues are fitted in this context, from productive

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process in queues, traffic flows and services. The queuing theory provides models for demonstration of the system behavior, allowing adequate sizing, in order to better serve the objectives of the system studied.

In the conjecture of Brazilian economy, the commodities exportation represents a large economic contribution. In the mining and logistic area, the use of technologies is a common circumstance, stimulating the need of ways for the best application of it, aiming at the maximum efficiency of the systems that contemplate this area.

Vale S/A is the largest iron ore producer of the world, containing many logical systems for its production flow. The named “Norte” system is responsible for moving material removed from the Carajás mine, in Pará, transporting through Carajás Railroad to Port Terminal of Ponta da Madeira, in São Luís, Maranhão.

Ponta da Madeira Port Terminal receives around 40 lots of wagons every day, each standard lot has 110 wagons being unloaded in 6 different ways, with large variability in the arrival of loads, which differ in material, quantity and type of wagons loaded, among other features. The application of the concepts of queuing theory is feasible to the proposed study, as it can be characterized as a system of queues containing multiple channels.

Considering the topic addressed by this work, this paper has as research problem: How could the application of queuing theory and simulation contribute for the analysis of the arrival process behavior at a port terminal? Such questioning must require mechanisms of observation and information gathering able to allow that the subject studied reaches the general aim of the research that is: To verify how the application of queuing theory and simulation could contribute for analysis of the arrival process behavior at a port terminal.

2. Theoretical Fundamentals

In this topic, theoretical aspects are provided to support the research, structured in “The operational research in organizational processes” and “Queuing theory and Simulation” issues.

2.1 The Operational Research in Organizational Processes

Operational Research emerged between 1939 and 1945 in England during World War II to solve logistical, tactical and military strategy problems when a group of scientists was called to decide about the most effective use of scarce military resources. In general, the Operational Research consists in use of scientific methods through mathematical, statistical and computational algorithms models to support decision making. (Fávero and Belfiore 2013, p. 1-2)

Operational research, also known as Management Science, is constantly expanding, using some models for its application like queuing theory. The waiting

lines (queues) models are used to improve the efficiency of facilities where the demand, the time event, the interval service and the client behavior when approaching to be received or waiting in the queue are the variables characterized by probability. (Moreira 2013, p. 27-28)

The mathematical approach of the queues began in the XX century (1908), with A. K. Erlang, from the application of mathematical concepts in scaling of telephone switchboards. It was only after World War II that the theory was applied in other queuing problems. (Prado 2009, p. 20)

According to Moreira (2013, p. 28-29), the most important area of application of mathematical models for process analysis is the production and operations area. The Table 1 illustrates the use of mathematical techniques in 125 great corporations in the production area.

Table 1. Use of Mathematical Techniques (% respondents). Adapted from Moreira (2013, p. 29)

Técnica	Nunca Usada	Uso Moderado	Uso Frequente
Análise Estatística	1,6	38,7	59,7
Simulação	12,9	53,2	33,9
PERT/CPM	25,8	53,2	21,0
Programação Linear	25,8	59,7	14,5
Teoria das Filas	40,3	50,0	9,7
Teoria dos Jogos	69,4	27,4	3,2

The Table 1 is a result of the study achieved in companies of the USA (1983), where is possible to notice that 50% of the analyzed companies present a moderate use of the queuing theory for processes modeling. Despite the existence of more widespread techniques in organizational environment, it is noted the relevance of queuing theory, therefore, numerous scenarios fit this model, from manufacturing to mining companies.

2.2 *Queuing Theory and Simulation*

According to Prado (2009, p. 19), queuing theory is an analytical technique that extends the theme through mathematical formula. For Hillier and Lieberman (2010, p. 746), queuing theory is the study of queuing behavior in different contexts, using mathematical models to simulate the several types of queuing systems that emerge in practice.

According to Prado (2009, p. 20), system modeling has diversified applications, from production in an industry to the documents movement in an administrative

area. Still according to the author, the modeling of queues began to be used in rail transport over the years.

In rail transport, the repair and service yard presents interesting problems, which include the number and location of deviations and allocation of service machines (based on a chart of trains and cars to be removed or added), as well as the schedule of direct trains that passing by the local. On the other hand, the rail system can be analyzed as a whole, in order to minimize the movement of empty cars.

The main elements that compose a queuing system are: (1) customers, which arise through a certain population and are those who form a queue and wait for some service, the term customer is used in a generic way and can designate person, train or ship; (2) queue, represent customers who waits for service; (3) service, consisted by one or more servers that perform the expected service. (Prado 2009, p. 23)

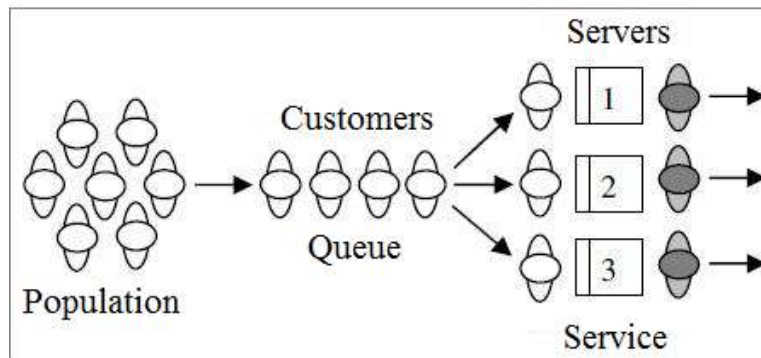


Figure 1. Elements of a Queue. Adapted from Prado (2009, p. 24)

The operation of each queue corresponds to mathematical formulations for each model, even the average wait time that will occur, in a sequence of situations. Therefore, these queue models are really important to determinate how to operate a queuing system in a way that minimizes the cost of services and waiting.

3. Methodology

According to Barros and Lehfeld (2000, p. 1), methodology corresponds to a set of procedures to be used to obtain knowledge, it is application of the method through processes and techniques that assure the legitimacy of the knowledge acquired. Still according to the author, method is the orderly and systematic way to approach an end, where the plan of scientific methodology, methods, technical procedures and referential are indispensable components in the investigation.

The research used as technical procedure the case study, focused on the collection and registration of information about one or several specific cases, elaborating critical, organized and controlled reports, allowing decisions and interventions about the object of investigation. The case study can be divided into: organizational histories, when it is about an institution that is to be examined; Observational, connected to qualitative and participant research; and case study, as a research technique performed through the evaluation of collected and documented data. (Barros and Lehfeld 2000, p. 95).

After the data collection and analysis, the simulation systems will be applied as methodology. According to Prado (2009, p. 100) it is a methodology that proposes to represent a real system, composed by two main stages: (1) Construction of the current situation model, that will reproduce in a computational model the situations in the current system; (2) Inclusion of changes in the current model to reflect desired future situations, where changes can be made in the model of step 1 in order to verify the viability of changes. For this study, the focus will be on step 1, different situations will be simulated aiming to analyze the current system and identify constrains and optimization opportunities. For analysis and discussion of results, an approach will be used from the concepts of descriptive statistics, as a tool for comparison and observation results, data and information resulting by research.

4. Case Study

The study was developed within a management of port operations, in the Vale S/A company at Port Terminal of Ponta da Madeira, located in São Luís – MA. The company has strong relevance in national scenario, especially in mining and logistic area. Currently, the unloading operation receives around 40 lots of wagons every day of the Carajás mine (Brazil), which is currently considered the largest open-pit mining in the world.

All the production is unloaded with eight wagon tippers, that has variables maintenance regimes due to the operating routines.

5. Results Achieved

The data were modeled by adhesion test, using the Input Analyzer tool, presenting adherent behavior to the negative exponential curve. Using the modeled data, it was simulated 4 different Situations, for one operation day, considering: 8 wagon tippers available for Operation; 7 wagon tippers available for Operation; 6 wagon tippers available for Operation; 5 wagon tippers available for Operation.

With 8 wagon tipplers in operation, the unloading capacity attends the current behavior of the supply, but using the behavior modeled by turn, the arrival concentration in the 15x23 turn generates queue in the system and incompatibility between supply and unloading, which could cause impact on the next turn.

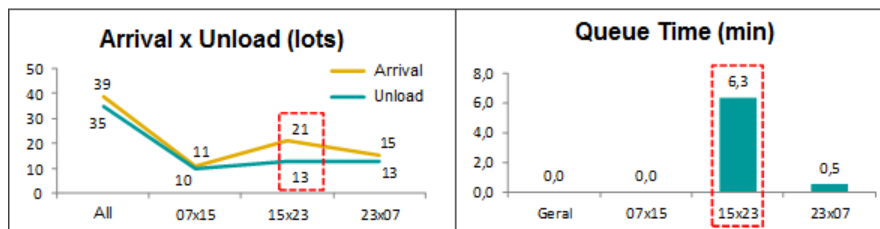


Figure 2. Simulation results of the situation I.

With 7 Wagon tipplers in operation, the unloading capacity still attends the current supply, and the same impacts are observed from the arrival concentration in the 15x33 turn. The simulation with 7 WTs allows to state that for the current supply only 7 WTs would be sufficient to serve the unloading.

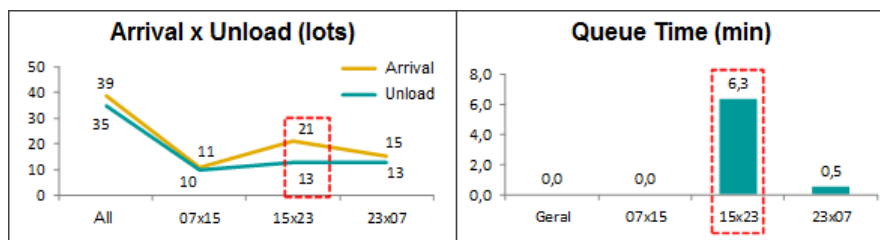


Figure 3. Simulation results of the situation II.

With 6 wagon tipplers in operation, the unloading capacity partially attends the supply, requiring more assertive operation to fulfill the supply. The concentration impacts on the 15x23 turn for this situation increase and also become evident in the 23x07 turn, becoming a critical factor for the fulfillment of the supply.

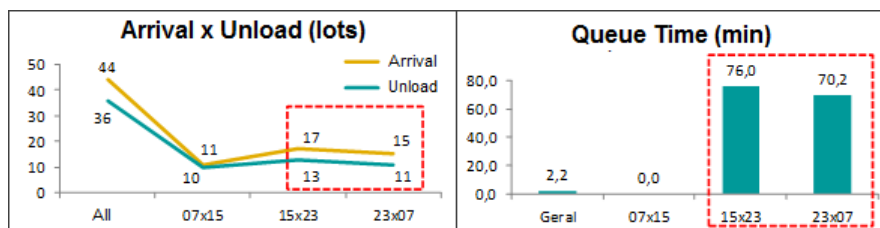


Figure 4. Simulation results of the situation III.

With 5 wagon tipplers in operation, the unloading capacity partially attends the supply, requiring more assertive operation to fulfill the supply. All the turns have

important queue time, the fulfillment supply to this situation will be strongly related to the arrival behavior through the turns.

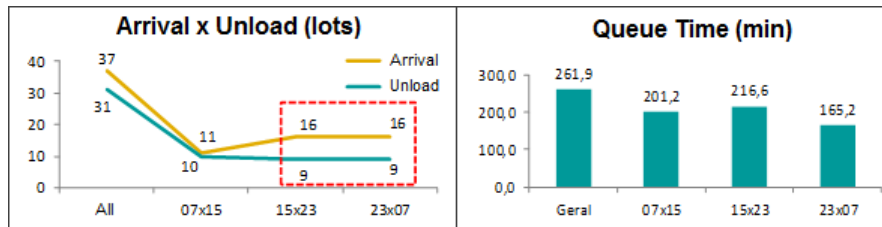


Figure 5. Simulation results of the situation IV

6. Final Considerations

At the end of the research it was possible to conclude that the application of queuing theory and simulation to analyze the arriving train process in the port terminal allowed to provide subsidies and information with more precision to the decision makers involved in the process, positively contributing to management and control of production in the studied system. It was observed that the current capacity of unloading attends the current supply behavior in theoretical terms, but the variability of process can still generate gaps and impacts in production.

Future analyses using simulation method can provide important subsidies for operational decision making. From the research made in this paper, several future approaches come to light, such as: the application of simulation for others parameters analysis, as well as implementation of others operational research techniques for similar problems.

References

- Barros AJS, Lehfeldd NAS (2000) Fundamentals of Scientific Methodology. Pearson Education, São Paulo.
- Fávero LP, Belfiore P (2013) Operational Research for Engineering Courses. Elsevier, Rio de Janeiro.
- Hillier FS, Lieberman, GJ (2010) Introduction to Operational Research. AMGH, Porto Alegre.
- Moreira DA (2013) Production Management and Operations. Cengage Learning, São Paulo.
- Prado DS (2009) Queuing Theory and Simulation. INDG Tecnologia e Serviços. Nova Lima.

Data Mining Association Rules Applied to Supermarket Transactional Data Modeling: a case study in Brazil

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Abstract The discovery of association rules is a data mining task that has been studied since the early 1990s. A major application of these rules is the Market Basket Analysis (MBA). In this type of problem the goal is to search for patterns in consumer behavior, acquiring knowledge of what products are usually brought together in a single purchase. The knowledge can be used to support decision-making on operational and strategic levels. The growing interest of researchers in this area is due to both practical use and the difficulties and limitations present in this type of analysis. Yet real applications are still few. The objective of this paper is to conduct a market basket analysis through association rules mining on transactional data from a typical supermarket and hold a discussion on the applicability of the technique. The technique used in this study proved capable of generating large amount of useful knowledge for decision making. The definition of a specific focus proved to be crucial to the success of the analysis.

Keywords: market basket analysis, association rules, data mining;

1. Introduction

During years, predominantly manual methods had been used to transform data into knowledge. With large datasets, these methods were dispendious, both in financial terms and time consumption. The analysis was subjective and in most of the time impracticable (Fayyad et al., 1996). The search for efficient and faster methods for acquiring knowledge from the dataset stimulated the research in the area, that is now known in the literature as Knowledge Discovery in Database (KDD) and Data Mining.

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The discovery of association rules is a technique of data mining that is being studied since the beginning of the decade of 1990. The association task look to characterize how much the presence of a set of items in the registers of a database implies in the presence of some another distinct set of items in the same register (Agrawal and Srikant, 1994). According to Piatetsky-Shapiro (2007), great success was achieved in the performance improvement of the association fetching algorithms rules and many of them had been widely accepted, but applications in real problems are still few.

One of the main applications of the association rules is in the Market Basket Analysis (MBA). In this kind of problem the goal is to search behavior patterns of the consumers, acquiring knowledge, for example, of which products they choose to be led together in the same purchase (Silverstein et al., 1998). The knowledge acquired through an analysis of the consumer basket purchase can be used to support decisions in operation and strategical levels. According to Chen et al. (2005), the MBA can help the organization managers in the layout project, e-commerce, mix of products and other marketing strategies.

Analytical tools for decision aid are helping retail to conquer new customers and to keep loyalty those that already they possess. According to Grewal and Levy (2007), the utilization of data analysis techniques for the retail decision aid related to the CRM (Customer Relationship Management) in general and for rewards programs in particular represent new and promising areas for academic research.

The objective of this article is to carry through an analysis of purchase basket through association rules mining on transactional data from a typical Brazillian supermarket and to carry through a quarrel on the applicability of this type of task of data mining. In Section 2 will be explained the involved concepts in the process of data mining and the concept related to the association rules. In Section 3 will be displayed the process on how the data from the market basket was obtained and processed to acquire the results. The applicability of the technique is also argued. Finally, in the Section 4, the final conclusions and considerations are described.

2. Theoretical Foundation

2.1 Association Rules Mining and MBA

Through the last 10 years the data mining evolved, having been influenced for external forces, such as the growth of the electronic commerce and great progress in molecular biology. New research are appeared, such web mining, and open source software were developed, as the WEKA, what led to spread of data mining applicability (Piatetsky-Shapiro, 2007).

2.2 Knowledge Discovery in Database (KDD)

Fayyad et al. (1996) defines the process of knowledge discovery based on data being the identification process of valid patterns, new, and potentially useful and understandable. The KDD Stages can be summarized, according to the authors:

- Selection: database attainment - or variables subgroup and samples on which the discovery process will be applied.
- Preprocessing: accomplishment of basic operations, as noise removal and definition of strategies to deal with missing, incomplete or inconsistent data.
- Transformation: possibly necessary operations: summary, generalization, normalization and attribute creation. The dimension reduction can be applied or another method to reduce the number of variables.
- Data Mining: data mining algorithm application on the dataset.
- Interpretation/Evaluation: evaluation of the results by a specialist in the area, or by knowledge measures already in the literature.

2.3 Association Rules

The discovery of association rules is a data mining technique that has received great attention from researchers. According to Hipp et al. (2002), the association has become a very popular mining technique due to its applicability to business problems with its inherent understandability, because even not experts in data mining can understand them.

An association rule is represented as an implication in the form of LHS \rightarrow RHS, so that LHS and RHS are respectively the previous (Left Hand Side) and the resulting (Right Hand Side) rule. Association rules were defined by Agrawal and Srikant (1994) as:

“D is a database consisting of a set of items $A = \{a_1, \dots, a_n\}$ ordered lexicographically, and a set of transactions $T = \{t_1, \dots, t_n\}$, where each transaction $t_i \in T$ is composed of a set of items (called itemsets) such that $t_i \subseteq A$. The transaction t_i supports the itemset X if $X \subseteq t_i$. The support $P(X)$ of an itemset X represents the probability of occurrence of event X.

The association rule is an implication in the form LHS \rightarrow RHS, in which LHS $\subset A$, RHS $\subset A$ e LHS \cap RHS = \emptyset . The rule LHS \rightarrow RHS occurs in the set of transactions T with confidence conf and support sup, where $P(\text{LHS}, \text{RHS})$ represents the support rule (the likelihood of the transaction LHS \cup RHS) and $P(\text{RHS} | \text{LHS})$ the confidence of the rule (the conditional probability RHS given LHS)”.

2.4 Market Basket Analysis

A major application of association rules is in the market basket analysis (MBA). Marketing research has been directed to the analysis of the co-incidence of

multiple categories of products in different shopping, in order to plan marketing activities so that maximum profit is achieved. Retailers typically have to make decisions about which products put on sale, how and when.

According to Solnet et al. (2016) the basic idea underlying Market Basket Analysis is that consumers rarely make purchase decisions that are isolated. For example, when shopping in a supermarket, customers rarely buy one product; they are far more likely to purchase an entire basket of products, typically from different product categories. Using information about peoples market baskets allows data analysts to not only extract which products and product categories tend to be purchased together, but also to determine which of the products or product categories are drivers for purchasing certain products. This knowledge enables managers to develop interventions aimed at influencing purchasing behavior, including stimulating demand overall, promoting specific product categories, or offering promotions for driver products which are likely to increase overall spending per purchase.

According to Chen et al. (2005) the market basket analysis is a useful method of discovering customer-purchasing patterns by extracting associations or co-occurrences from stores transactional databases. Because the information obtained from the analysis can be used in forming marketing, sales, service, and operation strategies, it has drawn increased research interest. The research and discovery, for example, that supermarket customers are likely to purchase milk, bread, and cheese together, can help managers in designing store layout, web sites, product mix and bundling, and other marketing strategies.

According to Groth (2000), the MBA can be applied to: cross-selling analysis; layout definition; product catalogs design; leadership loss analysis; definition of price and product promotions; among others. These applications are based on the belief that sales of different product categories are correlated. For example, a promotion of beers could increase the sale of peanuts.

3. Data Modeling

Following the model proposed by Fayyad et al. (1996), a supermarket was selected and all its transactions were stored in a relational database where, through SQL (Structured Query Language) was possible to perform advanced queries and then obtain the necessary information needed, for example: year, month, day of month, day of the week and the time the purchase was made and what products were obtained, what was the quantity purchased, the payment method, etc. A four months data window was selected (January, February, March and April). Table 1 shows the extracted information of each purchase made in this period.

Table 1. Extracted Information from Supermarket database

Information (<i>Y</i>)	Description (<i>X</i>)
Month	January, February, March or April
Month day	1, 2, ..., 31
Weekday	Sunday, Monday, Thursday, ..., Saturday
Day period	Morning, Afternoon, Evening
Day type	Normal, Holiday Eve, Holiday or Post-holiday
Value of Purchase	Total purchase price in Reais (BRL)
Shopping Basket Items	Example: apple, carrot, ...
Categories	Example: Fruit, Chocolates, ...

After the construction of the data file, a manipulation of the data was done in order to extract some basic information characterizing the purchases that are made at the supermarket and also to verify the quality of the data that have been selected and extracted. A table was created from the data file, where each line represents a purchase and each column the variables of this purchase (month, day, value, products, categories, etc.).

The first information retrieved from database was the volume of purchases made during supermarket first quarter. It was also noted that the purchasing volume changed according to the day time: morning, afternoon and evening. It has been found that there is an increased purchases in the morning, then afternoon and finally the period of night with a smaller volume.

By observing the total value of considered purchases made in these four months, it was revealed that approximately 96% of these purchases (245.042) are less than or equal to R\$200.00 and are responsible for approximately 62% of total sales in the period. It is a supermarket characterized by small purchases. Approximately 90% of purchases are less or equal to R\$100.00 and are responsible for approximately 43% of the total revenue.

In the analyzed period, a total of 2,398,050 products was purchased with 13,114 different products in 184 different categories.

The Apriori algorithm was used to generate the association rules and find all frequent k-itemsets contained in a database. This algorithm generates a set of candidate k itemsets and then seek the database to determine if they are frequent, thereby identifying all frequent k-itemsets. The main feature of this algorithm is its downward closure. Through the apriori-gen function, the algorithm seek the database looking for the of frequent 1-itemsets, that is, those itemsets with only one item, and that satisfy the minimum support.

The next step is the discovery of 2-itemsets that satisfy the minimum support. Now, instead of the algorithm go through the entire database, it covers only the frequent 1-itemsets discovered in the previous step, as the support is always the

same and then the 2-itemsets can only come from above. This procedure is based on the fact that an x-itemset has minimal support, then all subsets also have to. Likewise are generated 3-itemsets and so on. This property makes that is not necessary to go through the entire data set thus optimizing the generation task of frequent itemsets.

Table 2. Example of table created from the data file

Month	Day	Weekday	Period	Type	Value	Product 1	Category 1
January	2	Friday	Morning	Pos-h	23,84	Coca Cola 2L	Soft Drink
January	2	Friday	Morning	Pos-h	16,94	Hot Dog Sausage	Bakery
January	2	Friday	Morning	Pos-h	169,2	Cocamar Soybean	Oils
January	2	Friday	Morning	Pos-h	118,53	Mant. Orange 2L	Soft Drink
January	2	Friday	Morning	Pos-h	67,21	Sucrilhos	Cereal
January	2	Friday	Morning	Pos-h	95,24	Floresta Coffee	Coffee
January	2	Friday	Morning	Pos-h	156,56	Onion 500g	Vegetable
January	2	Friday	Morning	Pos-h	163,98	Ades Peach	Juices
January	2	Friday	Morning	Pos-h	2,35	Red Eggs	Bakery
January	2	Friday	Morning	Pos-h	10,47	Fructis Cond.	Hair Conditioner
January	2	Friday	Morning	Pos-h	3,82	Bread	Bakery
January	2	Friday	Morning	Pos-h	1,79	Pineapple Sweet	Candy
January	2	Friday	Morning	Pos-h	76,76	Bauducco Toast	Toast
January	2	Friday	Morning	Pos-h	210,06	Knuckle	Beef

The association rule mining algorithms generates as a result rules like:

$$\langle \text{beer} \rightarrow \text{peanut}; \text{sup}=20\%; \text{conf}=40\% \rangle$$

This means that in 20% of all purchases made, beer and peanuts were purchased together. Considering now only purchases in which there was beer, in 40% of these also occurred peanuts.

The number of rules generated depends on the amount of purchase, quantity and attributes considered, specified as support and minimum confidence. In most cases this number becomes impracticable to observe all the generated rules.

For post-processing in order to transform the information into knowledge, the lift was used as evaluation measure. This measure also known as interest, is one of the most used to evaluate dependencies between itemsets (Silverstein et al., 1998). Given an association rule $A \rightarrow B$, this measure indicates the more frequent becomes B when A occurs. The lift valor is calculated by equation 1:

$$\text{lift}(A \Rightarrow B) = \frac{\text{conf}(A \Rightarrow B)}{\text{sup}(B)} \quad (1)$$

If $\text{lift}(A \rightarrow B) = 1$, then A and B are independent. If $\text{lift}(A \rightarrow B) > 1$, then A and B are positively dependent. If $\text{lift}(A \rightarrow B) < 1$, A and B are negatively dependent.

This measure varies between 0 to infinite, and has quite simple interpretation: the higher the lift, the more interesting the rule is, because A lifted B at a higher rate. For example, it means that B has 5 times more likely to occur when A occurs.

The lift ≥ 2 parameter was set to include only the interesting rules, i.e. rules were only considered in which B had at least twice more chance to happen when A occurs. This has reduced the number of interesting rules but it was necessary to also observe the support and confidence of the rule to choose an interesting set of rules.

The final rule set was obtained through trimming, specifying a minimum lift equal to 2 and also by observation of support and confidence values of the rules. Knowledge was generated from rules showing some behavior unknown by experts and other with obvious behavior or already known, but still rather interesting to measure.

4. Results and Discussion

The aim of this study was the market basket analysis of purchases by mining association rules on transactional data from a supermarket in order to provide greater insight into the buying behavior of their customers and discuss the applicability of the technique. The existence of a structured database, noise free and organized proved crucial to the analysis. A database with these characteristics facilitates the pre-processing of the information and makes it possible to generate quality results that accurately represent customer behavior.

This research applied the association rule mining technique in modeling of data from a typical supermarket in order to generate knowledge. A large number of patterns that could be used to decision aid have been found. The association mining rules was most helpful when a specific problem was proposed reducing the number of rules. This provided a focus to the analysis, reducing the search field of information and reducing the number of generated patterns.

A problem encountered in this type of study is that the reporting (and the execution method) and the decision-making are usually not made by the same person. Usually, the responsible for generating the report does not know what information is crucial to the decision maker and does not know how to extract really useful information to the decision-making process; spending time and money to generate some useless reports. The association rules technique also has the advantage of being easy to interpret. It only takes a few basic statistical fundamentals to understand what can be extracted as a result of an application. The most difficult is to know what information is interesting for making a decision.

In short, the association rule mining technique provides an accurate summary of how the items are related. For future work a great inclusion to be explored is the

use of loyalty cards where the customer can be identified in terms of age, sex, marital status, income, address, among others characteristics; a multivariate Bayesian forecast could also provide interesting insights about the stock and sales.

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References

- Agrawal R, Srikant R (1994) Fast algorithms for mining association rules in large databases. In: Proceedings of the 20th International Conference on Very Large Data Bases. VLDB '94. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, pp. 487–499.
- Chen Y, Tang K, Shen R, Hu Y (2005) Market basket analysis in a multiple store environment. *Decis. Support Syst.* 40 (2), 339–354.
- Fayyad U, Piatetsky-shapiro G, Smyth P (1996) From data mining to knowledge discovery in databases. *AI Magazine* 17, 37–54.
- Grewal D, Levy M (2007) Retailing research: Past, present, and future. *Journal of Retailing* 83 (4), 447 – 464.
- Groth R (2000) *Data Mining: Building Competitive Advantage*. Prentice Hall PTR, Upper Saddle River, NJ, USA.
- Hipp J, Guntzer U, Nakhaeizadeh G (2002) Data mining of association rules and the process of knowledge discovery in databases. In: *Industrial Conference on Data Mining: Advances in Data Mining, Applications in E-Commerce, Medicine, and Knowledge Management*. Springer-Verlag, London, UK, UK, pp. 15–36.
- Piatetsky-Shapiro G (2007) Data mining and knowledge discovery 1996 to 2005: overcoming the hype and moving from “university” to “business” and “analytics”. *Data Mining and Knowledge Discovery* 15 (1), 99–105.
- Silverstein C, Brin S, Motwani R (1998) Beyond Market Baskets: Generalizing Association Rules to Dependence Rules. *Data Mining and Knowledge Discovery* 2 (1), 39–68.
- Solnet D, Boztug Y, Dolnicar S (2016) An untapped gold mine? exploring the potential of market basket analysis to grow hotel revenue. *International Journal of Hospitality Management* 56, 119 – 125.

Optimization of the industrial layout of a metallurgical using Tabu Search Metaheuristic and the FacPlan method: Analysis of the productive flow and departmental área

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Abstract The Generation of an Industrial Layout is a combinatorial problem that consists in determining the physical location of departments, in a way that the productive needs are satisfied. This departmental demarcation has a degree of complexity that makes it difficult to apply exact methods to obtain a solution in an acceptable time. This article presents one solution for layout optimization through the application of the Tabu Search Metaheuristic, working with the FacPlan (Factory Planning) method, which is a layout methodology planning. The strategy for solving the problem contemplates constraints that limit the productive flow with its affinities and the size of the departmental areas through the methodological concepts proposed in FacPlan. Our model covers more realistic aspects of the problem. With the combination of classical methods of layout planning and combinatorial optimization, more robust solutions are presented to address the productive needs of the industry.

Keywords: Industrial Optimization, Industrial Layout, Metaheuristic, Tabu Search, FacPlan.

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1. Introduction

The industries invest time and money in techniques, tools and ways to reduce the costs in their production processes. It can be possible improve the production using the same resources as before, changing the physical arrangement of departments in the company. In other words, the objective is optimize the flow of materials or/and people, and keep the quality of their products, what affects positively the production costs in a short and long term (Graziani, 2013).

This work shows a layout optimization where we use one Tabu Search implementation (TS), an improvement Meta Heuristic algorithm that exploits a neighborhood and interactively selects good solutions. We also made use of the FacPlan method, a layout planning methodology. The layout optimization presented in this article was applied to a Spanish metallurgical stamping and manufacturing of metal parts company, aiming gathering the best way of allocating the departments.

The efficiency we have obtained by using our heuristic procedure, allow a crescent increase in the use of these procedures. This work has two important objectives:

- Evaluate the feasibility of the Layouts optimizations using the TS *Meta Heuristic*;
- Propose an increase in layout planning with our optimization technique.

This study has been accomplished in a metallurgical company located in the province of Zaragoza, Spain, in which are produced many item parts, molds, metallic forms and other products that are sold to the automotive market and to national and international clients.

2. Problem Description

Industrial Engineers are constantly searching for methods to improve the production flow. Their objective are avoid some project failure and achieve quality through the improvement of the processes and areas, reducing costs with rationalization of floor plan resources (Gerlach, 2013).

This problem consists in the layout optimization of one industry. It must guarantee that the flow of processes does not have production bottleneck and do not have unnecessary stops. An improvement in work safety and an increase in the industry profit with the new productive arrangement are the main goal, considering the available departmental areas and the relationship among the manufacturing sectors.

Authors as Dominguez et al. (2004), Martins at al. (2003), and Sandri et al (2013) used optimization of layouts using Meta Heuristics algorithms in a relevant manner

with significant results. A reducing in distance traveled by workers, and an improvement of 30% compared with their initial solution.

The main contributions of this paper are permit the use of this methodology in a variety of layout problems, in terms of optimizing them, allowing the insertion of an alternative method to solve departments allocation issues.

3. Methodology

This search is classified as basic nature because it looks for the solution of a specific layout problem with specific constraints (Prodanov, 2013). The objective has an explanatory experimental classification, and it is the improvement of reality through the control and manipulation of different variables (Gil, 2002). It is classified as quantitative and qualitative research, because the algorithms are used to solve the problem and translate physical constraints into mathematical equations, thus, representing the reality of the problem studied (Nicolau, 2013). The technical procedure adopted in this work uses mathematical modeling and computer simulation, classified as modeling and simulation (Turrione, J, Mello, C, 2012). The necessary data for modeling the program as well as the understanding of the operation of the industry were collected through meetings with the supervisors responsible for production, maintenance and observation of the production routine of the industry, such as the production flows of certain parts. The data were also obtained from analysis of blueprint and departmental floor plan in a CAD document and we used a bibliographic research to accomplish our search.

3.1 FacPlan

Lee (1997), proposed a layout planning method that covers 5 levels or phases. They are: (I) global location, (II) supra space planning, (III) macro space planning, (IV) micro space planning and (V) sub-micro space. The phase I, has the determination of the geographical area where can be installed the new layout; in phase II, we have the general organization among the various areas planning space size, location of buildings, issues of necessary resources such as water, gas and energy; the phase III details planning of the location of machinery, equipment, all necessary structure for production, establishing material flow patterns, movements and determining SPU (Space Planning Units); the phase IV, the specific location of equipment and machines is determined by means of the connections defined in the previous phase. For the author, in this last phase the social-technical connection is of extreme importance. The phase V will define the organization of the individual workspaces considering efficiency, effectiveness and security.

3.2 Tabu Search

The Tabu Search algorithm (TS) is a Metaheuristic procedure that explores a search space through different solutions that were not found in a previous search. The advantage of this method is that it is a non-monotonic search. It has an adaptive memory that prohibits the search to visit previous solutions in a solution neighborhood, avoiding the cycling process (Lieberman, 2013; Dias, 2015).

Diversification and intensification are characteristics of the method, ensuring confidently that the algorithm has searched a lot of areas in the search space before arriving at the final solution (Glover; Laguna, 1997). At each iteration of the Tabu Search to prevent a movement from being exported in the next “tabu tenure” (TT) iterations, some attributes of the last solution are saved in the Tabu List (TL), avoiding that the same solution is reached during the next TT (Lai; Hao, 2016). A good idea to define the TT value is adopting it as a variable size and making it different at each iteration. This guarantees a better evaluation in the search space because if the TT be too small, is possible that the search back to one solution recently reached, causing cycling, and if it be too large, the search can be blocking some attributes that maybe are parts of the optimal solution.

In the TL, there are a set of solutions that the method does not want to examine in the next iterations. In every iteration, the last element from the TL has its TT decremented, and when the TT becomes zero (0) the solution may be reached again, and so a new different neighborhood can be created and the search can follow in a different path to some best solution. Therefore, the TS can be seen as a Variable Neighborhood Search (VNS) because it goes on until some stop criteria is reached. In other words, the procedure does not have a better solution during a certain number of iterations, or, if the maximum number of iterations is reached (Gomes, 2009).

4. Results and Discussion

In the first stage of our layout optimization work, we applied some activities corresponding to the level III (Macro) of FacPlan method.

We build a flow matrix by measuring the physical space and floor plan of the departmental layout. The SPU were organized into rectangular blocks. From this, we extracted our initial solution, by considering the layout as a cartesian plane, and the central coordinate (x, y) of the departments were used to calculate the Euclidian distance among them, and so, organizing them in another matrix. We call it the distance matrix.

We used the Quadratic Assignment Problem (QAP) to handle our problem. It is defined that for a set of n facilities, must have n localizations, in such a way that

one facility i is allocated to one localization j , for all i and j . The QAP can be expressed as the following equations:

$$MIN Z = \sum_{i=1}^n \sum_{j=1}^n F_{ij} D_{ij} \quad (1)$$

$$\sum_{i=1}^n X_{ij} = 1, j = 1, 2..n \quad (2)$$

$$\sum_{j=1}^n X_{ij} = 1, i = 1, 2..n \quad (3)$$

$$X_{AB} = 1 \quad (4)$$

$$X_{ij} \in (0, 1) \quad (5)$$

The first is the objective function and F is the flow matrix, D is the distance matrix and C is the cost matrix. The second equation guaranties that the facility i must be assigned to only one localization j . The third equation defines that the localization i has only one department j assigned. The fourth defines that any fixed department from A (where A is a set of departments) is assigned to one location from B (where B is a set of localizations). The last one defines the problem as an integer problem programming.

The implemented TS procedure worked to find a good physical organization for the 26 departments from the metallurgical, from whose 5 are fixed to specific places, which were defined by their actual layout organization. We built our own software using C programming language. Our Tabu Search Algorithm was compiled and executed in an Intel Core i3 2.20GHz machine running Debian 8 as operating system. We evaluated it many times and the average of execution time to find a good solution was about 65 seconds, considering the size of this layout. The solution found by our search made the solution closer to reality because we used the TS and the FacPlan method and real data, gathering more confidence to the solution.

DEPARTMENTS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Metal press 1	1	0																									
Metal press 2	2	1	0																								
Metal press 3	3	1	1	0																							
Metal press 4	4	1	1	1	0																						
Metal press 5	5	1	1	1	1	0																					
Stock of Dies	6	0	0	0	1	4	0																				
Matricula Workshop	7	3	1	3	3	3	2	0																			
ADMINISTRATIVE	8	0	0	0	0	0	0	1	0																		
ROBOT 1	9	2	2	2	2	2	0	0	0	0																	
Office Chair 3	10	1	1	1	1	1	0	2	1	2	0																
Washing machine	11	1	1	1	1	1	2	1	1	1	2	0															
CELL BSH	12	1	1	2	1	1	1	0	0	0	0	0	0														
Welding SS	13	2	2	2	2	2	1	0	0	0	0	0	1	4	0												
Stock BS	14	0	2	2	1	1	1	0	0	2	0	2	1	4	0												
Stock LI	15	2	1	1	1	1	1	0	0	1	0	1	1	1	0	0											
Empty containers	16	2	2	2	2	2	1	0	0	1	0	0	0	0	0	4	0										
Semi finished products	17	1	1	1	1	1	1	0	1	1	0	2	1	2	0	0	1	0									
Finished products	18	1	1	1	1	1	1	0	1	1	0	2	1	1	0	0	1	4	0								
Reprocessing	19	1	1	1	1	1	0	0	2	1	0	1	1	0	0	2	0	1	1	0							
Verification zone	20	1	1	1	1	1	0	0	1	1	0	0	0	0	0	2	1	3	3	1	0						
Exposition zone	21	1	1	1	1	1	0	0	1	0	0	0	0	0	0	2	1	3	3	1	4	0					
Dies 50E	22	1	1	1	4	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0					
Dies 3	23	1	2	4	2	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	0				
Dies 2	24	1	4	3	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	2	0			
STOCK BS	25	0	0	0	1	0	0	0	0	0	0	0	4	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Logistics office	26	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	1	4	0	4	4	0	0	0	0	0	0

Figure 1. Flow Matrix

The dimensions of the departments are showed below, where the length and the width, are represented respectively, for every department. The layout dimensions are 140.830 m length and 50.881 m width. The number after the dimensions is a way to know the fixed departments, so, the value 1 indicates that the department is fixed and cannot be moved. For the actual problem, is defined that the 5 (five) firsts have a fix location.

Length(m)	Width(m)	Fixed	Length(m)	Width(m)	fixed
12.062	13.701	1	1.680	0.920	0
6.220	11.266	1	12.000	7.304	0
16.710	11.283	1	7.697	9.393	0
18.900	10.600	1	8.125	14.500	0
10.200	10.500	1	19.539	14.500	0
6.937	10.500	0	0.820	0.520	0
33.046	1.227	0	2.966	11.241	0
28.778	13.998	0	2.966	10.862	0
0.860	0.830	0	15.124	1.200	0
0.860	19.038	0	9.000	1.040	0
10.500	0.830	0	4.500	1.040	0
10.803	1.680	0	14.436	1.261	0
7.442	1.680	0	7.000	3.200	0

Figure 2. Department's Dimensions

The solution obtained from the problem consists in one vector of index of the departments, in the order that they must be located in the layout, decreasing the total flow cost and production distance. The 5 departments in the beginning are allocated first, because they are fixed. The others, are allocated around that 5, as described below, where F_i indicated the fixed department indexed with i , and R_i is a random department indexed with i

FIXED: F1, F2, F3, F4, F5,

RANDOM: R9, R5, R20, R3, R14, R6, R11, R12, R1, R19, R13, R7, R8, R18, R2, R17, R4, R15, R16, R21, R10

By using the central coordinates of the departments, we used this result to put the departments in the physical area, following the sequence disposed in the obtained solution. For example, the department R9 must be allocated in the place that was occupied by the department R1, making the area adaptations needed to that the area that was occupied by R1, be able to support the R9 now.

To solve the assignment problem with a feasible solution, our proposed method must have departments of the same size, otherwise we will face the overlap problem, with is the fact of some departments be located the same area. To solve that, we needed to implement a collision detection algorithm like AABB (axis-aligned bounding box) to handle that.

In this way, our research using TS and FacPlan method have proved to be good in Layout Optimization, and we proved that this organization is the one that has the biggest flow between all departments and the smallest total cost in the process production of the industry.

5. Final Considerations

This paper proposes the optimization in the layout of an industry that is going to grow its total area. With the use of combined techniques of Tabu search and some basic concepts of computer graphics, we are able to explore the search area, which even in a limited way, we achieve to successfully optimize some layouts, as our simulations shows.

We have more to do with this work. Actually our neighborhood is just the exchange between the departments, which limit our search area in the points of our initial solution, to solve that we have to implement another type of neighborhood.

References

- Dias K, Chiwiacowsky L, Korzenowski A (2015) Otimização de quadro de lotação hospitalar: Aplicação da Meta heurística Busca Tabu. Espacios. Porto Alegre.
- Dominguez C, Gual D, David, J, HenaoV (2004) Space Distribution in Industrial Plants Using Tabu Search Method, Medellín, Colombia.
- Dib F, Rodgers P (2014) A tabu search based approach for graph layout. Gulf University for Science and Technology, Kuwait City, Kuwait.
- Gerlach G (2013) Proposta de melhoria de layout visando a otimização do processo produtivo em uma empresa de pequeno porte. Horizontina, Rio Grande do Sul.
- Gil AC (2002) Como elaborar projetos de pesquisa. Atlas, São Paulo.
- Gomes, A (2009) Uma Introdução à Busca Tabu. Instituto de Matemática e Estatística. São Paulo.
- Glover F, Laguna, M (1997) Tabu Search. Kluwer.
- Konzen, p. H. De a.; furtado, j. C.; Carvalho, C. W.; Ferrão, M. F.; Molz, r. F.; Bassani, i. A.; Hüning, S. L.(2003.) Otimização de métodos de controle de qualidade de fármacos usando algoritmo genético e busca tabu. Pesquisa Operacional, v. 23, n. 1, p. 189–207. Santa Cruz do Sul.
- Lai X, Hao JK (2016) A Tabu search based memetic algorithm for the max-mean dispersion problem Computers and Operations Research. 118-127. Paris.
- Lee Q, Amundsen AE, Nelson W, Tuttle H (1997) Facilities and workplace design: an illustrated guide. Geordia, USA.
- Lieberman G, Hillier FS (2013) Introdução à pesquisa operacional. Porto Alegre.
- Martins V (2013), Otimização de Layouts Industriais com Base em Busca Tabu, Paraná.
- Nicolau M (2013) Metodologia do trabalho científico. Rio de Janeiro.
- Prodanov C, Freitas E (2013) Metodologia do trabalho científico: Métodos e Técnicas da Pesquisa e do trabalho acadêmico. Universidade Feevale, Novo Hamburgo.
- Sandri S (2013), Algoritmo de Colônia de Formigas Aplicado ao Problema de Alocação de Equipamentos em Satélites, São José dos Campos- São Paulo.
- Sharafi P, Hadi M, Teh L (2013) Cost optimization of column layout design of reinforced concrete buildings. University of Wollongong, NSW, Australia.

Quality and Product Management

Application of Fuzzy Logic in the development of a solar light mechanical for the fight against mosquito aedes aegypti

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Abstract This article proposes the development of a solar-powered electric trap to combat mosquitoes. The method was conceived from project management adapted to the reference model of Product Development Process (PDP) with the definition of the logical characteristics. Added to this is the use of diffuse logic in the evaluation and selection of photovoltaic panels that will be part of the trap. Considering the current outbreak of dengue, zika virus, chikungunya fever, mayaro fever and more recently discovered urban yellow fever, all transmitted by a common vector, the *Aedes aegypti* mosquito, this work has the potential to contribute to Brazilian society in that it proposes an artifact composed of low-cost parts, easy access and simple assembly.

Keywords: Production Management, Fuzzy Logic, Mosquito *Aedes Aegypti*, Solar Energy

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1. Introduction

A complete description of the product design can be given considering a problem without a definitive formulation, a stop rule and an absolute solution and each case considered unique. The designer usually works on abstract problem design, before consulting the limits of the manufacturing process. With the introduction of computerization of the manufacturing process, manufacturing evolution was noticeably larger compared to the design process (Rozenfeld, 2003). The goal of a good project, regardless of whether it is a product or service, is to satisfy consumers by meeting their current and/or future needs and expectations. It can be observed, therefore, that the project of product and service has its beginning with the consumer and ends there (Slack *et al*, 2009). Traditional methodologies for product development do not incorporate in their functional structure the concern in the selection of materials, services and processes, ecologically responsible. Linked to this concern, the importance of electricity for society is added.

The generation of electric energy with solar origin is little explored in Brazil, representing only 0.02% of the total volume of energy generated, according to Aneel. And, according to the portal eCycle, solar energy is the electromagnetic energy whose source is the sun, which can be transformed into thermal or electrical energy. Among the most suitable materials for the conversion of solar radiation into electrical energy, which are usually called solar or photovoltaic cells, stands out the silicon. The conversion efficiency of solar cells is measured by the proportion of solar radiation incident on the surface of the cell that is converted into electrical energy. The best cells have an efficiency index of 25%.

2. Problem

Adapt an existing product in the market that uses electricity generated by the hydroelectric plants to a second concept where its operation takes place through the use of the photovoltaic plates, granting greater autonomy to drive the product to more remote places and external areas where it is not usually easily available Electrical outlets. The product is a contribution to the society that seeks to harness low-cost materials, clean process and clean energy to cooperate with the fight against the agent transmitting diseases like dengue fever and chikungunya: The mosquito *Aedes aegypti*.

The potential market for this product is the population of rural areas and also the population of urban areas mainly dwellers of house type residences.

Figure 1 shows an outline of the product. Given the above, the research problem is to verify the feasibility of building an efficient mosquito control product and of great utility even with limited technical knowledge.

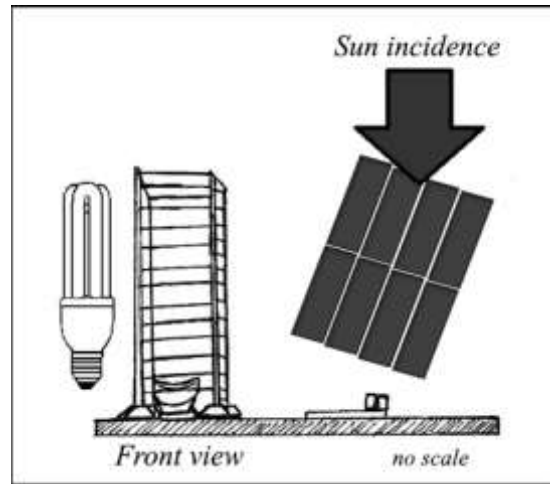


Figure 1. Outline of the proposed solar powered device. Source: Authors (2017)

3. Research Methodology

Initially, a brainstorming was developed to highlight possible product ideas, taking into consideration attributes such as innovation, sustainability, simplicity and low cost. The product scope declaration is presented in table 1, with the purpose of defining the basic parameters that characterize it, the expected functionalities and the audience it serves.

Table 1. Product scope statement

Project objectives: To develop a product to exterminate flying insects that transmit disease, that does not contaminate the environment, uses a percentage of recyclable products in its composition, and uses clean energy for its operation.

Project Product Description - Structural Analysis: an Electrical device to exterminate flying insects through electric shock. Low cost and you can use recyclable products in your assembly; Easy assembly, no need for industrial processes (Design yourself); Uses solar energy for its operation; Indicated mainly for outdoor areas; It does not harm the environment or people like insecticides;

Structure: Grids; Capacitors; Diodes; Resistors; lamp; socket; solar plate; Brush or soft brush

Materials: Grids: galvanized wire thickness 8mm; 02 diodes 1N4007; 02 polyester capacitors 3 mF x 250V; 01 10kx1 / 2W resistor; 01 purple incandescent lamp 5 to 10 W; 01 Socket for incandescent lamp; 01 heavy rectangular base (rest of wood of work)

Manufacturing Processes: Handmade manual assembly.

Description of the public: General public. Special attention for residents of rural areas, sites, interior regions, residences near regions of abundant vegetation.

Source: Authors (2017)

The entire assembly process of the product was mapped to facilitate the understanding of the constructive steps. Figure 2 illustrates the process steps.

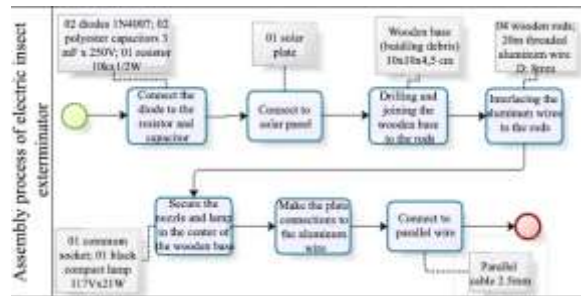


Figure 2. Assembly steps of the proposed product. Source: Authors (2017)

First of all, the diodes, resistors and capacitors are connected together to form the electronic part of the product. The system is then interconnected to the solar panel. The system is then fixed to the wooden base, which is already previously attached to the wooden rods. The steel wire is then interlaced to the rods, forming the railing. Then the nozzle is fixed in the center of the pre-drilled wooden plate and the lamp is then connected. Then the connections of the electronic system to the aluminum wire are made through the parallel cable.

4. Definition of the Type of Photovoltaic Panel by Means of the Fuzzy Logic

Another issue to be taken into consideration is the determination of the type of photovoltaic panel for the presented project, considering the best cost/benefit ratio among the studied plates. Such consideration is important because the intention is not to burden the production of the units, maintaining the artisanal and domestic character, allowing greater access of the population.

Santos *et al.* (2015) point out that operational research makes use of mathematical and logical models to solve real problems, presenting a highly multidisciplinary approach. Santos, Martha and Quintal (2016) also consider that a bad decision can seriously compromise the financial health of a company, and may even represent its bankruptcy.

Santos *et al.* (2016) study shows that Fuzzy Logic provides a method for translating verbal, vague, imprecise, and qualitative expressions common in human communication in numerical values. For this reason, the nebulous mathematics was chosen for the evaluation and selection of the photovoltaic panel. The process of fuzzification, inference and defuzzification of the fuzzy logic employed in the project solution will be analyzed. InFuzzy software was used to aid in calculations. Linguistic variables and linguistic terms were defined. The

first four items refer to the input linguistic variables and the latter to the output linguistic variable.

1. THEORETICAL EFFICIENCY: LOW; AVERAGE; HIGH;
2. LABORATORY EFFICIENCY: LOW; AVERAGE; HIGH;
3. COMMERCIAL EFFICIENCY: LOW; AVERAGE; HIGH;
4. COST: LOW; MEDIUM; HIGH.

The degree of relevance of each of the linguistic terms means how much information is true within a degree of pertinence.

In Figure 3, it is possible to observe the 4 diagrams referring to the input linguistic variables and their respective degrees of pertinence for each fuzzy set.

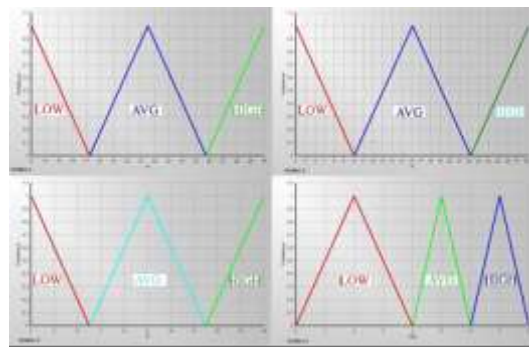


Figure 3. Relevance functions of the input language variables. Source: Authors (2017)

For the definition of the linguistic variables, the data provided in table 2 were considered, transforming them according to the scale presented in table 2.

Table 2. Classification of intervals of language terms

Intervals for definition of linguistic terms - Theoretical Efficiency						
LOW		AVERAGE			HIGH	
13	17,25	17,25	21,5	25,75	25,75	30
Intervals for definition of linguistic terms - Laboratory Efficiency						
LOW		AVERAGE			HIGH	
4	10,05	10,05	16,1	22,15	22,15	28,2
Intervals for definition of linguistic terms - Commercial Efficiency						
LOW		AVERAGE			HIGH	
4	6,5	6,5	9	11,5	11,5	14
Intervals for definition of linguistic terms - Cost						
LOW		AVERAGE			HIGH	
0	4	4		6	6	8

Source: Authors (2017)

From the intervals defined in table 3, the entries were classified according to table 3, as follows:

Table 3. Classification of the linguistic terms of the input variables

Cell type	Theoretical Efficiency (US\$/Wp)	Efficiency	Cost
Amorphous silicon 17.0	13,0	-	LOW
Polycrystalline silicon	25,0	4 a 7	AVERAGE
Concentrated silicon	27,0	5 a 8	HIGH
Single Crystal silicon	30,0	4 a 7	AVERAGE

Cell type	Laboratory Efficiency (US\$/Wp)	Efficiency	Cost
Single Crystal silicon	4	4 a 7	LOW
Concentrated silicon	19,8	5 a 8	AVERAGE
Amorphous silicon 17.0	24,7	-	HIGH
Polycrystalline silicon	28,2	4 a 7	HIGH

Cell type	Commercial Efficiency (US\$/Wp)	Efficiency	Cost
Polycrystalline silicon	4	4 a 7	LOW
Amorphous silicon 17.0	12	-	AVERAGE
Single Crystal silicon	13	4 a 7	HIGH
Concentrated silicon	14	5 a 8	HIGH

Source: Authors (2017)

After defining the functions and degrees of pertinence, the rules of inference are defined. This point is of fundamental importance in the modeling process since it is the one responsible for checking the antecedents and generating the outputs. Figure 4 below shows the set of combinations made between the registered inputs and the respective outputs.

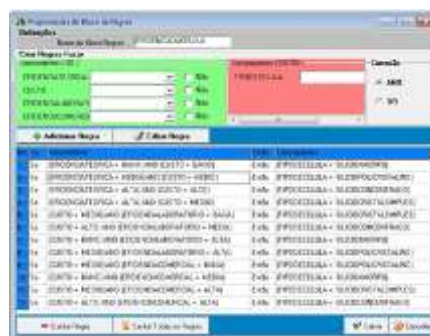


Figure 4. Inference rules definition screen in InFuzzy software. Source: Authors (2016)

After applying the rules of inference, we define the output sets with their respective pertinence, as can be seen in Figure 5, below.

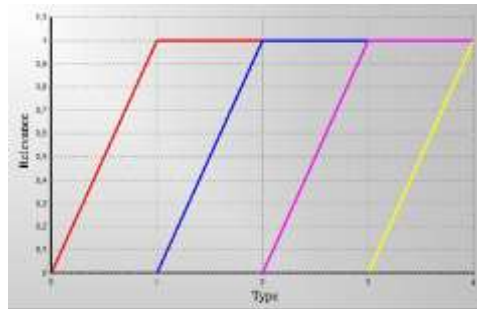


Figure 5. Relevance functions of output language variables. Source: Authors (2016)

The interval [0, 1] represents the cell of type Single Crystal Silicon; The interval [1, 2] represents the cell of the type Concentrated Silicon; The interval [2, 3] represents the cell of type Polycrystalline Silicon; And the interval [3, 4] represents the cell of type Amorphous Silicon.

With all the parameters inserted into the software, the defuzzification of the combinations was carried out, which can be verified in table 4 below.

Table 4. Defuzzification of InFuzzy software

Row	Normal Efficiency	Cost	Technical Efficiency	Commercial Efficiency	AA type
01	10,00	6,00	4,00	1,00	0,00
02	15,00	7,00	5,00	2,00	0,00
03	20,00	8,00	6,00	3,00	0,00
04	25,00	9,00	7,00	4,00	0,00
05	30,00	10,00	8,00	5,00	0,00
06	35,00	11,00	9,00	6,00	0,00
07	40,00	12,00	10,00	7,00	0,00
08	45,00	13,00	11,00	8,00	0,00
09	50,00	14,00	12,00	9,00	0,00
10	55,00	15,00	13,00	10,00	0,00
11	60,00	16,00	14,00	11,00	0,00
12	65,00	17,00	15,00	12,00	0,00
13	70,00	18,00	16,00	13,00	0,00
14	75,00	19,00	17,00	14,00	0,00
15	80,00	20,00	18,00	15,00	0,00
16	85,00	21,00	19,00	16,00	0,00
17	90,00	22,00	20,00	17,00	0,00
18	95,00	23,00	21,00	18,00	0,00
19	100,00	24,00	22,00	19,00	0,00
20	105,00	25,00	23,00	20,00	0,00
21	110,00	26,00	24,00	21,00	0,00
22	115,00	27,00	25,00	22,00	0,00
23	120,00	28,00	26,00	23,00	0,00
24	125,00	29,00	27,00	24,00	0,00
25	130,00	30,00	28,00	25,00	0,00
26	135,00	31,00	29,00	26,00	0,00
27	140,00	32,00	30,00	27,00	0,00
28	145,00	33,00	31,00	28,00	0,00
29	150,00	34,00	32,00	29,00	0,00
30	155,00	35,00	33,00	30,00	0,00
31	160,00	36,00	34,00	31,00	0,00
32	165,00	37,00	35,00	32,00	0,00
33	170,00	38,00	36,00	33,00	0,00
34	175,00	39,00	37,00	34,00	0,00
35	180,00	40,00	38,00	35,00	0,00
36	185,00	41,00	39,00	36,00	0,00
37	190,00	42,00	40,00	37,00	0,00
38	195,00	43,00	41,00	38,00	0,00
39	200,00	44,00	42,00	39,00	0,00
40	205,00	45,00	43,00	40,00	0,00
41	210,00	46,00	44,00	41,00	0,00
42	215,00	47,00	45,00	42,00	0,00
43	220,00	48,00	46,00	43,00	0,00
44	225,00	49,00	47,00	44,00	0,00
45	230,00	50,00	48,00	45,00	0,00
46	235,00	51,00	49,00	46,00	0,00
47	240,00	52,00	50,00	47,00	0,00
48	245,00	53,00	51,00	48,00	0,00
49	250,00	54,00	52,00	49,00	0,00
50	255,00	55,00	53,00	50,00	0,00
51	260,00	56,00	54,00	51,00	0,00
52	265,00	57,00	55,00	52,00	0,00
53	270,00	58,00	56,00	53,00	0,00
54	275,00	59,00	57,00	54,00	0,00
55	280,00	60,00	58,00	55,00	0,00
56	285,00	61,00	59,00	56,00	0,00
57	290,00	62,00	60,00	57,00	0,00
58	295,00	63,00	61,00	58,00	0,00
59	300,00	64,00	62,00	59,00	0,00
60	305,00	65,00	63,00	60,00	0,00
61	310,00	66,00	64,00	61,00	0,00
62	315,00	67,00	65,00	62,00	0,00
63	320,00	68,00	66,00	63,00	0,00
64	325,00	69,00	67,00	64,00	0,00
65	330,00	70,00	68,00	65,00	0,00
66	335,00	71,00	69,00	66,00	0,00
67	340,00	72,00	70,00	67,00	0,00
68	345,00	73,00	71,00	68,00	0,00
69	350,00	74,00	72,00	69,00	0,00
70	355,00	75,00	73,00	70,00	0,00
71	360,00	76,00	74,00	71,00	0,00
72	365,00	77,00	75,00	72,00	0,00
73	370,00	78,00	76,00	73,00	0,00
74	375,00	79,00	77,00	74,00	0,00
75	380,00	80,00	78,00	75,00	0,00
76	385,00	81,00	79,00	76,00	0,00
77	390,00	82,00	80,00	77,00	0,00
78	395,00	83,00	81,00	78,00	0,00
79	400,00	84,00	82,00	79,00	0,00
80	405,00	85,00	83,00	80,00	0,00
81	410,00	86,00	84,00	81,00	0,00
82	415,00	87,00	85,00	82,00	0,00
83	420,00	88,00	86,00	83,00	0,00
84	425,00	89,00	87,00	84,00	0,00
85	430,00	90,00	88,00	85,00	0,00
86	435,00	91,00	89,00	86,00	0,00
87	440,00	92,00	90,00	87,00	0,00
88	445,00	93,00	91,00	88,00	0,00
89	450,00	94,00	92,00	89,00	0,00
90	455,00	95,00	93,00	90,00	0,00
91	460,00	96,00	94,00	91,00	0,00
92	465,00	97,00	95,00	92,00	0,00
93	470,00	98,00	96,00	93,00	0,00
94	475,00	99,00	97,00	94,00	0,00
95	480,00	100,00	98,00	95,00	0,00
96	485,00	101,00	99,00	96,00	0,00
97	490,00	102,00	100,00	97,00	0,00
98	495,00	103,00	101,00	98,00	0,00
99	500,00	104,00	102,00	99,00	0,00
100	505,00	105,00	103,00	100,00	0,00

Source: Authors (2017)

The analysis of the result of the combinations and the defuzzification graph point to the choice of type 2 cell, which is the concentrated silicon cell, as the best cost x efficiency to be adopted for adaptation in the electric device proposed in this work.

5. Conclusion

The creation of the product presented in this work is in line with the moment when Brazilian society is passing, subject to the binomial economic crisis and outbreak of the mosquito *Aedes Aegypti*. In this research, a conceptual model of a low-cost product was developed, with easy-to-assemble components, solar-powered and efficient in the extermination of the dengue transmitting agent, chikungunya, Zika virus and Mayaro virus. Because there was a trade-off between the types of silicon

cells available in the market, the Fuzzy Logic was used as a decision support methodology. Through diffuse mathematics, it was possible to capture the vagueness of human thought and establish the rules of Fuzzy inference, which pointed to the cells of concentrated Silicon according to the judgment of the decision maker.

References

- Brasil. Atlas de Energia Elétrica. Agência Nacional de Energia Elétrica – ANEEL. Editora Brasília, 2008.
- Modeler, BizAgi (2009) Process. Disponível em: < <http://www.bizagi.com/esp/productos/ba-modeler/modeler.html>>, v. 6, 2009.
- O que é energia solar e como funciona o processo de geração de eletricidade via radiação solar?. sem data. Disponível em: <http://www.ecycle.com.br/component/content/article/69-energia/2890-o-que-e-energia-solar-como-funciona-radiacao-solar-painel-residencial-fotovoltaica-csp-heliotermica-nuclear-eolica-biomassa-desvantag>. Acesso em: 09/04/2016
- Posselt, E. L.; Frozza, R.; Molz, R. F.. Software Infuzzy 2011. Programa de Mestrado em Sistemas e Processos Industriais PPGSPI, UNISC, 2011. Disponível em: <http://www.unisc.br/ppgspi>
- Rozenfeld, H. (2003) Modelo de avaliação da gestão do conhecimento no processo de desenvolvimento do produto: aplicação em um estudo de caso. Revista produção, v. 13, n. 2, p. 7, 2003.
- Santos, Marcos dos; Quintal, R. S.; Paixão, A. C.; Gomes, C. F. S. (2015) Simulation of Operation of an Integrated Information for Emergency Pre-hospital Care in Rio de Janeiro Municipality. Elsevier - Procedia Computer Science, v. 55, p. 931-938, 2015. doi: 10.1016/j.procs.2015.07.111
- Santos, Marcos dos; Bahiana, B. R.; Reis, M. F.; Martins, E. R.; Dias, F. C. (2016) Fuzzy logic application in the evaluation of performance of a prototype vehicle powered from solar energy and water electrolysis process. International Journal of Applied Mathematical Research, vol. 5, issue 4, p. 176-181, 2016. doi: 10.14419/ijamr.v5i4.6720
- Slack, Nigel; Chambers, Stuart; Johnston, Robert. (2009) Administração da produção. Atlas.

Integration of QFD and TRIZ in defining engineering product requirements

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Abstract: The Product Development Process (PDP) involves the definition of product technical requirements, which starts identifying customer needs and translating them to technical parameters. This paper presents an application of the use of Quality Function Deployment (QFD) to facilitate this translation, as well as the application of Inventive Problem Solving (TRIZ) to the resolution of technical contradictions, as well as in predicting the product technical evolution towards an increasing degree of ideality.

Keywords: product development; QFD; TRIZ; technical systems; constraint satisfaction.

1. Introduction

New product development is a complex activity and also a knowledge-based process in which data, information and knowledge are processed simultaneously by a team of engineers. It is a knowledge-driven activity in which requirements and constraints are transformed in a product description, and encompasses a series of activities such as product planning, product development and problem solving. Product planning involves the creation of a hierarchical list of customer needs with their importance weighting, and also translating them to some quantitative parameters that express the implicit customer statements. Product development involves problem solving, in which constraints and requirements must be satisfied. The difficult arrives when attempting to meet one constraint make another one unattainable, which leads to adopt compromise solutions with partial fulfilment of each parameter. In order to surpass suboptimal design, there is a set of principles establish within the Theory of Inventive Problem Solving (TRIZ) stating that the

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evolution of technical systems is not random, but governed by certain laws and following repeatable patterns in the long term.

2. Objectives

The main goal of this paper is to present a case of defining product requirements integrating QFD and TRIZ. The example was the development of a mortar design and applied to the initial steps of the Product Development Process.

3. Methods

The two methods used in this paper were “Quality Function Deployment” (QFD) and “Theory of Inventive Problem Solving” (TRIZ). QFD was used to transform qualitative user demands into quantitative parameters, leading to the identification of engineering characteristics which may be relevant, and assigning objectives and priorities for system requirements. TRIZ was used to support the resolution of systems conflicts without achieving a balanced solution between two desirable but incompatible features, as well as to predict the product technical evolution towards an increasing degree of ideality. Initially a patent search was conducted in order to identify and select potential patents followed by the extraction of relevant product technical parameters from them. At the same time, the application of QFD allowed to figure relevant user requirements, which were quantified and weighted. The dependency between user and technical requirements were ranked and evaluated to permit face the contradictions among them. The TRIZ principles were used to solve the contradictions and enabled to establish the product requirements specification.

4. Results

The main result was to demonstrate the viability of a systematic innovation process to the mortar technical system, in which was possible to establish a set of requirements to be fulfilled, as well as to predict the evolution path of its subsystems.

5. Conclusion

Product development is a complex activity in which constraints satisfaction is a hard goal to achieve. This paper showed with an example that it is possible to integrate QFD and TRIZ, utilizing QFD to identify and quantify engineering parameters and TRIZ inventive principles to achieve solutions.

In this paper it was emphasized the analytical power of TRIZ in order to establish the patterns of evolution of mortar technical systems, allowing identify subsystems with high potential of evolution, and indicating areas of design with maximum potential for value generation.

References

- Altshuller G.S., 2002, "40 Principles: TRIZ Keys to Technical Innovation", Technical Innovation Center, Worcester, USA, 138 p.
- Clausing, D.; Fey, V. Effective Innovation: the development of winning technologies. New York: ASME Press, 2004.
- Fey, V.R. and Rivin, E.I., 2005, "Innovation on Demand – New Product Development using TRIZ", Cambridge University Press, Cambridge, UK, 242 p.
- Labouriau F.; Naveiro R. "Using the Evolutionary Pattern to Generate Ideas in New Product Development", Journal of the Brazilian Society of Mechanical Sciences and Engineering, 37: p.231–242, 2015.
- Terninko J., Zusman A. and Zlotin B., 1998, "Systematic Innovation – An Introduction to TRIZ", CRC Press LLC, Boca Raton, USA, 208 p.
- Yeh, C. H.; Huang, J. C. Y.; Yu, C. K. 2011. Integration of four-phase QFD and TRIZ in Product R&D: a notebook case study. Research In Engineering Design, v. 22, p. 125-141, 2011.

Risk Assessment of Critical Factors in the Implementation of Safety Management System (SMS) via Analytic Hierarchy Process (AHP) and the impact of risks on Sustainability and Quality of a Maintenance Organizations.

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Abstract: Civil aviation has been developing very quickly in recent decades and with the technology advances it has become one of the most used and safest transportation means in the world. The existence of a safety management system in aviation maintenance organizations is very important to respond to hazards and risks before a catastrophic accident happens. The search in scientific data base revealed the inexistence of methodology to implement SMS in maintenance organization. This paper aims to present a method for risk assessment in the implementation of an operational risk management system (SMS) in aviation maintenance organizations and to evaluate the impact of the risks on quality and sustainability. Aviation Regulatory Agencies sites such as ANAC, FAA, EASA, ICAO and Scientific databases such as Isi Web of Knowledge and Scopus were searched for research papers about SMS. The relevant risks in the implementation of SMS obtained in this search were assessed with the aid of AHP (Analytic Hierarchy Process) by experts on quality and safety. The critical factors identified in the preliminary result of the present study are lack of a just culture, followed by the production versus safety dilemma, and organizational culture failure to support the safety culture. The findings of this study represent an important source of motivation for companies to utilize the method to improve safety and quality and attain organization sustainability.

Keywords: Safety, Operational Safety, Safety Management System; Organization Sustainability.

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1. Introduction

Recent changes in regulatory requirements moving from a reactive approach to a more proactive and predictive one, based on hazard analysis and risk mitigation, are challenging all levels of the aviation maintenance industry. Travel at high speeds and high altitudes in complex traffic systems means that even small human and technical errors can quickly lead to disasters (Atak & Kingma, 2010). These significant changes in SMS regulations are forcing organizations to rethink their processes and change their culture to meet high safety levels (Gerede, 2014; Gill & Shergill, 2004; Liou, 2008; McDonald et. al, 2000; Reason, 2000). Maintenance Organizations will need to embrace this culture change by encouraging employees in all level to raise hazards that could put the operation at risk and create an infra structure to assess risks by estimating the likelihood and severity of the consequence or outcome from an existing hazard or situation (ICAO, 2003). The current interest in term “safety culture” can be traced directly back to Chernobyl accident in 1986. (Remawi, Bates & Dix, 2010). There is a need to carry out aviation activities safely otherwise confidence in air transport will reduce, direct and indirect effects of unsafe aviation actives will increase (Gerede, 2014). The paper is structured in five section. Section 2 is the objective of the paper, following by section 3 where the methodology used in the study is presented and the steps to use Analytic Hierarchy Process (AHP) is explained. The next section is the section 4, where the results are listed and the final section is the conclusion where all final considerations are covered.

2. Objective

Considering the context presented above, this paper aims to present a method for risk assessment in the implementation of an operational risk management system (SMS) in aviation maintenance organizations and to evaluate the impact of the risks on quality and sustainability of organizations. The research questions to be responded by the study are: RQ1) what are relevant risks in the implementation of SMS and the critical factors to consider and RQ2) what is the impact of risks on the quality and sustainability of the organization.

3. Methodology

Aviation Regulatory Agencies sites (ANAC, FAA, EASA), ICAO and Scientific databases such as Isi Web of Knowledge and Scopus were searched for regulations and papers covering SMS. The gathered information applicable to maintenance organizations were reviewed by experts in Quality and Safety to identify the relevant risks in the implementation of SMS. After the search, the methodology showing in the Fig. 1 was used. The first step was to establish the risk factor for SMS structure, at this point the list from Gereade (2014) was adapted and 12 items were used in the study. The following step was to use AHP methodology to calculate the relative impact of the factors based on the expert's feedbacks. Also AHP was used to calculate the impact of SMS elements in order to identify the most critical factors and elements for the SMS structure.

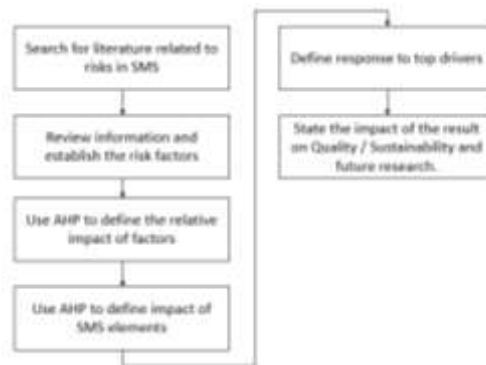


Figure 1. Methodology structure

3.1 Analytic Hierarchy Process (AHP)

The analytic hierarchy process (AHP), which was proposed by Saaty (1980), is used to describe the relationship between components and elements. Based on Rai and Bhushan (1996) the AHP methodology starts with the point where the problem is decomposed into hierarchy structure as shown in Fig. 2, with criteria and alternatives. This structure shows the relationship between elements of all levels.



Figure 2. Format of AHP structure

In the following by second step pairwise comparison matrix of challenge of SMS is done based on the expert's rates. In this study the authors estimated the relative

importance of the risks considering the failure in the implementation of safety management system and a consequent effect on quality and sustainability. Using the rates from Table 1 from Saaty (1980).

A second level of pairwise is done with the risks for SMS implementation with all criteria for AHP analysis of the following elements, as alternatives for prioritization based on Chen, C. & Chen (2012);

1. Documentation
2. Safety Promotion and Training
3. Executive Management Commitment
4. Safety Management Policy

Table 1. Relative importance table

Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Absolute Extreme Importance

The pairwise comparisons of the criteria listed above are organized in a square matrix (Fig. 3), like the matrix listed below.

$$\begin{array}{c}
 A_1 \quad A_2 \quad \dots \quad A_n \\
 A_1 \begin{pmatrix} w_1/w_1 & \dots & w_1/w_n \\ w_2/w_1 & \ddots & w_2/w_n \\ \vdots & & \vdots \\ w_n/w_1 & \dots & w_n/w_n \end{pmatrix} \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} = n \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix}
 \end{array}$$

Figure 3. Square matrix from pairwise comparisons

At this point, where importance of various criteria being compared are given by main eigenvalue and the corresponding normalised right eigenvector matrix.

The consistency of the matrix is calculated. This calculation is necessary once we are using the data from experts and some inconsistency are expected. For consistency index (CI) as shown in the equation (1) and detailed in the equation (2), the authors adopt the Saaty (1980) reference for its calculation, where:

$$CI = \frac{(\lambda_{max} - n)}{(n - 1)} \quad (1)$$

$$\sum_{j=1}^n \alpha_{ij} \cdot w \cdot j = \lambda_{max} \quad (2)$$

According to Saaty (1980), this value is compared with same index obtained as an average over a large number of reciprocal matrices of the same order whose the entries are random. Saaty (1980) also proposed what is called Consistency Ratio (CR) as equation (3), which is a comparison between Consistency Index (CI) and Random Consistency Index (RI). The value of RI is extracted from the table 2 below and if the value of CR calculation is smaller or equal to 10%, the inconsistency is acceptable. As following:

$$CR = \frac{CI}{RI} \quad (3)$$

Table 2. RI value table

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0,58	0,9	1,12	1,14	1,32	1,41	1,45	1,49	1,51	1,48	1,56	1,57	1,59

The final rating of the alternatives is multiplied by the weights of the criteria and added to have local rates. These values are multiplied to weight of the criteria and added to have global rates.

4. Results

The list of top risks factors affecting the success of SMS identified by Gerede (2014) was adapted and then analysed using AHP (Analytic Hierarchy Process). The list is consisted by: 1-The Fear of punishment that impairs reporting; 2-The belief that reporting does not provide any benefits; 3-Failure to creating a just culture; 4-Pressure by top management to operate engines overhauled on time; 5-The pressure derived from a concern of top management about loss of income; 6-The failure of top management to understand the significant of SMS; 7-Failure to change current habits; 8-Difficulties in integrating various management systems into the company (ISO 9001/14001/18001/SMS/AS9100/145/M); 9-Failure to

reflect in-company reports completely because company managers apprehensive of the Civil Aviation Authority; 10-Failure of organization and staff adapt to the immediate enforcement of regulations amendments; 11-Lack of sufficient knowledge of risk management and risk analysis causing challenges in practice; 12-Failure of organizational culture in supporting a positive safety culture. Table 3 shows the pairwise comparison matrix of the critical factors. The criteria presented in the Table 3 are independent from one another. The weights obtained for each criteria is shown in the last column of Table 3.

The AHP method revealed the 3 top following items to consider in the SMS implementation: Risk of failure in creating a just culture, the failure to solve the production versus safety dilemma and the risk of failure of organizational culture in supporting a positive safety culture, as shown in table 3. The impact of these risks on the quality and sustainability of the organization is evident, since it affects competitiveness performance, due to its positive effect on organization's image, reputation and productivity and economic-financial performance, due to its positive influence on sales, profit and profitability.

Table 3 . Pairwise Results

Alterntive	1	2	3	4	5	6	7	8	9	10	11	12	W
1	0,024	0,024	0,003	0,005	0,008	0,024	0,008	0,048	0,048	0,008	0,003	0,003	0,017
2	0,024	0,024	0,003	0,003	0,008	0,024	0,008	0,008	0,024	0,005	0,003	0,003	0,011
3	0,214	0,214	0,024	0,071	0,071	0,119	0,071	0,071	0,119	0,119	0,071	0,024	0,099
4	0,119	0,167	0,008	0,024	0,095	0,071	0,095	0,095	0,119	0,071	0,095	0,024	0,082
5	0,071	0,071	0,008	0,006	0,024	0,012	0,024	0,012	0,048	0,048	0,003	0,012	0,028
6	0,048	0,048	0,005	0,008	0,048	0,024	0,024	0,012	0,119	0,048	0,024	0,012	0,035
7	0,071	0,071	0,008	0,006	0,024	0,024	0,024	0,024	0,048	0,048	0,024	0,012	0,032
8	0,012	0,071	0,008	0,006	0,048	0,048	0,024	0,024	0,024	0,012	0,008	0,005	0,024
9	0,012	0,024	0,005	0,005	0,012	0,012	0,012	0,024	0,024	0,024	0,005	0,005	0,013
10	0,071	0,119	0,005	0,008	0,012	0,012	0,012	0,048	0,024	0,024	0,012	0,012	0,030
11	0,167	0,167	0,008	0,006	0,167	0,024	0,024	0,071	0,119	0,048	0,024	0,003	0,069
12	0,167	0,167	0,024	0,024	0,048	0,048	0,048	0,119	0,119	0,048	0,167	0,024	0,083

The pairwise comparison matrix for global priorities for the SMS elements are presented in Table 4.

The global priority of SMS elements is shown in the Fig.s 5 and 6.

Consistency number ratio for all the pairwise comparison matrix for the risk factors and SMS elements, were found to be under 0.10.

Table 4 . Final AHP results

Alternatives	1	2	3	4	5	6	7	8	9	10	11	12	Weight
Priority Vector	0,02	0,01	0,10	0,08	0,03	0,03	0,03	0,02	0,01	0,03	0,07	0,08	
Criteria													
Documentation	0,59	0,44	0,45	0,80	0,80	0,44	0,42	0,46	0,67	1,33	0,36	0,47	0,30
Safety Promotion and Training	2,50	1,28	2,83	0,79	0,79	5,00	1,16	2,00	1,33	0,51	4,25	0,85	1,08
Executive Management Commitment	4,00	7,00	4,00	5,50	5,50	1,80	4,75	1,88	2,50	1,21	1,61	5,50	2,05
Safety Management Policy	0,62	1,28	0,88	0,78	0,78	1,13	2,06	1,50	0,83	3,00	2,83	2,30	0,83
Global Vector	0,13	0,11	0,81	0,64	0,22	0,29	0,27	0,14	0,07	0,18	0,62	0,76	

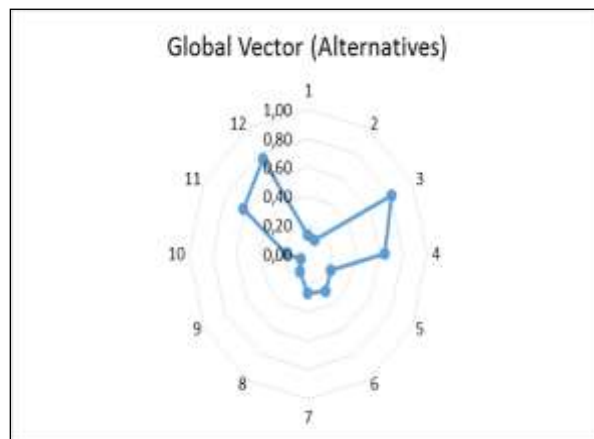


Figure 5. Graph of AHP Alternatives results

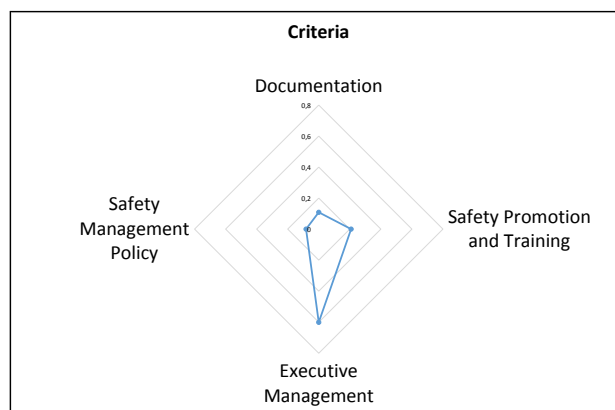


Figure 6. Graph of AHP Criteria results

5. Conclusion

In response to the first research question, the relevant risks in the implementation of SMS are listed in Table 4. The critical factors identified in the preliminary result of the present study demonstrate that lack of a just culture, followed by the production versus safety dilemma, and organizational culture failure to support the safety culture, are the three main factors to be considered during SMS implementation in an aviation maintenance organization. The findings show that SMS must be supported by a just culture, with open mindset for the identification of hazards and open communication about the risks, where top management understands, supports and allocates the resources needed for such an initiative. The SMS elements prioritization is shown in Fig. 6 and Table 4.

In response to the second question the impact of risks on the quality and sustainability of the organization are clear and the findings of this study represent an important source of motivation for companies to utilize the method to improve safety and quality. Addressing the critical factors is an opportunity, since it has several positive effects on quality and consequently company performance. One of the positive effects is the competitiveness performance, due to its positive effect on organization's image, reputation and productivity. Other meaningful effect would be the economic-financial performance, due to its positive influence on sales, profit and profitability. All these effects would lead to organization sustainability.

References

- Agência Nacional de Aviação Civil [Nacional agency of Civil Aviation] (ANAC) (2014) Instrução suplementar No.: 145.214-001 Rev. A [Supplemental Instruction No.: 145.214-001 Rev. A], Brazil.
- Atak, A. & Kingma, S. (2010) Safety Culture in an aircraft maintenance organisation: A review from inside. Safety Science, Amsterdam.
- Bhushan, N. & Rai, K. (1996) Strategic Decision Making: Applying the Analytic Hierarchy Process (Decision Engineering), Springer, UK.
- Chen, C. & Chen, S. (2012) Scale Development of safety management system evaluation for the airline industry. Accident Analysis and Prevention, Taiwan.
- Chang, Y.; Shao, P. & Chen, H. (2013) Performance evaluation of airport safety management systems in Taiwan, Taiwan.
- Federal Aviation Administration (FAA) (2006) Introduction to Safety Management System for operators, No.: AC192-92.
- Federal Aviation Administration (FAA) (2006) Introduction to Safety Management System for service providers, No.: AC192-92A.
- Gerede, E. (2014) A Study of challenges to the success of the safety management system in aircraft maintenance organizations in Turkey. Safety Science, Turkey.

- Gill, G. K. & Shergill G. S. (2004) Perceptions of safety management and safety culture in the aviation industry in New Zealand. *Journal of Air Transport Management*, New Zealand.
- International Civil Aviation Organization (ICAO) (2003) *Safety Management Manual*, Doc. 9859 A/N 474, third ed., Montreal.
- Liou, J.; Yen, L. & Tzeng, G. (2008) Building an effective safety management system for airlines. *Journal of Air Transport Management*, Taiwan.
- McDonald, D. N.; Corrigan, S. & Cromie D. S. (2000) Safety management system and safety culture in aircraft maintenance organization. *Safety Science*, Ireland.
- Remawi, H. & Bates, P. (2010) The relationship between the implementation of safety management system and the attitudes of employees towards unsafe acts in aviation. *Safety Science*, Australia.
- Reason, J. (2000) *Safety Paradoxes and Safety Culture*. Injury Control & Safety Promotion, United Kingdom.
- Saaty, T.L., (1994). How to make a decision: the analytic hierarchy process. *Interfaces* 24 (6), 19–43.
- Saaty, T. L., (1980). *Decision Makers for Leaders: The analytic Hierarchy Process*. McGraw-Hill, New York, United States.
- Wiegmann, D.A.; Zhang, H.; Thaden, T.V.; Sharma, G.; Mitchell, A. (2002) *Safety Culture: A Review*. University of Illinois, United States.

Sustainable performance: analysis between certified companies

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Abstract The number of companies certified in management systems has been constantly increased. Some of the most recognized management systems are: ISO 9001, ISO 14001 e OHSAS 18001. Researchers indicate that the use of these management systems contributes to sustainability. A survey was done with 189 Brazilian companies. It was possible to conclude that companies with at least two management systems (ISO 9001, ISO 14001, OHSAS 18001) have a better social performance than companies with only ISO 9001. There are not statistical evidences that confirm this difference for economic and environmental performance.

Keywords: Performance; Sustainability; ISO 9001; ISO 14001; OHSAS 18001

1. Introduction

There is an increase in the number companies that are certified in management systems (MSs). One of the most known MSs is ISO 9001 (Quality Management System). Between 1993 and 2015 the number of ISO 9001 certifications rose from 46.571 to 1.033.936 (ISO, 2017). Others MSs are known worldwide such as: ISO 14001 (Environmental Management System) and OHSAS 18001 (Occupational Health and Safety Management System).

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According to Jørgensen (2008), management from the standpoint of sustainability should include quality, occupational health and safety, as well as the environment. The continuous improvement in quality, health and safety, and environment impacts sustainable development (Hamidi *et al.*, 2012). In the book “Cannibals with fork and knife”, Elkington (2001) presents the triple bottom line (TBL). This concept establishes that it is necessary to look at for social, environmental and economic dimension to achieve sustainability. The GRI (Global Reporting Initiative) sets guidelines for sustainability report based in TBL. According to KPMG (2015), 92% of 250 largest companies in the world have sustainability reports. About 60% of these reports are prepared following the GRI standard. The GRI proposes some indicators that are divided into social, environmental and economic. Nunhes *et al.* (2016) reported the need to investigate the impact of certifiable MSs to promote sustainable development.

The objective of the present research is to make a descriptive analysis followed by inferential analysis of the sustainable performance (social, environmental and economic) in two blocks. These blocks are: companies certified only in ISO 9001 and companies certified in at least two management systems (ISO 9001, ISO 14001, OHSAS 18001).

2. Literature Review

2.1 Management Systems (MSs)

A norm is a document drawn up by consensus and approved by a recognized organization. Norms can cover all areas of knowledge, ranging from technical issues to complex administrative models, such as quality and the environment management systems (Ferreira, 2006).

MSs consist of a set of procedures that an organization needs to follow in order to achieve its objectives (ISO, 2015). There are a variety of MSs such as: ISO 9001 (Quality Management System), ISO / TS 16949 (Quality Management System for the automotive sector), ISO 14001 (Environmental Management System), OHSAS 18001 (Occupational Health and Safety Management System), ISO 22000 (Food Safety Management System), ISO 50001 (Energy Management System), ISO 27001 (Information Security Management System), among others.

The companies normally have adopted more than one management system and consequently have come across with the challenge of integrating their MSs. An integration of different MSs is known as Integrated Management System (IMS). For Beckmerhagen *et al.* (2003), the integration of management systems can be defined as the process of joining different functions specifics of each MSs.

In the review by Bernardo *et al.* (2015), the authors state that there are studies that evaluate separately the effects of ISO 9001 and ISO 14001 standards on financial performance (such as market share, sales, among others). Jang and Lin (2006)

found that the implementation of ISO 9000 leads to an improvement in operational and market performance. The research of Ochieng *et al.* (2015) evaluated the effect of ISO 9001 on the economic performance of organizations. The study by Melnyk *et al.* (2003) revealed that certification of environmental management systems such as ISO 14001 brings real benefits such as performance improvement (cost, delivery time, quality, etc.). Considering that management systems impact on sustainability according to Jørgensen (2008) and Hamidi *et al.* (2012), the following topic addresses sustainable performance.

2.2 Sustainable Performance

Sustainability can be defined according to the Lowell Center for Sustainable Production as the creation of goods and services through non-polluting systems that conserve energy and natural resources, ensure the health and safety of workers, community and consumers, as well as being economically feasible and rewarding for all workers (Veleva *et al.*, 2001). Elkington (2001) defines sustainability through the Triple Bottom Line (TBL), which establishes the social, environmental and economic dimensions.

According to Delai and Takahashi (2011), measuring sustainability is a key activity of the organizational management system and can support the decision making process. The sustainability evaluation can be carried out by means of indexes or a set of indicators. Among several possible initiatives, Global Report Initiative (GRI) and Dow Jones Sustainability Index are one of the most famous and used by companies worldwide. More and more companies have been pressured in order to be transparent and present annually reports such as for sustainability. However, the measurement of sustainability is not yet fully matured.

Searcy (2012) conducted a review of the literature and pointed out some gaps related to the performance measurement system with a focus on sustainability. A sustainable performance measurement system is not limited to measure environmental and social performance alone. But it provides the organization with the necessary information to assist in control, planning, and execution of activities that address the social, economic, and environmental aspects.

According to the KPMG (2015) survey, the importance of GRI for sustainability is evident. The GRI is an independent international organization that helps companies to prepare sustainability reports. It emerged in 1997 in Boston and is now present in more than 90 countries (GRI, 2015).

The report proposed by GRI has two types of standard content: general and specific. The general contents are divided into 7 parts and include information on: strategy and analysis; organizational profile; material aspects identified and limited; stakeholder engagement; profile of the report; governance; and ethics and integrity. The specific contents are divided between information on the form of management and indicators. The indicators are divided into 3 categories (social, environmental and economic), and for each one of the three categories there are a set of indicators to be considered. The economic category does not focus on the

financial situation of the organization, but focuses on the impacts on economic systems at local, national and global level. A total of 9 economic, 34 environmental and 48 social indicators are suggested (GRI, 2013).

3. Methods

A bibliographic research on management systems and sustainable performance was carried out. A questionnaire was developed to evaluate sustainable performance considering GRI indicators (GRI, 2013). Perceptual measures were used using the 5-point Likert scale (very high, high, intermediate, low, very low). In addition, the respondent had the option to tick as not applicable or does not know the answer (“N/A”). According to Hensley (1999), perceptual measures have traditionally been developed by researchers in the field of psychology and the scale developed by Likert has become widely used by several areas of knowledge.

The questionnaire was sent via Survey Monkey for a pilot test. According to Forza (2002), the pilot test helps to verify if the questionnaire is good, because, although the careful planning, difficulties can occur in the understanding of the questions. The test was done with 19 people, obtaining 12 answers. These people came from the industry and academia. Based on the pilot test, some modifications were made to the questions. Subsequently, the questionnaire was re-evaluated by 3 experts resulting in further changes, including the reduction of the number of questions and the use of the paper of Delai and Takahashi (2011), which assisted in the selection of questions cuts. The experts came in the academic field.

The questionnaire was sent to companies certified in ISO 9001, ISO 14001 and OHSAS 18001. In order to select the companies, the database used was INMETRO (Brazilian Institute of Metrology, Quality and Technology) and Revista Proteção (Brazilian magazine focused on health and safety at work). These two sources provided only the name of the companies, being necessary to search the Google site to get the phone from them. Phone calls were made to get the participant's contact. A total of 254 contacts were obtained. Subsequently, a partnership with 7 certifying bodies was sought to help in the dissemination of the research. Only 1 accepted to participate. A database was also used with companies certified in ISO 9001 and this base was previously used by the research group. The survey was conducted between November and December 2016. A total of 254 responses were obtained, but 189 were valid.

Descriptive and inferential statistics were obtained in order to compare the performance of the two groups of certified companies. The median was calculated and the non-parametric Mann-Whitney test was performed. These tests sought to analyze whether there was a difference between the indicators of the group that only has ISO 9001 and the group that owns at least two of the following ISO 9001, ISO 14001 and OHSAS 18001 management systems. The median is the

intermediate value that separates the upper half of the lower half of the data set. The Mann-Whitney test is used to compare the central position of two populations (Barbetta *et al.*, 2010). The test is significant if $p < 0.05$. Then, it is possible to conclude that there is a significant difference between the observed groups (Field, 2009). For both calculations, the responses marked "N/A" were excluded from the calculation.

4. Results

A total of 189 respondents participated in this research, 93 of them worked in organizations certified in only ISO 9001 and 96 respondents in organizations that had at least two management systems (ISO 9001, ISO 14001, OHSAS 18001). Of the 96 companies, 60 had the three certifications cited; 28 had ISO 9001 and ISO 14001; 6 had ISO 9001 and OHSAS 18001; and 2 had ISO 14001 and OHSAS 18001.

The economic performance showed no difference between the two groups (companies certified only ISO 9001 and companies with at least two management systems). Although the median was different for the indicator relative to purchase from local suppliers, the Mann-Whitney test did not detect significant statistical difference. In table 1, it is presented all indicators used in this research.

For the environmental performance, the indicator that evaluated the water use presented different median. But this difference was not proven by the Mann-Whitney test. Therefore, it cannot be said that this indicator presents a difference between the groups. The indicator regarding environmental protection presented a statistical difference between the groups, although their medians were equal.

The social performance presented a difference in 9 indicators. Seven indicators showed a statistically significant difference by the Mann-Whitney test and in all cases the companies that have more than one management system presented medians larger than those with only ISO 9001. These indicators are: occupational injuries; anti-corruption policies; political parties; unfair competition; compliance with laws; providers; and impacts on society. The indicators about local communities and products/services presented statistical difference although the median remained the same. For the indicators related to forced/slave labor and labeling of products and services, it cannot be said that the two groups present a statistically significant difference, although the medians are different.

Table 1 shows the results achieved by the tests. The column M presents information from companies that have more than one management system (ISO 9001, ISO 14001, OHSAS 18001). The column U presents information from companies that have only one management system (ISO 9001). The p-value is the result of the Mann-Whitney test.

Table 1 - Performance comparison between companies with single management system (ISO 9001) and multiples (ISO 9001, ISO 14001, OHSAS 18001)

Construct	Item Description	Code	Median		p-value
			M	U	
Economic Performance	Wealth distribution	EC1	3	3	0,877
	Salary difference	EC2	3	3	0,809
	Impact of investments in infrastructure	EC3	3	3	0,584
	Purchases from local suppliers	EC4	3	4	0,089
Environmental Performance	Use of materials	EN1	4	4	0,478
	Energy	EN2	3	3	0,180
	Water	EN3	4	3	0,820
	Atmospheric emissions	EN4	3	3	0,150
	Effluents and waste	EN5	3	3	0,124
	Environmental protection	EN6	3	3	0,03*
Social Performance	Retention of employees	SO1	3	3	0,365
	Injuries and diseases	SO2	4	3	0,010*
	Training	SO3	3	3	0,291
	Remunerations of men and women	SO4	4	4	0,427
	Forced or slave labor	SO5	5	4	0,369
	Local communities	SO6	3	3	0,038*
	Anti-corruption policies and procedures	SO7	5	2	0,000*
	Political parties	SO8	3	2	0,03*
	Unfair competition	SO9	4	3	0,05*
	Compliance with laws and regulations	SO10	5	4	0,000*
	Suppliers	SO11	4	3	0,000*
	Impacts on society	SO12	4	3	0,002*
	Products and services	SO13	4	4	0,031*
	Customer satisfaction	SO14	4	4	0,854
	Legislation and advertising	SO15	4	4	0,215
	Labeling of products and services	SO16	5	4	0,261
	Customer privacy	SO17	5	5	0,221

*Sig<0,05.

When calculating the percentage of indicators that statistically differed, for economic performance it can be affirmed that there was no difference, for the environmental performance the difference was in 16.6% of the indicators, while for the social performance in 53%.

5. Conclusion

According to a survey conducted in Brazil with companies certified in management systems, it was possible to reach some conclusions when comparing two groups. One group was formed by companies that only have ISO 9001 certification and the other by companies that have at least two of the following management systems: ISO 9001, ISO 14001 and OHSAS 18001. These standards were taken as a basis for two reasons: these management system standards are widely used; and some studies indicate that the adoption of these standards contributes to sustainability. The objective of the present research was to make a descriptive and inferential analysis of the sustainable performance (social, environmental and economic) and verify if the adoption of more management

systems impacts in sustainability. It was expected that organizations certified in more than one management systems would have a higher social and environmental performance than organizations certified only ISO 9001. Normally, ISO 9001 is associated with economic performance, ISO 14001 with environmental performance and OHSAS 18001 with social performance. When comparing the two groups, it was possible to note a higher social performance in the group formed by companies that adopt more than one management system. For economic and environmental performance, the differences were not representative for the most indicators. Therefore, the adoption of more management systems provides upper social performance.

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References

- Barbetta PA, Reis MM, Bornia AC (2010) Estatística para cursos de engenharia e informática. Editora Altas, São Paulo
- Beckmerhagen IA, Berg HP, Karapetrovic SV, Willborn WO (2003) Integration of management systems: focus on safety in the nuclear industry. *International Journal of Quality & Reliability Management*, 20 (2), 210–228
- Bernardo M, Simon A, Tari JJ, Molina-Azorin JF (2015) Benefits of management systems integration: a literature review. *Journal of Cleaner Production*, 94, 260-267
- Delai I, Takahashi S (2011) Sustainability measurement system: a reference model proposal. *Social Responsibility Journal*, 7 (3), 438-471
- Elkington J (2001) *Canibais com Garfo e Faca*. Makron Books, São Paulo
- Ferreira JJA (2006) Modelos Normalizados de Sistemas. In: CARVALHO, M.M.; PALADINI, E.P. (Org.). *Gestão da Qualidade: Teoria e Casos*. Elsevier, Rio de Janeiro, 153-186
- Field A (2009) *Discovering Statistics using SPSS*. 3ª ed. SAGE Publications, Dubai
- Forza C (2002) Survey research in operations management: a process based perspective. *International Journal of Operations & Production Management*, 22 (2), 152–194
- GRI (2013) *Diretrizes para relato de sustentabilidade: princípios para relato e conteúdos padrão*. 93 p.
- GRI (2015) About GRI. Retrived from www.globalreporting.org
- Hensley RL (1999) A review of operations management studies using scale development techniques. *Journal of Operations Management*, 17 (3), 343-358

- ISO (2015) Management system standards. Retrived from <http://www.iso.org/iso/home/standards/management-standards.htm>
- ISO (2017) ISO Survey. Retrived from <http://www.iso.org/iso/home/standards/certification/iso-survey.htm?certificate=ISO%209001&countrycode=AF>
- Jang W, Lin NC (2008) An integrated framework for ISO 9000 motivation, depth of ISO implementation and firm performance. *Journal of Manufacturing Technology Management*, 19 (2), 194-216
- Jørgensen TH (2008) Towards more sustainable management systems: through life cycle management and integration. *Journal of Cleaner Production*, 16 (10), 1071–1080
- Hamidi N, Omidvari M, Meftahi M (2012) The effect of integrated management system on safety and productivity indices: Case study; Iranian cement industries. *Safety Science*, 50 (5), 1180–1189
- KPMG (2015) Currents of change: The KPMG Survey of Corporate Responsibility Reporting 2015. KPMG, Netherlands, 48 p
- Melnyk SA, Srour RP, Calantone R (2003) Assessing the impact of environmental management systems on corporate and environmental performance. *Journal of Operations Management*, 21 (3), 329–351
- Nunhes TV, Motta LCF, Oliveira, OT (2016) Evolution of integrated management systems research on the *Journal of Cleaner Production*: Identification of contributions and gaps in the literature. *Journal of Cleaner Production*, 139, 1234-1244
- Ochieng J, Muturi D, Njihia SN (2015) The impact of ISO 9001 implementation on organizational performance in Kenya. *The TQM Journal*, 27 (6), 761–771
- Searcy C (2012) Corporate Sustainability Performance Measurement Systems: A Review and Research Agenda. *Journal of Business Ethics*, 107 (3), 239-253
- Veleva V, Ellenbecker M (2001) Indicators of sustainable production: framework and methodology. *Journal of Cleaner Production*, 9, 519-549

Comparison on a Lean Production System: A State of Mexico Automotive Industry Case Study

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Abstract Lean manufacturing (LM) is a management system that increases the productivity and quality in organizations. It focuses in eliminating waste and activities that do not add value. LM has been adopted in diverse industries and several countries due to its advantages in cost, flexibility and rapid response (Muslimen et al. 2013). The objective of this present investigation is to analyze the implementation level to the Lean System via the SAE J4000 (SAE 1999a) standard carried out among companies of the State of Mexico automotive industry. In addition, this investigation shows the inferential and descriptive statistics data analysis of Mexican companies compared to the automotive industries in Spain and Brazil. Results show that the implementation level of the automotive industry is at 48.4% in the State of Mexico according to the SAE J4000 standard. Moreover, the involvement of suppliers and processes is higher in the State of Mexico compared to automotive industries in Spain and Brazil. However, previous studies ranked the State of Mexico at a lower level of LM in production lines in contrast with Spain and Brazil.

Keywords: Lean Manufacturing Implementation, SAE J4000, Automotive Industry, Automaker-Supplier-Customer Relationship, Lean Implementation, Automotive Comparison.

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1. Introduction

The Toyota Production System (TPS) is a rational manufacturing method that seeks to eliminate waste, with the aim of reducing costs and improving the quality and productivity of organizations (Monden 1983). This concept was first introduced to the western world in 1990, with the name of Lean Manufacturing (LM), after (Roos et al. 1990) publication. The just-in-time (JIT) manufacturing concept, however, was introduced in the west for almost a decade. (Holweg 2006).

The aim of the present investigation is to analyze the implementation level of the Lean System according to the SAE J4000 standard (SAE 1999a) in the State of Mexico automotive industry companies. Collection of data is carried out, organized, and analyzed to study the Mexican automotive industry. Comparisons are made with the Spanish and Brazilian automotive industries, using data from a previous investigation (Araújo et al. 2012). A comparison is made with similar annual production ranking such as Spain and Brazil –rank eighth and ninth respectively- to Mexico -rank seventh. Further investigation was also made with recent data (Expansión 2016).

2. Literature Review

Lean System focuses on manufacturing products with the highest quality, fastest delivery, and lowest cost (Hosseini et al. 2015). Some analysts (Srinivasaraghavan & Allada, 2006) even pointed out that if an organization ignores the LM strategy, the company would not stand a chance against the current leading companies due to the high requirements demanded by customers.

LM implementation has also shown to improve quality and productivity in the automotive industry (Muslimen et al. 2013), therefore several methodologies have been developed to analyze it. Researchers can determine the implementation level and carry out classifications by taking into account specific criteria. For example, Panizzolo (1998) classified Italian companies into three categories: flexible, network and customer-driven enterprises. Nordin et al. (2010) divided the Lean System into five categories (Process and equipment, Manufacturing planning and control, Human Resources, Supplier relationship, Customer relationship) and classified the Malaysian automotive companies into three types: non-lean, in-transition, and lean firms.

On the other hand, other researchers focused to determine the main factors that influenced the successful implementation and prevented the adoption of The Lean System. Achanga et al. (2006) identified critical factors in implementing LM: leadership and management, finance, skills and expertise, and supportive organizational culture of the organization. However, Nordin et al. (2010) states the factors that drive LM implementation focus on customers' satisfaction to achieve continuous improvement within the organization. He also states that the main

barriers which prevent LM implementation are lean concepts lack of understanding and shop floor employees' attitude.

The Lean System implementation level in Mexican Automotive companies is arising; so the authors want to compare LM implementation level with the Mexican state automotive industry - 3'465.615 vehicles produced in 2016 (AMIA 2017) - with Spain since it is the second largest vehicle manufacturer in Europe - with 2'885.907 units (ANFAC 2017) – and Brazil - 1'016.680 vehicles (OICA 2017)- being the second largest in Latin America.

2.1 SAE J4000

The Society for Automotive Engineers (SAE) approved the Lean System best practices specifications, the J4000 standard (SAE 1999a) in 1999. The standard includes elements (Process and equipment, Manufacturing planning and control, Human resources, Product design, Supplier relationships, Customer relationships) identified in a study carried out by Panizzolo (Bergmiller & McCright 2009). A previous standard study also included the development of a survey that allows to determine the critical factors which impact LM implementation in the organizations (Panizzolo 1998).

The standard mentioned lists of criteria through LM can be reached. The main portion of the standard is made up of 52 components, divided into 6 elements. They are: Management/Trust (element 1), People (element 2), Information (element 3), Supplier/Organization/Customer Chain (element 4), Product (element 5), Process/Flow (element 6). Each element possesses a weight in the implementation (estimated by the relative importance they have for the Lean Production System) as established by the standard SAE J4000.

This standard was complemented by SAE J4001 (SAE 1999b) which provides the necessary instructions to carry out the evaluation suggested by SAE J4000 standard.

3. Design of Research and Methodology

This effort seeks to determine the Lean System implementation level in the State of Mexico automotive industry and how the existing knowledge can be expanded in LM (exploratory research).

A field of research that analyzed each company, using a survey as measurement instrument proposed by SAE J4000, was utilized. Interviews with managers were corroborated with field information to validate the information provided. This process allowed to collect and select the required information to measure the LM implementation level of each specific element for each company in the sample.

Moreover, the Cronbach's Alpha reliability test was used to measure the stability and consistency of the research instrument. Several researchers (Sekaran &

Bougie 2010) (Nordin et al. 2010) (Eswaramoorthi et al. 2011) agreed that 0.7 is lower limit value for Cronbach's alpha. However, this value may be used as low as 0.6 for exploratory research. (Panizzolo 1998).

The Cronbach's alpha calculation was performed for each of the elements of the standard and for the overall result. All the results proved to be highly consistent, and therefore reliable with a Cronbach's alpha greater than 0.7.

4. Discussion of Results

The results are divided in two sections: the first one focuses on the analysis of the implementation level to the Lean Production System in Mexico State; The second comprises a comparison between Mexico, Brazil, and Spain, with the corresponding statistical inferential analysis.

Evaluation on the Lean Production System implementation level. The analysis of the implementation level was performed for each company in the sample. The current level of each element was determined, and an overall score was established for each company. Figure 1 shows the best and the worst result obtained for each element of the sample.

Companies with higher implementation level obtained scores for elements 1 (Management/Trust) and 2 (People) as best overall ratings. This could indicate that the involvement of LM techniques in strategic planning, the commitment of the managers, the inclusion of Lean principles in the organizational objectives and in the Human Resources policies are essential in the organization to successfully implement the Lean System in the whole organization.

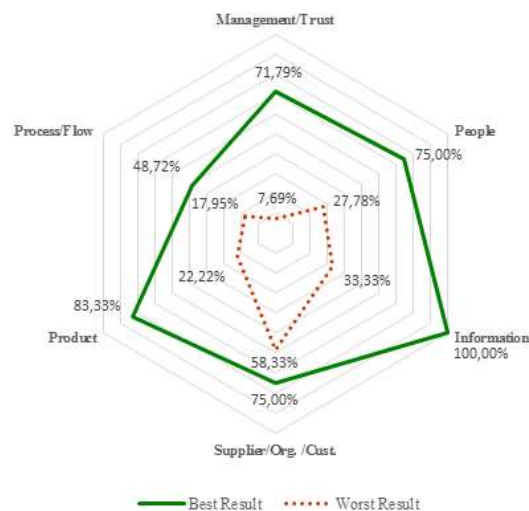


Figure 1 State of Mexico Implementation level to the Lean Production System

Additionally, the State of Mexico average implementation level for each element and a total score was determined, as shown in Table 1. This information shows that the data has a high standard deviation resulting from the large confidence intervals. Thus, these results exhibit that the State of Mexico Lean System implementation level is 48.42%. However, the confidence interval obtained indicates with an 80% confidence that this level is between 35.15% and 61.68%. This range can be reduced by adding more observations to this research.

Table 1. Results obtained for The State of Mexico

n=5	Element 1	Element 2	Element 3	Element 4	Element 5	Element 6	Total
Mean	0.4308	0.5611	0.7000	0.6667	0.5444	0.3077	0.4842
Standard deviation	0.3250	0.1908	0.3151	0.0589	0.2558	0.1256	0.1935
C.I. 80% Inferior Limit	0.2079	0.4303	0.4839	0.6263	0.3691	0.2216	0.3515
Superior Limit	0.6536	0.692	0.9161	0.7071	0.7198	0.3938	0.6168

Comparison of Results between the State of Mexico, Brazil and Spain. Based on the information gathered through the methodology mentioned above, the information for the State of Mexico is compared with the data from Spain and Brazil according to Araújo, Henrique, Guilherme and Carretero, in 2012 (Araújo et al. 2012). The data was incorporated through the SAE J400 standard and it is shown in Table 2.

Table 2. Confidence intervals for Brazilian, Mexican and Spanish companies' implementation level

Element		Spain	Brazil	State of Mexico
		n = 7	n = 6	n = 5
Management/Trust	μ	0.5824	0.5085	0.4308
	σ	0.2494	0.2446	0.3250
	C.I. 80%	0.4467 - 0.7181	0.3611 - 0.6559	0.2079 - 0.2229
People	μ	0.6270	0.5000	0.5611
	σ	0.2096	0.3068	0.1908
	C.I. 80%	0.5129 - 0.7411	0.4421 - 0.8119	0.4303 - 0.1309
Information	μ	0.6310	0.5278	0.7000
	σ	0.1791	0.2396	0.3151
	C.I. 80%	0.5335 - 0.7285	0.4866 - 0.7754	0.4839 - 0.2161
Supplier/Organization/Customer Chain	μ	0.5119	0.4722	0.6667
	σ	0.3021	0.0592	0.0589
	C.I. 80%	0.3475 - 0.6763	0.4762 - 0.5476	0.6263 - 0.0404
Product	μ	0.6190	0.5185	0.5444
	σ	0.1936	0.2781	0.2558
	C.I. 80%	0.5136 - 0.7244	0.4514 - 0.7866	0.3691 - 0.1754
Process/Flow	μ	0.6886	0.5385	0.3077
	σ	0.1773	0.2427	0.1256
	C.I. 80%	0.5921 - 0.7851	0.5424 - 0.8348	0.2216 - 0.0861
Total	μ	0.6218	0.5139	0.4842
	σ	0.2016	0.2415	0.1935
	C.I. 80%	0.5121 - 0.7315	0.4763 - 0.7673	0.3515 - 0.1327

Likewise, in Table 3 and Table 4 hypothesis tests were performed to compare the average of The State of Mexico with Brazil and the average of The State of Mexico with Spain respectively.

In order to develop the hypothesis tests of all the elements, except for the fourth (supplier / organization / customer), the test statistic and the critical value correspond to the mean difference of two random samples of size n_1 and n_2 , respectively. This information was taken from two normal and independent populations with unknown but equal variances.

Only for element four, which evaluates the relationship of the organization with its customers and suppliers, the test statistic and the critical value correspond to the means difference of two random samples of size n_1 and n_2 , respectively. This data was calculated from two normal and independent populations with unknown but different variances.

As shown in Table 3, the null hypothesis that evaluates if the mean of the State of Mexico and Brazil is equal for element 4 is rejected with 95% confidence. This means that it can be confirm that the degree of implementation of this element is greater in the State of Mexico than in Brazil. This results may be due to Mexico having automakers since 1962 (Holweg 2006) and Brazil started significantly after 1990 when a "New Automotive Regime" law was introduced (Vanalle & Salles 2012). Another reason may be due to the present political circumstances in Brazil.

Table 3. Hypothesis test for mean values of the implementation levels between Brazil and The State of Mexico

Element	Sampling average		t-Test statistic	One-sided critical value	p-value	Ho	H1	Result for Ho
	Brazil n=6	State of Mexico n=5						
1	0.5085	0.4308	0.4533	1.8331	0.3305	$\mu_1 = \mu_2$	$\mu_1 > \mu_2$	Do not Reject
2	0.5000	0.5611	0.3857	1.8331	0.3544	$\mu_1 = \mu_2$	$\mu_1 < \mu_2$	Do not Reject
3	0.5278	0.7000	1.0313	1.8331	0.1646	$\mu_1 = \mu_2$	$\mu_1 < \mu_2$	Do not Reject
4	0.4722	0.6667	5.4390	1.8595	0.0003	$\mu_1 = \mu_2$	$\mu_1 < \mu_2$	Reject
5	0.5185	0.5444	0.1596	1.8331	0.4384	$\mu_1 = \mu_2$	$\mu_1 < \mu_2$	Do not Reject
6	0.5385	0.3077	1.9121	1.8331	0.0441	$\mu_1 = \mu_2$	$\mu_1 > \mu_2$	Reject
Total	0.5139	0.4842	0.2218	1.8331	0.4147	$\mu_1 = \mu_2$	$\mu_1 > \mu_2$	Do not Reject

Automakers focuses their efforts in developing successful relationships with their suppliers. They achieve these successful relationships by sharing their best practices and information, contributing to improve their technical skills and plant

capacity. Through this, they target the acceleration of new products development and promoting JIT delivery (Vanalle & Salles 2012). Therefore, Mexico has almost 30 years of advantage versus Brazil.

In the same way, the results observed in Table 3 and Table 4 allow the rejection of the element 6 equality of means null hypothesis with a 95% confidence. Then, it can be concluded that The State of Mexico shows a lower level of implementation to the elements related to LM techniques in the production lines compared to Spain and Brazil. This result was not expected because North America was the first regional group to establish vehicle assembly plants that implemented LM techniques (Holweg 2006). For this reason, this unexpected result could be the answer to the fact that data from Spain and Brazil was collected through surveys sent by mail and there was not on-site verification of the information provided. (Araújo et al. 2012).

Table 4. Hypothesis test for mean values of the implementation levels between Spain and The State of Mexico

Element	Sampling average		t-Test statistics	One-sided critical value	p-value	Ho	H ₁	Result for Ho
	Spain n=7	State of Mexico n=5						
1	0.5824	0.4308	0.9180	1.8125	0.1901	$\mu_1 = \mu_2$	$\mu_1 > \mu_2$	Do not Reject
2	0.6270	0.5611	0.5562	1.8125	0.2951	$\mu_1 = \mu_2$	$\mu_1 > \mu_2$	Do not Reject
3	0.6310	0.7000	0.4853	1.8125	0.3190	$\mu_1 = \mu_2$	$\mu_1 < \mu_2$	Do not Reject
4	0.5119	0.6667	1.3207	1.9432	0.1174	$\mu_1 = \mu_2$	$\mu_1 < \mu_2$	Do not Reject
5	0.6190	0.5444	0.5772	1.8125	0.2883	$\mu_1 = \mu_2$	$\mu_1 > \mu_2$	Do not Reject
6	0.6886	0.3077	4.1001	1.8125	0.0011	$\mu_1 = \mu_2$	$\mu_1 > \mu_2$	Reject
Total	0.6218	0.4842	1.1849	1.8125	0.1317	$\mu_1 = \mu_2$	$\mu_1 > \mu_2$	Do not Reject

5. Conclusions

The State of Mexico implementation level is 48.42% but this response presented a wide confidence interval ranging from 35.15% to 61.68%. This ranging can be reduced by adding more observations to the research as mentioned previously.

Based on the hypothesis tests carried out, the element 4 degree of implementation is greater in the State of Mexico compared to Brazil. This may be due to Mexico possessing automakers for almost 30 more years compared to Brazil. Consequently, the State of Mexico automotive industry has developed successful relationships with its suppliers for a longer time.

Statistical results show that the State of Mexico presents a lower level of LM techniques implementation in the production lines, compared to Spain and Brazil.

However, this result was not expected, given that *Mexico is part of the first regional group to establish vehicle assembly plants that implemented LM techniques*. Future research is suggested in this element since the data collected was only in the State of Mexico. Further verification of information collected from Spain and Brazil is recommended since it was not face-to-face.

The State of Mexico has shown a significant difference in the elements 4 and 6, but for the others (1, 2, 3, and 5) have remained the same with 95% of confidence. Despite of these results, the total adherence level for the State of Mexico, Spain, and Brazil is about the same.

Finally, other researchers use their own evaluations different than the SAE J4000 standard, thus it is complicated to compare their results with our data to establish the LM adherence level.

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References

- AMIA, 2017. *Cifras de diciembre y cierre del 2016*, Ciudad de México.
- ANFAC, 2017. *España supera los objetivos de producción de vehículos para 2016 con 2,88 millones de unidades fabricadas*, Madrid.
- Araújo, F. et al., 2012. Evaluation of Lean Production System by using SAE J4000 standard : Case study in Brazilian and Spanish automotive component manufacturing organizations. *African Journal of business Management*, 6(49), pp.11839–11850.
- Bergmiller, G. & McCright, P., 2009. Parallel Models for Lean and Green Operations. *Industrial Engineering Research Conference*, pp.1138–1143.
- Eswaramoorthi, M. et al., 2011. A survey on lean practices in Indian machine tool industries. *International Journal of Advanced Manufacturing Technology*, 52(9–12), pp.1091–1101.
- Expansión, 2016. Producción de vehículos 2015. Available at: <http://www.datosmacro.com/negocios/produccion-vehiculos>.

- Holweg, M., 2006. The genealogy of lean production. *Journal of Operations Management*, pp.420–437.
- Hosseini, A., Kishawy, H.A. & Hussein, H.M., 2015. Lean Manufacturing. In *The Lean Manufacturing in the Developing World*. SPRINGER, pp. 249–269.
- Monden, Y., 1983. *Toyota production system: practical approach to production management*, Michigan: INDUSTRIAL ENGINEERING AND MANAGEMENT PRESS.
- Muslimen, R., Yusof, S.M. & Abidin, A.S.Z., 2013. A Case Study of Lean Manufacturing Implementation Approach in Malaysian Automotive Components Manufacturer. *Electrical Engineering and Intelligent Systems*, 130, pp.327–335.
- Nordin, N., Deros, B.M. & Wahab, D.A., 2010. A Survey on Lean Manufacturing Implementation in Malaysian Automotive Industry. *International Journal of Innovation, Management and Technology*, 1(1), pp.1467–1476.
- OICA, 2017. 2016 Q2 Production Statistics. Available at: <http://www.oica.net/category/production-statistics/>.
- Panizzolo, R., 1998. Applying the lessons learned from 27 lean manufacturers.: The relevance of relationships management. *International Journal of Production Economics*, 55(3), pp.223–240.
- SAE, 1999a. *SAE J4000 - Identification and measurement of best practice in implementation of lean operation.*, Warrendale: Society of Automotive Engineers.
- SAE, 1999b. *SAE J4001 - Implementation of lean operation user manual*, Warrendale: Society of Automotive Engineers.
- Sekaran, U. & Bougie, R., 2010. *Research Methods for Business: A skill building approach* 5th ed., JOHN WILEY & SONS.
- Srinivasaraghavan, J. & Allada, V., 2006. Application of mahalanobis distance as a lean assessment metric. *International Journal of Advanced Manufacturing Technology*, 29(11–12), pp.1159–1168.
- Vanalle, R.M. & Salles, J.A.A., 2012. Buyer-supplier relationships in the Brazilian automotive industry. *African Journal of Business Management*, 6(31), pp.9056–9064.

Photovoltaic Solar Energy and Environmental Management and as a tool for Industrial Systems: Case study in Brazil

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Abstract In organizational development, environmental management plays a decisive role for the betterment of the institution. Some industrial companies use this tool of sustainable development as an administrative strategy. This work presents a study of photovoltaic solar energy and environmental management through a case study in Brazil. A manufacturing company of alcoholic beverages (mill) through Cleaner Production was analysed. Therefore, investing in environmental management strategically adds value to the product, service and image of the institution and, thus, what would be cost becomes a competitive strategy that produces economic growth in a clean way.

Keywords: Solar Photovoltaic Energy; Environmental Management; Cleaner Production

1. Introduction

Nowadays the idea that economic development and environmental management create new business opportunities in the current market scenario is seen as a factor

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of competitive advantage. In organizational development, environmental management plays a decisive role for the betterment of the industrial companies. Some companies resort to this tool of sustainable development as an administrative strategy: competitive advantage and cost reduction (Porter; Van Der Linde, 1999).

2 Theoretical Aspects

2.1 Environmental Management (EM)

Environmental management is determinant for business maintenance and competency in the market, besides being a relevant topic in society and an imperative within organizations. When deployed, it can generate many benefits for organizations. The more evolved the EM of an organization, the more intense and more diversified the benefits will be. This improves production systems through practices that contribute not only to cost reduction, but also to the preservation of the environment. Thus, it is noted that sustainable development requires that the business sector adopts a socio-environmental protection policy consonant with economic development (Hoffman, 2005).

Wong, W.P. and Wong, K. Y. (2014) mention that Environmental Management and the Lean Production of processes, facilitates sustainability, allowing the organization to have a sustainable operational management. Sustainable development proposes the improvement of production systems through practices that contribute not only to cost reduction but also to the preservation of the environment. With this, it is understood that efficient EM has been a key issue for the development of companies and society

2.2 Cleaner Production and Sustainability

Cleaner Production is the "continuous implementation of an integrated and preventive environmental strategy for processes, products and services, to increase overall efficiency and reduce risks to people and the environment", a concept given by United Nations Environmental Program - UNEP in 1988. The main function of Lean Production is to reduce the waste of the raw material, that is, it tries to make the most of each material used in production, thereby minimizing the environmental impacts with more efficient use of natural resources in order not to generate waste or pollution. The Cleaner Production is a way of reconciling or harmonizing environmental aspects with economic interests to the point of promoting sustainable development. From the assertion that waste is everything that does not attribute value to the product or service, Lean Production proposes that there is no generation of waste

3. Solar Photovoltaic Energy

3.1 Energy Policies

The Brazilian solar program in the electric energy matrix tends to grow because there are continuous reduction of device costs, increasing interest of investors, rise of new technologies and a tendency to the solidification of policy incentives and Reduction of CO2 emisiona, which are already applied worldwide (Perlotti *et al.*, 2012, Hasnain, 1995, Januzzi, 2000, Cardoso *et al.* 2010, Nascimento, 2015 (Cullen *et al.* 2010, Sitonen *et al.* 2010, Melo 2013).

Solar energy is one of the most important factors to improve the quality of life. In addition to this, the investment costs of photovoltaic systems present a wide range of variation and depend on several factors, such as location, configuration, type and size of the system. In the case of distributed generation, the cost of a system of up to 5 kWp installed in Brazil in 2014 was close to US \$ 2.64/Wp. Therefore, it is understood that costs continue to decline as shown in Figure 1 (EPE, 2016):

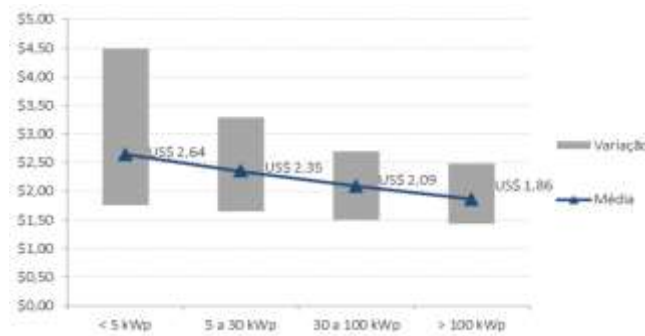


Figure 1. Average price of photovoltaic systems in Brazil in 2014 by power

Source: EPE (2016).

The implementation of this type of technology in companies will bring financial profitability, in addition to the industry adherence to the new sustainable production formats. This is an extremely important theme for companies that want to expand and innovate in the new competitive and globalized market (Nascimento, 2015).

Several strategies for efficient energy use have been used in the industrial sector in several countries A large increase in its development and facilities is shown in the Table 1 from year 2000 until 2030:

Table 1. Development and installation of photovoltaic solar energy in several countries
Source: (Nascimento, 2015).

YEAR	EUA	EUROPE	JAPAN	WORLD
2000	140	150	250	1000
2010	3000	3000	5000	14000

2020	15000	15000	30000	70000
2030	25000	30000	72000	140000

In addition to this, recent research conducted by International Energy Agency (2016) claims that the need for electricity in emerging economies will boost an increase of nearly 80% worldwide. For better visualization, Figure 2 shows a projection from the year 1990 until 2040:

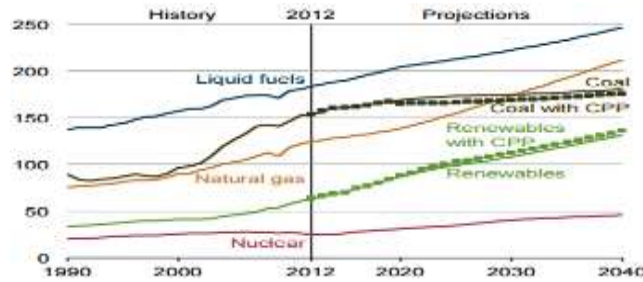


Figure 2. Total world energy consumption by energy source (1990 – 2040)
Source: IEA, 2016.

The maps below illustrate the regions where solar radiation is the highest in Brazil, indicating, initially, the best areas for solar exploitation. Analyzing only this factor, it is observed that the region of Northeast Brazil is of the most favorable places. The Figures 3 and 4 outline production costs in relation to solar radiation levels. The colder the color, the lower the costs of production. Figures 5 and 6 show the distributed generation and PV system ON – GRID:

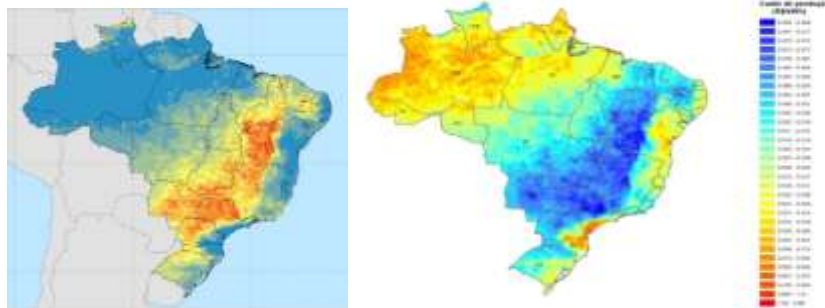


Figure 3 and 4. Solar irradiation in Brazil and the production cost of photovoltaic
Source: EPE (2016)

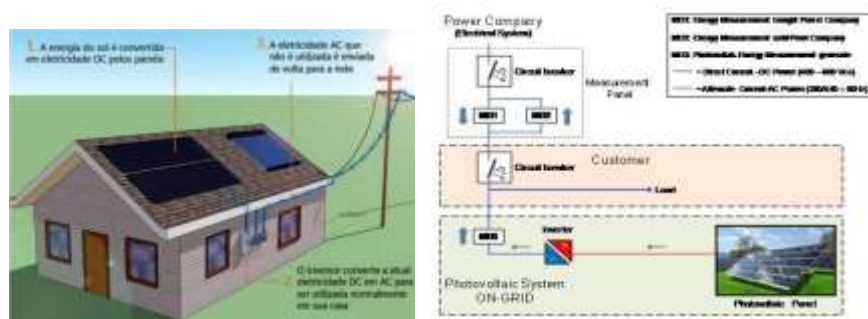


Figure 5 and 6. Distributed generation and PV system ON – GRID
Source: Carneiro, 2009

4. Methodology

As regards the technical procedures, this research is about a manufacturing company of alcoholic beverages in Northeast Brazil through Cleaner Production and Environmental Management. There was a study of application of solar energy in their plants. Afterwards, economic viability studies were made and the return period of investment (pay back) was calculated. Their products are organic, without chemical additives, flavourings, fermentation accelerators, and all stages of the process emerge products for reuse of the inputs. There is also the production of brown sugar, liqueurs, candies and cachaça jelly. The production plan of the organization is based on the principles of cleaner production and sustainability.

4.1 Sustainable Layout

The analyzed company resorted to a Layout in order to take advantage of gravity in the productive process, thus, eliminating the use of pumps or turbines as shown in the Figure 7. This kind of decision favored the use of devices and technologies that would require investments and would impact directly on the fixed costs of the organization. In addition, this layout reduces the need for sustainable use of natural resources using the law of nature, by serving efficiently the production process of the product.

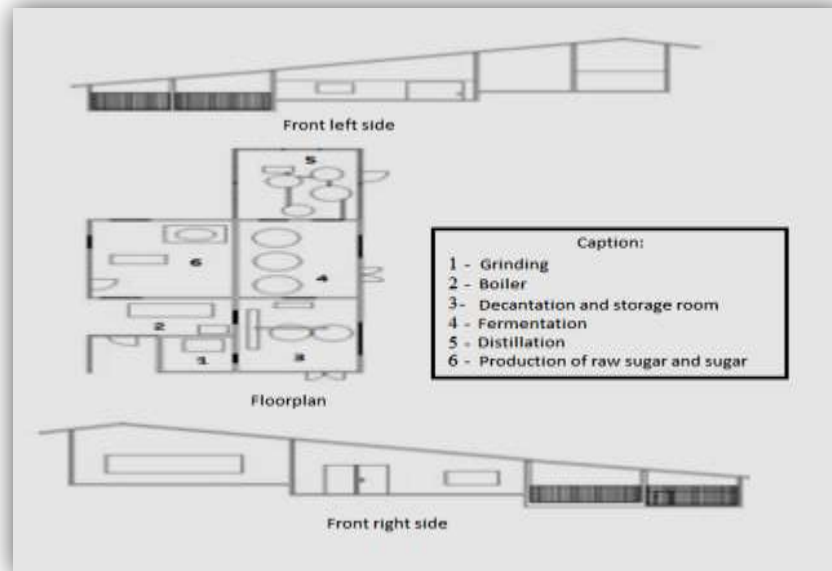


Figure 7. Layout
Source: Own elaboration

4.2 Cleaner Production Process

Table 2. Details of the process and action of Cleaner Production.

STEPS	ACTIVITY/PROCESS	SUSTAINABLE ACTION
1	Cutting sugar cane <ul style="list-style-type: none"> · The timeout between the cutting and processing of raw material is 12:00 am · Two tons of sugarcane per day are cut during the period of harvest 	The cane is planted in the lands and cultivated without chemicals.. The company has invested in agroforestry planting to produce food in a native forest environment.
2	Grinding <ul style="list-style-type: none"> · Sugarcane extract 	About 1/3 of all of the pulp produced is used as fuel in the boiler. The remaining 2/3 are watered down with vinasse and organic materials, including the ashes from boiler, form an excellent compost, returning to the plantation as a natural fertilizer.
3	Preparation of the broth <ul style="list-style-type: none"> · Water is added to the broth · 12% sucrose · Maximum duration period of 12:00 am, being overseen every 2 hours. · Use of 15 to 20 thousand liters of water per day in the production period 	Use of water from a well that meets the need of the local water supply.
4	Fermentation process <ul style="list-style-type: none"> · Add the yeast to the transformation of sugar into alcohol 	Using natural yeast: During fermentation, the yeast "work" listening to good quality instrumental music. This action is the result of scientific research claiming the benefits of classical and instrumental music to living

STEPS	ACTIVITY/PROCESS	SUSTAINABLE ACTION
		things.
5	Distillation process · Steam power · Separation of water and alcohol (heating at 90 degrees Celsius) · Change from liquid to gas (boil)	The steam produced by the boiler energy originates from sugar cane bagasse and copper pot stills are used in order to minimize the emission of chemical substances in the process. In addition, the Copper Alembic still provides special features of aroma and flavor.
6	Condensation process · Cooling jacket · Alcohol passes from the gaseous to the liquid	For the use of the water that is thrown into a tank and that will be pumped by a windmill to supply homes. All the water used for cooling in the production of cachaça is reused thus providing savings of over 50%.
7	Generation and separation Three types of products: · 10%-Rum (low quality and high concentration of alcohol) · 80%-Rum of heart (main product to be commercialized after aging) · 10%-Rum syrup (composition similar to the cachaça of head)	The cachaça of syrup and head are not sold. A new process of distillation generates a compound formed by more than 95% of alcohol to be used as fuel for domestic use.
8	Aging process · The cachaça of heart is stored in three types of wooden barrels: Freijó, oak and Umburana	The machine plants on the property trees that make available the timber to the aging process.
9	Marketing	

Source: Own elaboration

4.3 The Solar Photovoltaic Industrial Installations

This innovation would generate, in the liquor industry, a productive process totally dependent on a photovoltaic solar energy.

The cost of a complete Solar Photovoltaic Plant in Industrial Installations, provided on fully installed and commissioned turn-key, varies depending on the installation power scheme. In Table 2 Technical Feasibility Studies and Economic (TFSE) for some plants of a commercial installation of plastic and food industries 4 kW and 40kW are respectively presented.

Table 3. Detailing. Basic example of TFSE Solar Photovoltaic Plant

Source: own elaboration,

General Data	Value	Unit
Potential of Plant	4	kWp
Of each PV panel Power	255	Wp
Number of panels	18	Panels
Electricity Production Plant	7,771	kWh/year
Annual Financial Savings	1,069.75	US\$ /year
Specific Cost of Plant	1.94	US\$/kWp
Total investment	9,000	US\$

R.O.I. (pay-back)	5.9	year
Internal Rate of Return	22	%
Area installation	30	m ²

5. Results and Discussion

The company uses the most productive inputs to generate waste and pollution to the environment. It is understood that this type of policy has contributed to cost reduction and environmental preservation.

Regarding the sustainable *Layout*, this initiative is the result of a study of topography. It allows the good use of local relief and choice to improve the process. This allows for opportunities in a smart way, for example, the reduction of time and movement attributed to production.

The company stands out nationally for being the only to produce organic products in a sustainable way and through a clean energy generation system. These actions can be identified as a result of a GA efficient. With this, it is understood that the competitive differential part of a singular strategy or even the bold action planning that can add value to the final product and the institutional image.

6. Conclusions and Final Considerations

From the study, it is understood that the strategy adopted by the analyzed company is structured in integrated Environmental Management actions that gave the sustainability cause for the existence of the organization. It is appropriate to highlight the importance of EM as a successful strategy for organizations. Therefore, this assertive shows how to reconcile economic development with the maintenance of the environment. In addition, investing in an EM strategically adds value to the product, service and image of the institution and, thus, what would be the cost becomes a competitive strategy that produces economic growth in a clean way;

It was verified that the energy efficiency studies using solar photovoltaics in Brazil today are already economically viable. The return of investment income (pay back) for micro distributed generation is around 5.9 years with an installed capacity of 4 kWp;

The Northeast of Brazil is a world power in terms of solar radiation and can be considered almost self-sufficient in energy due to the high solar potential and the investment of energy efficiency for use of micro generation distributed the cost is from US\$ 1.94 US\$/kWp to a plant 4kWp.

References

- Cardoso R., Nogueira, L.; Haddad, J. (2010). Economic feasibility for acquisition of efficient refrigerators in Brazil, *Applied Energy*, v. 87, January, pp 28–37.
- Carneiro J. Dimensionamento de Sistemas Fotovoltaicos.(2009) Universidade do Minho, Portugal,
- Cullen J. M.; Allwood, J. M.(2010) . Theoretical efficiency limits for energy conversion devices, *Energy Review*, v. 35, Issue 5, May, pp. 2059-2069.
- EPE (2016) Empresa de pesquisa energética/ Nota técnica - Análise da Inserção da Geração Solar na Matriz Elétrica Brasileira. Rio de Janeiro.
- Hasnain S, Elani U, Alawaji S.; Abaoud H.; Smial M.(1995) Prospects and proposals for solar energy education program. *Apply Energy*, v.52, pp.307-14.
- Hoffman A. J. (2005) Climate change strategy: the business logic behind voluntary greenhouse gas reduction. *California Management Review*, v. 47, n. 3, p. 21-46, 2005.
- IEA. International Energy Outlook (2016) With Projections to 2040
- Januzzi, G. M. (2000). Policies for Energy Efficiency and Renewable Energy Market in the New Context: An Analysis of Recent Experience in the U.S. and Brazil (in Portuguese),
- Melo M, Campello, S, Silva L.(2012) Industry Energy Efficiency Analysis In Northeast Brazil: Proposal of Methodology and Case Studies. *International Journal Of Industrial Engineering: Theory Application And Practice*, v. 19, no 11.
- Nascimento Adriana. (2015). Solar Energy Photovoltaic: Cases Studies in Northeast Brazil. Master Dissertation, Federal University of Paraiba, João Pessoa-PB, Brazil.
- Perlotti E *et al.* (2012) Proposals for the insertion of Photovoltaic Solar Energy in the Brazilian energy matrix, Study the industry group of photovoltaic ABINEE
- Porter, M, Van der Linde, C. (1999) Verde e competitivo: acabando com o impasse. In: PORTER, M. *Competição: estratégias competitivas essenciais*. Rio de Janeiro: Campus,
- Sii-tonen S, Tuomaala, M, Suominen, M, Ahtila, P. (2009). Implications of process energy efficiency improvements for primary energy consumption and CO₂ emissions at the national level, *Applied Energy*,
- Wong, W P.; Wong K Y Synergizing an ecosphere of lean for sustainable operations. *Journal of Cleaner Production*. v. 85, p. 51-66, 2014.

Analysis of Lean Healthcare Implantation Results at Hospital Santa Lucia de Cruz Alta - Rio Grande do Sul - BRAZIL

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Abstract An imperative need in the health area is to improve the quality and the efficiency and, at the same time, to control costs. A promising management approach implemented by some leading institutions in the health area is the Lean, a quality improvement philosophy and a set of principles original from Toyota. The interest in the use of Lean thinking in the Brazilian health system is crescent and the subject is starting to get repercussion, following observed tendencies around the world. This article analyzes the results of the Lean methodology in a private hospital in Cruz Alta – RS – Brazil. The actions generated as results the reduction of 2,5 hours to 50 minutes the average discharge time; the modification in the shift change procedure; and, lastly, the change in the process of separation of dirty laundry.

Keywords: Lean Healthcare; hospital care; patient; hospital management; hospital laundry

1. Introduction

Lean thinking was developed at the Toyota plant in Japan. However, the quality management as we know it today, just had its recognition with the creation of the term "Total Quality Management", with Edwards Deming and Joseph M. Juran in 1950's (Lins, 2000).

From them, other researchers have developed different tools to improve industrial productivity, increase production capacity, reduce waste, increase profits, and reduce variability, among other reasons.

Some researchers began to study the applicability of those tools to areas other than industrial and so, in 2002, the Lean Healthcare arises.

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The Lean Healthcare aims to use the tools already employed in industries in hospitals: in the operating theater, in hospital bureaucracy, the general administration of the hospital and in their laboratories, with inventory control, valuation of employees and layout, among others (Bertani, 2012).

Lean in the healthcare environment becomes an important tool in the fight to eliminate waste and reduce operating costs in order to achieve high productivity. Especially when it comes to bureaucratic and slow processes with unmotivated and apathetic employees and the performance of its functions, especially in a complex system such as Brazil (Lima, 2007).

The Lean already shows excellent results in industry since its birth in the 1950s, with the development of the Toyota Production System. After its spread around the world with the Toyotism, some scholars have realized the potential of lean thinking to other areas such as hospital. The main point of this paper is to justify the use of Lean Healthcare can provide a significant improvement in health.

The relevance of the subject can be supported by the contribution of lean thinking has given to numerous organizations in various sectors, industrial or administrative, and especially the potential benefits of this approach to the various stakeholders of health care operations, both for employees and for patients or service users (Silberstein, 2007).

In this context, this paper aims to propose the implementation of Lean Healthcare to increase productivity of a Brazilian private hospital.

1.1 Theoretical Review

Through Deming, Japanese industry had contact with the concept of quality at the time when their companies went for his uplifting, just after World War II (Silberstein, 2007). Thus, from the 1950s, the Japanese began to develop quality improvement programs, and soon begun to create their own techniques, developing tools currently known in the midst of quality Engineering: just-in-time (where minimizing inventories), the 5S (sense of organization and cleaning the desktop) and kanban (production control made by card, the type of production system "pulled") (Bertani, 2012).

With the application of these tools and concepts, in less than 30 years the Japanese have already offered to the customer quality products and services at an affordable price and short-term deliveries.

With the spread of the principles of lean thinking, most recently, the quality tools began to be used in different areas of industry, such as the administrative area. Thus, different models have also emerged Lean, including the Lean Hospital, also known as Lean Healthcare (Lima, 2007).

1.1.1 Tools of Lean Production

There are several quality tools, especially of lean thinking, that can be applied in the health sector. Some of these tools are described below:

5S: There are five Japanese words that begin with the letter S and that describes organization practices in the workplace, visual management (layout) and lean production. These Japanese terms are Seiri, Seiton, Seiso, Seiketsu and Shitsuke. Translating these terms into English, respectively, are sense of disposition, sense of organization, cleanliness of sense, sense of standardization and sense of self-discipline. The 5S enables to exist on the desktop only the tools necessary for the operation. Thus, by organizing and following pre-established standards, the work becomes more efficient, easy and secure. Consequently, people become more motivated and productive (Rother, 2003).

Kaisen: Two Japanese words that represent the philosophy of "Continuous Improvement" (Gonçalves, 2012). It is applied in organizations to implement a continuous improvement involving everyone and seeks the best results at the lowest possible cost (Kaizen Institute Brazil, 2014).

Kanban: Japanese word for registration or visible plaque. It is a visual system that tells the employee what, how and when to produce. The main goal of the tool is to reduce inventories (Gonçalves, 2012).

Other stock concepts are also relevant to the job as economic lot purchase (LEC), which is the amount required to be purchased and stored to have the best relationship between the possible cost of acquisition and the cost of stock maintenance (Bowersox et al., 2006 cited Valentine, 2007), the point of reorder (R), which is the point of the stock in amounts, which should make the request to purchase the item and stock safety (SS), which is the safety stock, that is, it serves to protect themselves from potential demand uncertainties (such as delays or other unforeseen) (Gasnier, 2002).

2. Methodology, Actions and Results

2.1 Methodological Approach

The method used in this study was the qualitative case study. The case study documents and analyzes in detail the activity of a company or organization or a part of it.

According to Cauchik and Sousa (2012), a case study is defined as "an empirical work investigating a given phenomenon in a real contemporary context through deep analysis of one or more objects of analysis (cases)." According to Yin (2001), the case study is considered adequate when it comes to an empirical investigation of "how" and "why" on a number of recent events on which the researcher has little or no control.

This case study analyzed the results obtained in the implementation of some Lean Thinking tools in a private hospital located in Cruz Alta, Rio Grande do Sul, in the South of Brazil.

The Santa Lúcia Hospital has 100 beds, 350 employees, 10758 annual medical treatments which 32% are from other counties.

2.2 Actions and Results

2.2.1 Average hospital discharge time

From an initial chronoanalysis performed in September/2016, it was observed that the average hospital discharge time on the 5th floor was 02h 30min.

Based on this, improvements were made both in the hours of sanitizers, concentrating a larger number of employees with the highest incidence of hospital discharges, as can be seen in Figure 3, and in the inspection process by the hotel supervision. After such improvements the average time of discharge was 50 minutes in the month of November/2016. The following are the changes in the two process flowcharts: BEFORE (Fig. 1) and AFTER (Fig. 2)

Before

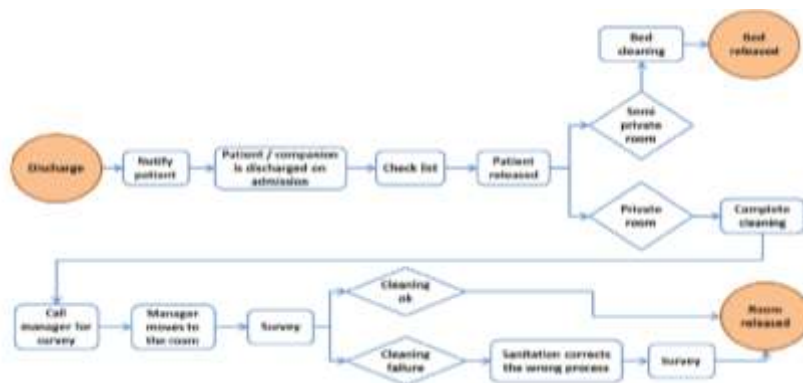


Figure 1. Discharge flowchart before the Lean method, that took an average discharge time of two hours and thirty minutes.

After

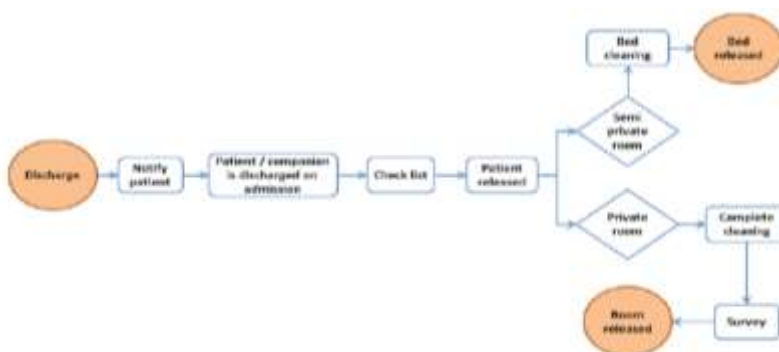


Figure 2. Discharge flowchart after the Lean method, that took an average discharge time of 50 minutes.

Before the journey adjustment



Figure 3. Flow of working day time and discharge flow prior to adjusting the working hours of hospital staff.

After the journey adjustment

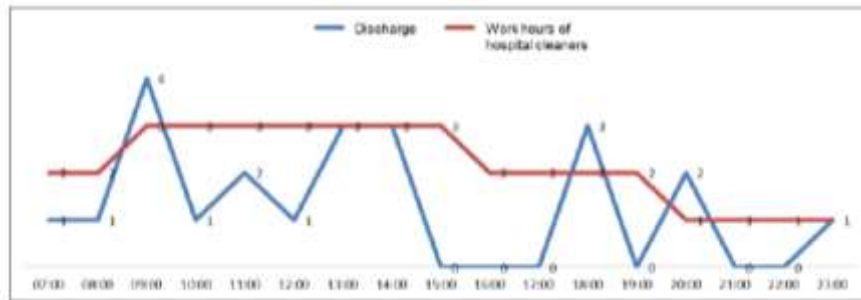


Figure 4. Flow of working day time and discharge flow after adjusting the working hours of hospital staff.

2.2.2 Hospital shift change

In this case, the chronoanalysis studied the time taken to change the hospital shift, because of the overtime at work. This analysis was carried out in the 3 floors for 3 days, it was identified that the technicians passed the shift to all colleagues, regardless of who would be with each patient, it was also identified that some employees arrived on time, but arrived at the sector with delays of 5 to 8 minutes. Besides that, it was found that each employee took about 3 minutes to change the shift, which added up to 12 minutes to complete the process in its entirety.

To solve this problem, it was developed, together with the health care management, a new model of hospital shift change. In this model, the technicians pass their patients' shift only for the colleague who will assume them. Thereby, the change shift time was reduced to a maximum of 4 minutes, reducing also the overtime at work and the waste (Fig. 5).

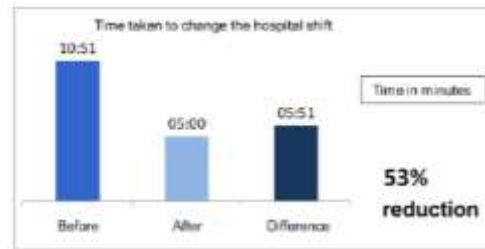


Figure 5. Graph of the average time reduction of shift changes.

2.2.3 Laundry flow

By monitoring the discharge process, it was identified that the amount bedding items either did not meet the demand, or needed to be replaced due to wear. For this, the laundry washing process was followed up and it was found in the chronanalysis that the clothes did not arrive separated according to dirtiness, because of this all washes were carried out in the heavy cycle.

A employee training was carried out along with the area of hospital infections control and the process of separation of dirty laundry was modified in the hospitalization units, intensive care unit, imaging diagnostic center and the surgery center. It is important to note that with the proper unbundling of laundry, it is possible to provide a greater durability of the bedding, since its cleaning will be according to the dirt presented at the moment. The result obtained after the adjusting of the separation of laundry are presented (Table 1).

Table 1. Laundry data

Average	Heavy cycle	Light cycle	Cover washing	Comprese washing
January 2016 à November 2016	113	0,5	32	24
December 2016	90	17	24	25

After three months of improvements in this process, it is possible to do a light cycle laundry washing per day, which reduces the material costs in about R\$ 1.000,00 per month.

3. Conclusions

The efficacy and efficiency in the application of the Lean methodologies in the described processes can be proved from the results obtained. There were presented only 3 cases of analysis, but the implementation of Lean philosophy has brought several other gains to the Santa Lucia Hospital in waste elimination, It can be cited: the reduction of 2,5 hours to 50 minutes the average discharge time, due to both the method change and the adjustment in the work schedule of the hospitality staff, the modification in the shift change procedure, reducing the incidence of

overtime and, lastly, the change in the process of separation of dirty laundry, providing more durability and reducing the costs with materials in this process and other more.

Among all the gains in productivity and costs that were obtained by the Lean, there is no doubt among the hospital employees that the greater gain was obtained in relation to the improvement in patient care, resulting in a higher satisfaction index of these patients, which is evidenced by the many thank you letters the hospital has received from their clients and family members.

References

- Bertani, T. M. (2012) Lean Healthcare: recomendações para implementações dos conceitos de Produção Enxuta em ambientes hospitalares. 166 f. Dissertação (Mestrado em Engenharia de Produção) – Escola de Engenharia de São Carlos, da Universidade de São Paulo, São Carlos, São Paulo.
- Bowersox, D.J; Closs, D. J.; Cooper, M. B. (1996) Gestão logística de cadeias de suprimentos. – Cingapura: Mc Graw Hill. 752 p.
- Cauchik, P. A. M.; Sousa, R. (2012) Metodologia de Pesquisa: Em Engenharia da Produção e Gestão de Operações. 2ª Edição, Editora Campus.
- Gasnier, D. G. (2002) A dinâmica dos estoques: guia prático para planejamento , gestão de materiais e logística. São Paulo: IMAM.
- Gonçalves, D. G. (2012) Kaizen Lean em Laboratórios de Análises Clínicas. 83 f. Tese (Mestrado Integrado em Engenharia Industrial e Gestão). FEUP. Porto, Portugal.
- Kaizen Institute Brasil (2014). Disponível em <<http://br.kaizen.com/home.html>>. Acessado em 11 mai. 2014.
- Lima, A. C. (2007) Práticas do pensamento enxuto em ambientes administrativos: aplicação na divisão de suprimentos de um hospital público. 185 f. Tese (Doutorado em Engenharia Mecânica) - UNICAMP, Campinas, São Paulo.
- Lins, B. E. (2000) Cadernos Aslegis, v.4, n.12, p. 53-65, set/dez 2000
- Rother, M.& Shook, J. (2003) Aprendendo a enxergar: mapeando o fluxo de valor para agregar e eliminar o desperdício. Lean Institute Brasil, São Paulo.
- Silberstein, A. C. L. (2006) Um estudo de casos sobre a aplicação de princípios enxutos em serviços de saúde no Brasil. 161 f. Dissertação (Mestrado em Administração) – UFRJ, Rio de Janeiro, Rio de Janeiro.

Service Systems

Smart-safe: Determination of relevant functionalities in development of mobile app for personal safety and safe áreas

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Abstract The purpose of this paper is to identify relevant functionalities for safety mobile app. This study contributes to the development of a dynamic, real-time intelligent platform that enables sharing information, to integrate user data with public security agents, with various functionalities. **Method** Literature review on “safe smart” in Scopus database, exploratory analysis, quality and quantity methods, research on database with main app's electronic catalogs, in timeless period. The sample represents 57 smartphone app's, most commonly used on the major mobile application distribution platforms. Play-store and Apple-store presented the features most required by users, as well as highlighted the most indicated new app that meets the greatest usability. **Results** It was verified the existence of 57 app's for smartphones related to the main functionalities. Therefore, it was developed a comparative analytical framework with existing mobile app's to assist the user focused on safe urban areas analysis, structuring, functionalities, definition of instructional objectives and the choice of evaluation instruments for classifying the existing technological systems and classify their main functionalities.

Keywords: Urban public safety, smart-safe, smart cities, safety personal mobile app development, social network mobile app.

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1. Introduction

Security and citizen protection become an important strategy for municipalities, as insecurity establishes a strong relationship with how people relate to the elements that make up the urban complex, since the absence of a safe space restricts the confidence of Inhabitants to that place and its accesses.

Insecurity causes irreparable damage to its victims demonstrates that actions and plans of public or private security agents still need to be improved in order to be able to act in a dynamic way, since actions may prevent the occurrence of an event Require reliable, real-time and integrated information to these security agents, so that they can generate protective actions that reduce the chance of occurrence by discouraging actions against citizens by the elements of misconduct.

In order to meet citizens' needs, city managers must foster innovation in specific areas in order to promote growth on the sustainability tripod (Hollands, 2008).

With the advancement of technology to all fields of society, its application in the context of public security becomes an element of integration between the citizen and the security agents, as it allows to include intelligent systems that will anticipate possible vulnerabilities and insecure areas.

The concept of Smart City has gained emphasis in the last years, being initially considered as an environment capable of making the connection between the digital and the real, delimited in a geographic area with high concentration of knowledge, having its management based on information and communication technologies (ICT)(Komines, 2002).

Intelligent cities are areas with great innovative capacity, constituted through the intellectual production of their populations, as well as the use of knowledge management and communication as a way of improving the structure and services in the city, thus increasing the quality of life of people. (Junckes, 2016).

With the dissemination of the use of mobile phones, with functions and applications for the most diverse uses the citizen has become a potential generator of data and information that can be used to power intelligent systems where a network connected between the citizens themselves and the Agents create a safe field of action, allowing access and safe use of that location.

2. Methodology

The research for the term "Smart Cities" and "Smart Safe" was in the official application sales platforms of the operating systems; Android, iOS. No temporal delimitation or any other refinement was applied in the search, only the applications characterized as inactive by the criterion of absence of own website were disregarded.

It was obtained 57 applications, 49 in the Play Store and 8 in the Apple Store. The classification of applications was performed considering the number of downloads and number of functions. Due to the number of downloads being reported by companies in the approximate range format, it was considered the lowest value.

A research consists of a systematic investigation, which aims to develop theories, establish evidence and solve problems. It is fundamental that the researcher is sufficiently informed of what was researched, how it was researched, what results were found and what has not yet been researched (Morandi & Camargo, 2015).

3. Development

By defining the functionality that characterizes mobile applications as belonging to the smart-safe category, a relationship based on the applications found on the distribution platforms listed above was elaborated.

It was cataloged by assigning an ID for each application in Table 1 and sorting them by descending order of downloads, the last positions were destined to the applications whose number of downloads is not informed. Also related was the number of functions related to the concept of smart safe in each application.

Table 1. Mobile applications and mobile application functions

ID	App	Functionalities														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	LXT Smart Safety														X	
2	Smart Cities Pro	X		X	X			X								
3	KrumbssSDK Smart Cities	X	X	X	X		X	X								
4	SmartCity Alerta NFC	X	X	X	X		X	X								
5	JERU Smart City	X						X								
6	Smart Cities	X				X			X							
7	smArt	X														
8	Guia Smart Cidades	X	X													
9	smart city MX								X							
10	Smart Safe Trace	X		X												
11	Qliq Watch:SOS			X					X							
12	Urban Air- The Smart City	X					X		X	X						
13	Smart City Lens						X									
14	Smart City						X			X						

47	Localizador Familiar e Cel	X	X					X			X			
48	Rastrear Celular GPS	X						X			X			
49	Buscar Amigos							X			X			
50	Smartwatcher Segurança Pers	X	X					X						
51	Bsafe	X	X					X						
52	SafeForUs Plus													X
53	CityCop - GPS de Alerta													X
54	Segurança pessoal & familia		X					X						X
55	ZOEMOB Assistente	X						X						
56	Life 360	X						X			X			
57	Prescient Traveler													X

In table 2 are enumerated the total of 15 functions functions chosen as belonging to the smart safe category and assigned caption with identification form.

Table 2. Legend mobile app functionalities.

Caption functions			
GPS	1	Data and analysis	9
Traffic	2	News	10
SOS	3	Public transparency	11
Denunciations	4	Chat	12
Transport	5	Monitoring	13
Report abuse	6	Monit. SOS	14
Services of secure./health	7	Unsafe areas	15
Social Network	8		

In Table 1, the functionalities found in each app according to the legend developed in Table 2.

The sum of the amount in which each feature was found throughout the sample space was listed in Table 3.

Table 3. Number of applications containing certain functionality

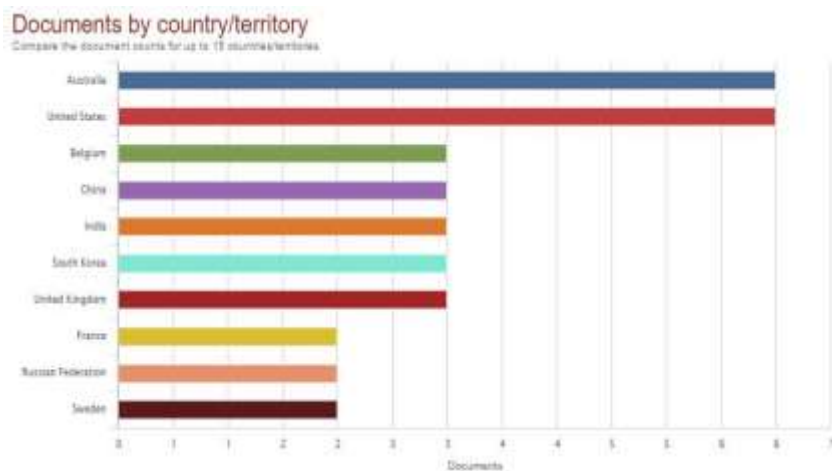
Functionalities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantities	31	6	18	8	4	12	12	17	5	3	2	7	5	1	4

Within the chosen functionality was carried out ranking of the five main ones, which are listed below.

Table 4. Ranking of functionalities.

Position	Function	Quantities
1	GPS	31
2	SOS	18
3	Social network	17
4	Report Abuse	12
5	Services of secure/health	12

As a basis for comparing the history of publications containing the term “Smart Safe”, research was developed within the Scopus Elsevier database. Quantitative results on the total sample provided by the database.

**Figure 1.** Publications by year.**Figure 2.** Publications by country.

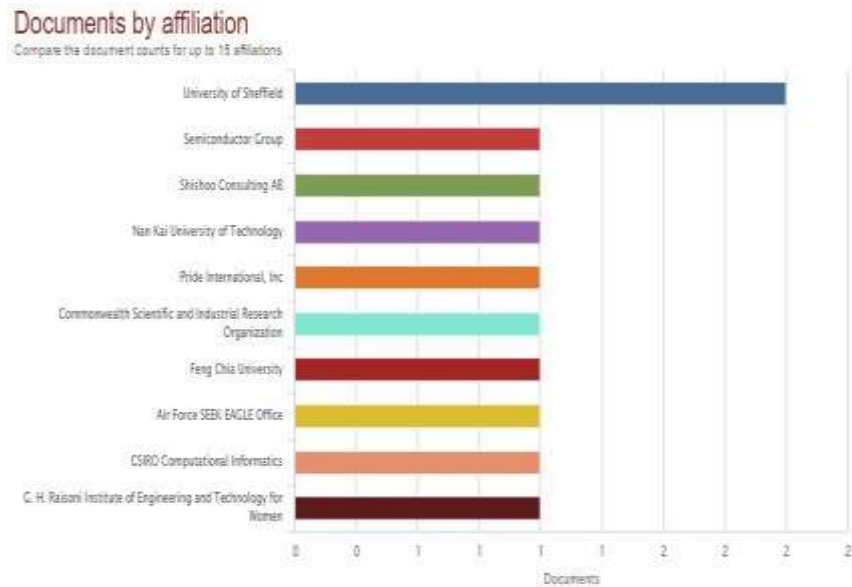


Figure 3. Publication by institute.

4. Conclusion

This article aimed to determine which features are most common for today's personal security applications in app distributors around the world.

Regarding the functionalities, it was accomplished through the adoption of methods of systematic review of the cross-reference to establish the quantitative-qualitative analysis. The term "smart safe" researched on Scopus database resulted in major countries as Australia and United States of America with greater generation in scientific publication, as Fig.02 (Publications by country). We obtained five key functionalities with greater relevance from fifteen functionalities presented in the mobile applications, per Table 05 (Ranking of functionalities). In this way, some functionalities will be initially inserted in the mobile platform in development: GPS, SOS, Network of Reports, Denunciations and Services of Secure/Health. Besides ID 15 (insecure area indication functionality) was less frequent, this functionality is prevalent in mobile applications for iOS operating system platform, the Apple Store, with high relevance and quality. In this way, the ID 15 has been added to the functionalities that will be present in the app, totalizing six key features.

References

- Hollands RG (2008) Will the real smart city please stand up? Intelligent, progressive or entrepreneurial? *City*, 12 (3), pp. 303-320.
- <https://itunes.com> <access em 16/02/2017>
- <https://play.google.com/store/search?q=smart%20cities> <access em 16/02/2017>
- <https://play.google.com/store/search?q=smart%20safe> <access em 16/02/2017>
- Junckes D, Teixeira CS (2016) Modelo Brasileiro de maturidade para cidades inteligentes: Análise dos municípios do estado de Santa Catarina. Universidade Federal de Santa Catarina.
- Komninos N (2002) *Intelligent Cities: Innovation, Knowledge Systems and Digital Spaces*. London: Routledge.
- Morandi MIWM, Camargo LFR (2015) Revisão sistemática da literatura. In A. Dresh DP Lacerda, JAV Antunes Junior (Eds), *Design science research: método de pesquisa para avanço da ciência e tecnologia* (p.141-172) Porto Alegre: Bookman.

A Conceptual Model of Healthcare Supply Chain Network

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Abstract This paper presents a conceptual model of the healthcare supply chain management. To achieve this, a business process map and a SIPOC diagram for healthcare facilities were developed. The proposed SIPOC diagram illustrated the flows of material, patients, information and cash between a healthcare facility and its key suppliers and customers. Understanding such interactions can help improve communication, standardize processes, and reduce the overall cost of healthcare supply chain.

Keywords: Healthcare service sector, Service supply chain management, Healthcare service supply chain management, Healthcare facilities' processes.

1. Introduction

Due to the global growth of business services and its substantial contribution to the gross domestic production, managing the supply chains of service sectors becomes as important as for the manufacturing sector. However, implementing manufacturing supply chain management (SCM) approaches to services' supply chain is very challenging as both sectors have relatively different nature of processes and management. In fact, processes of service sectors, such as banking, tourism, education, and healthcare; can vary making it hard to develop mutual principles for service SCM and apply it to all service sectors (Ellram et. al, 2004)

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The significance of the healthcare services is increasing by the day. The aging and growing populations, the drive of innovating technologies, and the focus of care delivery's value and quality; are all leading to rising costs and increase of spending for health care provision. On the other hand, the healthcare sector is overwhelmed by poor management, inflated prices, outdated information technology systems and infrastructure, poor inventory and distribution management, ad-hoc procurement systems, lack of executive involvement, and no process improvement culture. To cope with the rapid change of the healthcare services and the increasing competition in the industry, many healthcare facilities have realized the importance of adapting SCM principles (De Vries et.al, 2011, Toba et. al, 2008, Supeekit et. al, 2015).

Research in service SCM is scarce; an integrated concept of SCM in healthcare services is still fragmented, and a collaborative framework that incorporates the healthcare SCM is absent (Toba et. al, 2008, Barnard, 2006, Basu, 2011). In this paper, a conceptual model for the healthcare supply chain (HSC) network is proposed based on SIPOC (Supplier-Inputs-Processes-Outputs-Customer) diagram. Two levels of healthcare facility's processes are used to create the SIPOC diagram: General and detailed.

The rest of the paper is organized as follows: Section 2 presents the research methodology, section 3 describes the business process map of a health care facility, section 4 presents the proposed SIPOC diagram and concluding remarks are presented in section 5.

2. Research Methodology

Figure 1 summarizes the methodology followed in this research. Review of literature and experts-interviewing were the steps adopted to understand the HSC network. Semi-structured interviews, a qualitative method of inquiry that combines a pre-determined set of questions as well as improvised questions to bring up new ideas, with healthcare facility's head of department were conducted. The interviews covered departments of purchasing, storage, emergency rooms, intensive care units, and top management in several Jordanian healthcare facilities. The interviews involved discussions about the main processes occurring in healthcare facilities, processes' steps, and, in order to understand the interactions between the different departments of the facility and other supply chain network components; what documents and/or materials are issued from and to each process.

In order to visually depict the business processes and the flows within a healthcare facility and to fully comprehend the detailed processes occurring, a general business process map was first created and then used to create a detailed business process map. Next, the built map was integrated with the SIPOC diagram. Researchers have used SIPOC diagrams to identify/define process/systems as it

offers a greater capability of focusing on customer satisfaction, identifying improvement and defining their scope in order to improve quality and standards of processes (Mishra and Kumar, 2014, Marques and Requeijo, 2009). The built SIPOC diagram allow a clear understanding of the HSC network based on the detailed processes of a healthcare facility, processes' inputs and outputs, and the processes interactions with other supply chain network components, including suppliers and customer. Eventually, experts from Jordanian healthcare facilities were consulted, through interviews, to validate the SIPOC diagram and their modification suggestions were considered.

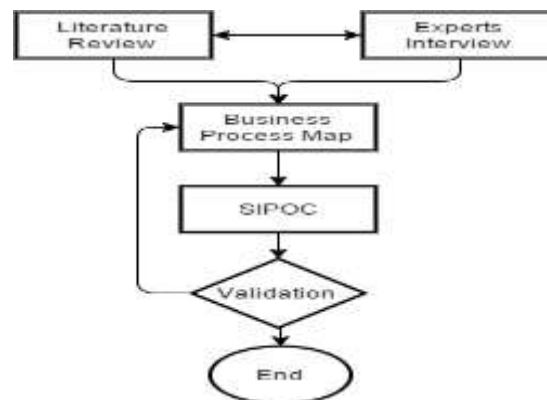


Figure 1. Methodology of proposed work

3. Business Process Map of a Healthcare Facility

Business process mapping is usually adopted to document how business operates and how inputs and outputs flow through. To build a business process map, processes and their connection should be understood. In this section, general and detailed levels processes are presented. The general level describes the main deliverables of the processes, how they are categorized based on their contributions, and an overview of how supply chain components are connected. The detailed process level encompasses processes occurring within each process category in healthcare facilities, how they are interrelated, and how they interact with supply chain components.

3.1 General Level Processes

The main processes occurring in healthcare sector are divided into three main categories (Smith et. al, 2012, Supeekit et. al, 2016): Clinical care processes, supporting processes, and financial processes. Figure 2 illustrates these processes.

The clinical care processes are the processes responsible for delivering medical services to patients; yet, these services require resources from the supporting

processes. The supporting processes help in the completion of clinical care processes by providing the required medical materials such as pharmaceutical supplies, medical supplies, medical apparatus, and other non-medical supplies purchased from pharmaceutical suppliers, medical suppliers, and non-medical suppliers (Bhattacharjee and Ray, 2014, Kujala et. al, 2006, Rahimnia and Moghadasian, 2010, Kumar et. al, 2005, Kumar et. al, 2008, Singh, 2008). Financial processes, the third category, handle the cash flow with both suppliers and customers. It is responsible for calculating revenues by keeping records of costs owed to suppliers in addition to other types of costs, and keeping records of profits from patients and insurance companies (Smith et. al, 2012).

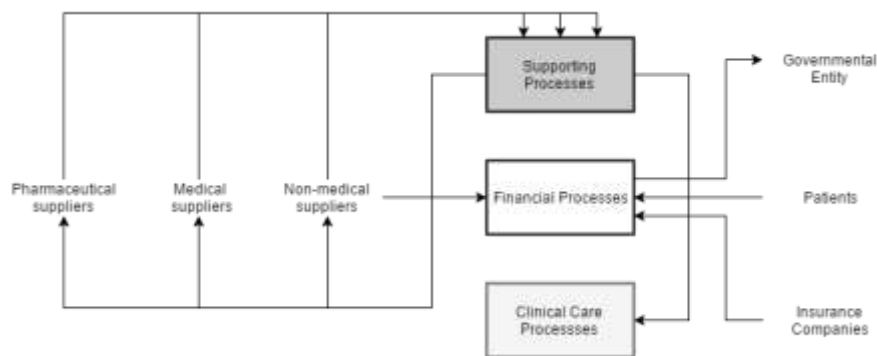


Figure 2. General process map in a healthcare facility

3.2 Detailed Level Processes

The detailed processes of the three processes' categories occurring in a healthcare facility, the interactions within the facility, and the interactions between the facility and other HSC network components are illustrated in the processes part of the SIPOC diagram shown in figure 3.

Clinical care processes can be divided into five processes (Bhattacharjee and Ray, 2014, Kujala et. al, 2006, Rahimnia and Moghadasian, 2010): demand/capacity management, patient admission, patient investigation, care delivery, and discharge/transfer. Demand/capacity management, which is usually a joint process with supporting processes for achieving high coordination between these two processes categories; ensures that patients' waiting and delays of treatment are lessened by proper scheduling of the staff's shifts and accurate updating of the healthcare facility resources after patients discharging. Upon arrival patient must go through certain process that include registration, triage, and patient admission. Patient investigation is performed by the nurses and doctors using medical supplies and pharmaceuticals from the storage department. Sometimes, patient investigation requires tests or body scans—conducted in various departments. Care delivery is where the actual treatment is provided including performing surgeries, providing medicine, and controlling the patient's medical condition. Finally, the discharge/transfer process occurs after the patient is treated as planned (discharge)

or when the patient's illness is beyond hospital's proficiency so the case is transferred to another hospital.

As explained by several researchers (Kumar et. al, 2005, Kumar et. al, 2008, Singh, 2008), the supporting processes include demand/capacity management, purchasing/sourcing, receiving, inventory management, transportation, and returns. The demand/capacity management contribution in the supporting processes involves forecasting the healthcare facility's changing demand for products and services, and adjusting ordering patterns to compensate for these changes. Purchasing/sourcing is the process that includes the procuring and sourcing of the hospital's supplies from suppliers based on the needs while maintaining quality standards with competitive prices. Receiving is the process of taking possession of products from suppliers; and inspect the products to assure quality, quantity, and expiry dates. This step has to be successfully completed in order for invoicing to take place as will be explained later in the financial processes. Inventory management is the process of specifying the quantity and space requirements of products, and where they should be stored in storage locations within the facility. Transportation is the processes of transferring materials and patients to the point of care or where they are required to be, for example transporting medical equipment to the emergency room and transporting a patient from his room to surgical operations' room. Return process includes the returning of products to suppliers due to inspection results, maintenance or shelf life expiration.

Financial processes include accounts payable, accounts receivable and financial accounting. Accounts payable includes the processes where invoicing occurs—defining how much the hospital owes to suppliers by managing the records of receiving products and returned products. Accounts receivable includes all the revenues that are generated from patients and insurance companies based on the medical services provided to patients. Financial accounting is the process of preparing financial statements for decision makers, stakeholders, banks, employees and government entities. The financial statements include information on the financial transactions that take place in the hospital with its suppliers, customers and government entities and are used to calculate the taxations, return on investment, revenues, etc.

4. The Proposed SIPOC Diagram

A SIPOC diagram is a high-level process mapping tool which assesses companies' performance in satisfying customer requirements in the overall supply chain (Basu, 2011). Constructing a SIPOC diagram includes defining the processes; listing their outputs, customers, inputs, and suppliers. The proposed SIPOC diagram was generated to encompass the details of the three processes' categories occurring in healthcare facilities, the interactions within the facility, and the interactions between the facility and other supply chain network components.

Different types of flows are tracked including, material, information, patients and cash flows. Figure 3 shows the proposed SIPOC diagram for the HSC network.

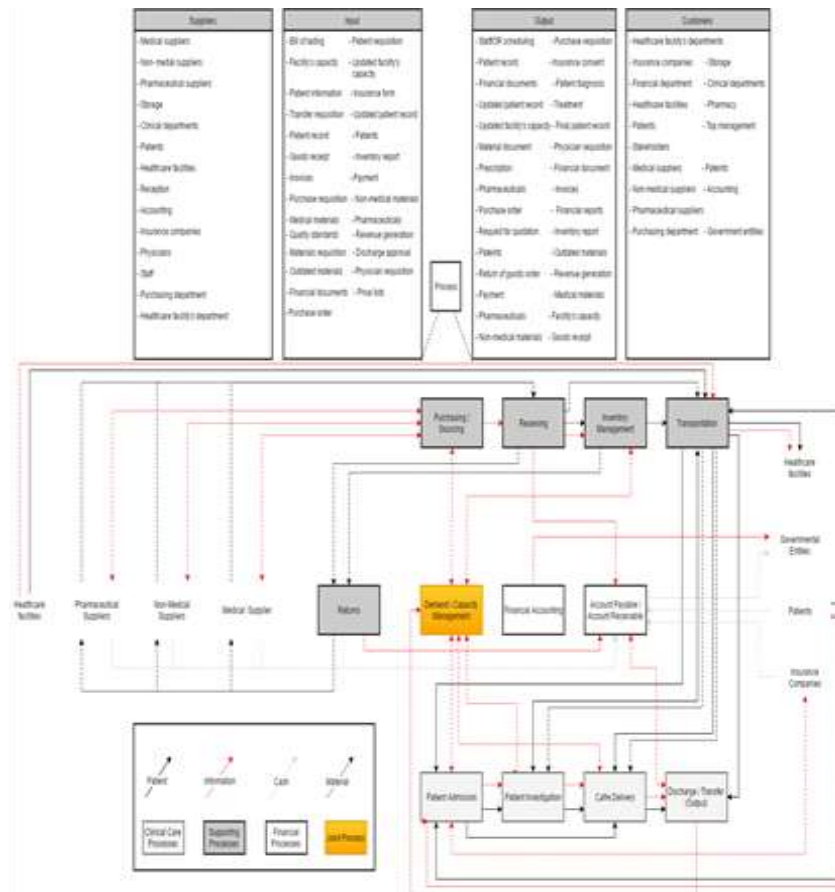


Figure 3. The proposed SIPOC diagram for the HSC network

The patient's arrival, alone or by an ambulance, initiates the clinical care processes. Upon arrival patient must go through registration, triage, and inpatient admission. The receptionist enters patient's information into patient's medical record. In special cases, insurance companies are contacted to approve treatment's coverage. Afterwards, the patient's is diagnosed, required treatment is decided, and medical record is updated. Actual treatment is provided in form of performing surgeries, providing medicine, and controlling the patient's medical condition. After each discharge/transfer process, demand capacity management process updates the capacity information (beds, rooms, and medical staff). Material documents that describe all materials utilized in patient's treatment is generated and used for replenishment purposes by supporting processes. A financial

document is also generated and sent to accounts receivable in the financial processes.

The demand/capacity management processes' information is passed to the purchasing/sourcing process as a purchase requisition in order to compensate for the consumed supplies. The relationship between purchasing/sourcing process and suppliers is bidirectional as it includes information exchange to ensure competitive prices and on-time delivery. When the right supplier is chosen according to predetermined criteria, the purchase requisition is turned into a purchase order. After the ordered materials are received from suppliers through the receiving process they are inspected for quality, expiry dates, and quantity. The successful completion of the receiving process triggers a financial and a material document. The financial document acquires the suppliers with the amount of the invoice that the healthcare facility has to pay. This is done through the accounts payable in financial processes. The corresponding material document states the amount of each type of supply present in the facility. Afterwards, the received products are transferred to "inventory management" responsible for specifying the storage requirements. In emergency conditions, received goods are directly transported to the care delivery point. In cases of nonconforming products, expired products, and malfunctioning machines; goods and supplies are returned to suppliers using a return of goods order. The return process triggers a financial document in the accounts payable resulting in deducting the returned products worth from suppliers' credit. Lastly, transportation process is responsible for delivering supplies from the storage department to local clinical departments as well as transferring patients to the point of care delivery within the facility.

5. Conclusions

In order for the healthcare service business to accommodate with increasing competition, new technologies, and increasing service levels' requirements in an effective efficient way, an integrated model for HSC network is required. To conceptually understand such model, a business process map to depict the healthcare facilities' processes along with the inter-departments flows was constructed. A SIPOC diagram was then generated to incorporate the inputs, outputs, suppliers, and customers of the processes. The presented diagram illustrated the flows of materials, patients, information and cash between a healthcare facility and its' key suppliers and customers. Understanding such interactions can help improve communication, standardize processes, and accordingly reduce the HSC overall cost. Future work includes building an analytical model that aims to optimize costs of the HSC network while maintaining a minimum required patients' service level.

References

- Barnard, J.H., 2006. A multi-view framework for defining the services supply chain using object oriented methodology (Doctoral dissertation, University of Central Florida Orlando, Florida).
- Basu, R., 2011. Managing project supply chains. Gower Publishing, Ltd.
- Bhattacharjee, P. and Ray, P.K., 2014. Patient flow modelling and performance analysis of healthcare delivery processes in hospitals: A review and reflections. *Computers & Industrial Engineering*, 78, pp.299-312.
- De Vries, J. and Huijsman, R., 2011. Supply chain management in health services: an overview. *Supply Chain Management: An International Journal*, 16(3), pp.159-165.
- Ellram, L.M., Tate, W.L. and Billington, C., 2004. Understanding and managing the services supply chain. *Journal of Supply Chain Management*, 40(3), pp.17-32.
- Kujala, J., Lillrank, P., Kronström, V. and Peltokorpi, A., 2006. Time-based management of patient processes. *Journal of Health Organization and Management*, 20(6), pp.512-524.
- Kumar, A., Ozdamar, L. and Peng Ng, C., 2005. Procurement performance measurement system in the health care industry. *International journal of health care quality assurance*, 18(2), pp.152-166.
- Kumar, A., Ozdamar, L. and Ning Zhang, C., 2008. Supply chain redesign in the healthcare industry of Singapore. *Supply Chain Management: An International Journal*, 13(2), pp.95-103.
- Marques, P.A. and Requeijo, J.G., 2009, April. SIPOC: A Six Sigma Tool Helping on ISO 9000 Quality Management Systems. In XIII Congreso de Ingeniería de Organización (pp. 1229-1238).
- Mishra, P. and Kumar Sharma, R., 2014. A hybrid framework based on SIPOC and Six Sigma DMAIC for improving process dimensions in supply chain network. *International Journal of Quality & Reliability Management*, 31(5), pp.522-546.
- Rahimnia, F. and Moghadasian, M., 2010. Supply chain legality in professional services: how to apply decoupling point concept in healthcare delivery system. *Supply Chain Management: An International Journal*, 15(1), pp.80-91.
- Singh, M., 2008. Chronic care driving a fundamental shift in health care supply chains. Boston, MA: Massachusetts Institute of Technology.
- Supeekit, T., Somboonwiwat, T. and Kritchanchai, D., 2016. DEMATEL-modified ANP to evaluate internal hospital supply chain performance. *Computers & Industrial Engineering*, 102, pp.318-330.
- Supeekit, T., Somboonwiwat, T. and Kritchanchai, D., 2015. Linking Hospital Supply Chain Processes and Performance to Identify Key Performance Indicator. In *Industrial Engineering, Management Science and Applications 2015* (pp. 927-938). Springer Berlin Heidelberg.
- Smith, B.K., Nachtmann, H. and Pohl, E.A., 2012. Improving healthcare supply chain processes via data standardization. *Engineering Management Journal*, 24(1), pp.3-10
- Toba, S., Tomasini, M. and Yang, Y.H., 2008. Supply chain management in hospital: a case study. *California Journal of Operations Management*, 6(1), pp.49-55.

The necessity of customization of mobile device interfaces for elderly people.

Alves do Santos Medina F¹, Medina Pereira SG, Gonçalves R

Abstract This work aims to identify the physical and cognitive needs of the elderly user. The theoretical basis is focused in human computer interaction concepts, and the characteristics of the aging process. A survey of a sample of 30 people was held. The questionnaire was made in two stages, the first one on particular questions and the second one on satisfaction in the process of interaction with the touch screen interfaces. We found that age did not influence the process of interaction. The biggest difficulty is pointed out in the typing process in the touchscreen style key-board.

Keywords: Elderly; Mobile Device; Human-Computer Interaction; Interface.

1. Introduction

The development of mobile devices, specifically smartphones, caused a change of use of technology. According Jin and Ji (2010), those changes go far beyond making a phone call or send a message. It is related to the complexity of tasks that are now used in such devices.

Negahban and Chung (2014) point out in their studies the difficulty in list all the features available on mobile phones. Also, deal on the high personalization and customization of these devices according to what the user desires and / or needs.

With the inclusion of several functionality and tasks in these devices, it becomes necessary the study of these interfaces. The process of interaction humancomputer is very relevant, because the interface is the layer that connects the human with the machine requirements, especially in the touchscreen type interfaces, where the user at the same environment performs the input and output.

Results from previous studies have been pointed out four relevant factors regarding the use of this technology, as follows: perceived satisfaction in use, its

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ease of use, its usefulness and finally the subjective value (symbolic) (Negahban and Chung, 2014).

For what a user can reach an access with good usability, we must also consider the studies on human-computer Interface (HCI). Which can be defined it as a field of research that aims to study the relationship of the interactions between man and computer (Khalili and Auer, 2013). In his research are being considered the interface design and implementation, Evaluation and Comparison between them and finally the models and theories on ways of interaction. As from the increasing importance of these devices, they create new fields of study. One of them is related to adaptability of the devices, despite their accessibility features.

Accessibility is still not enough for people who have some kind of limitation in your ability, cognitive or physical. In this group the elderly users are included.

The increase in life expectancy, on a global scope, causes healthy aging of the population especially in more developed societies, with special emphasis in industrialized countries (Cardoso, 2012).

The development of new technological solutions to issues involving elderly people is rarely considered. For the authors, there are still many older people who do not feel able to use the technology and there are several factors that can lead them into demotivation, one being the lack of functional ability and physical. For elderly users, lack of confidence or previous negative experiences are also aspects that may intimidate and undermine confidence in the process of interaction (Benoit et al., 2009).

Aging can cause physical and psychological limitations. These factors can become problems in the interaction of the elderly people with technology. Due to the fact that the interfaces do not consider the sensory motor and cognitive changes, that occur in the body when they get older (Benoit et al., 2009; Valles, 1996).

This study aims to verify and point out the difficulties of the elderly in the handling of touchscreen smartphones by questionnaire and statistical data analysis.

Compiling this information to provide an indication in the development of new applications consider each user and their particularities. Through this information, we propose guidelines to customization of mobile device interfaces for elderly people.

2. About User Interfaces

The graphical user interfaces on mobile devices, when compared to other technologies of information and communication (ICT) even allows a broad field of study it is attributed to its rapid growth. Researches shows that exists few studies aimed at users, and that this gap allows for more detailed studies on the user's efforts (Park, 2010).

Mobile phones have been chosen as a platform for studying intuitive interaction. His form of interaction is considered a demanding cognitive task, as evidenced by recent studies that concluded that cognitive actions related to mobile phones are more difficult to perform than other forms of technology (Langdon et al., 2010).

2.1 The elderly and the Users Interfaces

In accordance with World Health Organization, although much of the developed countries consider the elderly from 65 years in developing countries is considered belonging to the group of elderly person over 60 years old. The world is ageing rapidly. The population above aged 60 and older make up 12.3 per cent of the global population, and the expectative is by 2050 that number will rise to almost 22 per cent in a world population.

Considering the growing elderly population and the Internet more and more functional so does the need to make these services easy to perform, with good usability, accessible, and with an aesthetically pleasing interface. It must also provide an interactive process with a user-centered design, which consider their past experiences, their level of education, and physical and / or cognitive limitations.

The aging process goes beyond the strictly chronological and biological factors which tend to be associated with. One must consider the aging process as being a dynamic balance between the issues that involve the physical, psychological and social factors. A multidimensional approach is required in order to provide an aging process with the elderly remain active and healthy (Veríssimo et al., 2008).

The interactivity of the Internet and its impact on the inclusion of the older population is, in a way, being ignored. Consider social and cultural factors in this context, such as low levels of education, lack of family support digital inclusion, economic factors that are barriers to investment for adoption of these devices. But a change in the positioning of the elderly is promoting greater awareness for this inclusion may occur (Silva and Correia, 2014).

The complexity of a task can be evaluated by several factors; one of them is the number of steps that need to be done to achieve the goal. One proposal would be to hide the low-level tasks solutions, preventing the elderly unnecessary decisions and even if there are ways to guide the elderly in your decision-making process (Murua et al., 2010).

The level of usability of a tool or application is defined by the specific context being used by the user. Also, relates to specific tasks that are connected to it (Hollender et al., 2010). Still points out that there are still many problems to be solved in the existing inter-faces. There is the need to develop a universal interface design that considers the physical and cognitive limitations of the elderly, for the purpose of reduce the operating load and adjust the operational capacity of the elderly users (Hsieh and Huang, 2013).

The technological changes, which occur very quickly, impact differently each individual category. Although it is part of the elder life, such resources can not be absorbed by them completely and instantly, the way it happens with young people.

The authors highlight that 60% of the elderly are still of the opinion that smartphones are difficult to use, categorizing smartphones as an intermediary device between an ordinary mobile phone and a personal computer (Hamano and Nishiuchi, 2013).

2.2. Special features of elderly people

With advancing age, the human body starts to have a reduction in their physical and psychological capacities. That process inherent in the body is more evident as age increases. Regarding the physiological characteristics, this is considered a situation that varies not only with age but also with the characteristics of each person (Dongfang and Qiang, 2009).

Are observed that 85% of environmental stimuli received are visual, and that fact indicates how much a failure in vision can affect a person's daily life. In accordance to the Brazilian Council of Ophthalmology (CBO), the old vision can be affected in different aspects such as colour perception, visual field, night vision, near vision and far (Kuo and Wu, 2011).

Another important factor to be studied for the development of accessible interfaces to the elderly is related to the tact functions. The loss of sensitivity can make the handling of interfaces touchscreen a very hard task.

In accordance with Fisk et al. (2009) haptics is a term that is related to the feeling in touch, handling and tactile perception. In the elderly is observed the difficulty of controlling the position of the body movements or unconsciously; the loss of their kinesthetic senses what leaves them vulnerable to accidental drops and causes postural instability. Each person depends, in part, the receptors located in the muscles, joints and skin for your sense of movement and touch function properly. Studies show that these perceptions are inherent in age compared with younger people. They also claim that at higher thresholds, the elderly may become less sensitive to tactile stimuli (Fisk et al., 2009)

Table 1 depicts the sort of decline that can occur and the characteristics that are affected by such factors, adapted to Fisk et al. (2009).

Table 1. Description of characteristics may decline with age.

Type	Feature
Sensation and Perception	Changes in tactile sensitivity especially in relation to temperatura and vibrations. View of the decline; visual acuity begins to decline after 40 years. High brightness makes it difficult to view. Can also occur: adaptation to more slowly dark environment; decreased visual range and visual processing speed.
Control motion	Elderly people have a slower response time. Around 1.5 to 2 times compared to a young person. The movements tend to be less accurate and with more variations.
Cognition	The memory as one multifaceted construct is affected only in some areas: working memory, semantic memory, prospective memory. Spatial cognition corresponds to maintenance and manipulation of visual images that tend to decline with age.

Table 1 shows that it is possible to realize that exists many variables can occur for the interaction of an elderly person with a smartphone, become a task difficult to perform. As, for example, the difficulty caused in vision by exposure to high gloss. Light-emitting computing devices as a whole, this fact alone can cause discomfort in the handling with these devices.

3. Methodology

For the construction of the theoretical basis of this work the following databases were searched, three of them are interdisciplinary (Science Direct, Scielo and ISI) and other one in specific technical area (IEEE). The search took place across the keywords: elderly, interfaces, interaction and accessibility. Papers were researched published only in journals or conference proceedings.

The survey was conducted by questionnaire composed of a sample size of 30 people. The sampling was done for convenience. In the approach, they were discarded issues that could come to constrain interviewees, such as health-related (diseases).

The questionnaire was composed of two parts. The first step was the identification of personal factors such as age, sex, education and familiarity with smartphones. In the second stage the users indicated how they felt about related tasks (satisfactory to unsatisfactory). For this step, we used the Likert scale ranging from very satisfactory, neutral to unsatisfactory.

For the data analysis, we used descriptive statistics. To the satisfaction of questions using the Likert scale, it was possible to obtain more relevant data by

grouping tables. For each parameter established a scale ranging from (1) to poor (5) very satisfactory. With the analysis of these results it was possible to assess how users over 60 years punctuate their interaction with the smartphone interface.

4. Results

This section will present the results obtained from the analysis of questionnaires. The sample used for tabulation of the data is $n = 26$. Four results were discarded by problems in its completion. In this case, 100% of the sample uses or has used a smartphone. And felt able to give their opinion in the survey.

Table 2 presents the descriptive statistics of the data of interaction according to the age of the respondent and your perception of the process. It is possible to observe that the mean difference of the ages of those who considered the process was very satisfactory to unsatisfactory is only 1.3 points. We can conclude that this group age had no influence, either positively or negatively.

Table 2. Descriptive statistics of the data - Interaction in relation to age.

Evaluation	Minimum	Maximum	Average	s.d	CV(%)
Dissatisfied	62	77	69,8	5,56	7,96
Little satisfied	65	70	67,5	3,53	5,23
Neutral	65	70	66,5	2,38	3,57
Satisfied	60	68	64	5,65	8,83
Very satisfied	60	77	68,5	8,74	12,75

Table 3 is grouped to make the most relevant results in their analysis. Data were grouped in relation to typing on the keyboard, with the interaction process in the smartphone. The goal of the grouping is to verify that minor issues influenced the perception of the interactive process and users can realize this set. About the process of interaction with the smartphone 23% of the sample considered satisfactory, 23% maintained a neutral stance and 54% as unsatisfactory.

Table 3. Distribution of data obtained through the perception of use of smartphones as its process of interaction and typing, values (%).

Evaluation	n	Very			Little Satisfied	
		Satisfied	Satisfied	Neutral	isfied	Dissatisfied
Dissatisfied	12	17	-	-	-	83
Little Satisfied	2	-	-	-	-	100
Neutral	6	25	-	67	-	25
Satisfied	2	100	-	-	-	-
Very satisfied	4	100	-	-	-	-

Table 3 shows that the interaction is strongly influenced by typing process.

Mostly there is a relationship between the answers. Who considered that the interaction process was very satisfactory and satisfactory in its entirety also applied the same concept to typing. Existing a coherence in these results.

5. Discussion

Preliminary studies point out the need for improved interfaces so there is a good process of interaction between user / machine in the universe of mobile devices.

The rapid growth of these devices has not allowed a deeper study of the interface problems.

Today, there are researches that address and display solutions for these tasks, but focused on the elderly are still few. There are several studies focused in websites, but for interfaces in mobile devices, are still found few solutions.

It was verified a lack in literature when there is a reduction in scope of the search, focused on a specific audience, where the elderly population above 60 years. The touchscreen interfaces have not been developed considering the peculiar characteristics of this age group.

The arrangement of letters, numbers and signs on the keyboard are targeted to a population having familiarity with pre-existing keyboards, personal computers for example. The key size, the touch-sensitive area, is small for anyone who has any limitations in vision, or your motor skills of hands.

The elderly people needs its own model that captures your needs and enable digital inclusion, which should take place gradually, following the limitations of each group, respecting the learning time and providing satisfaction in the use of computerized systems.

As an additional contribution, this work intended to find papers on the subject, which also address the interaction issues, and check with the elderly users such difficulties and which ones need further attention from developers.

References

- Jin B S, Ji Y G (2010) Usability risk level evaluation for physical user interface of mobile phone. *J. Computers in Industry*. 61, 350–363
- Negahban A, Chung CH (2014) Discovering determinants of user's perception of mobile device functionality fit. *Computers in Human Behavior*. 35, 75–84
- Khalili A, Auer S (2013) User interfaces for semantic authoring of textual content: A systematic literature review. *Web Semantics: Science, Services and Agents on the World Wide Web*. 22, 1–18

- Cardoso C (2012) Avaliação da eficácia de um programa de treino cognitivo com a consola Wii TM Nintendo TM em pessoas com doença de alzheimer: estudo de caso múltiplo. Universidade Católica do Porto (in portuguese)
- Benoît O, Marc K, Femand F, Dieter F, Martine H (2009) User-centered activity management system for elderly people: empowering older people with interactive technologies. IEEE Luxemburgo
- Valles M, Manso F, Arredondo M T, Del Pozo F (1996) Multimodal environmental control system for elderly and disabled people. In 18th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, pp. 516 – 517. Amsterdam
- Park N (2010) Adoption and use of computer-based voice over Internet protocol phone service: toward an integrated model. *J. Communication.* 60, 40–72
- Langdon P, Persad U, Clarkson P J (2010) Developing a model of cognitive interaction for analytical inclusive design evaluation. *Interacting with computers.* 22, 510-529
- WHO - World Health Organization. Health statistics and information systems, <http://www.who.int/healthinfo/survey/ageingdefnolder/en/>
- United Nations Population Fund, <http://www.unfpa.org/ageing>
- Veríssimo M, Moraes A, Botelho M, Pinto A, Rosa M, Oliveira C (2008) Estudo do perfil do envelhecimento em Portugal. Faculdade de Medicina da Universidade de Coimbra, Gerpi, (in portuguese)
- Silva M, Correia S (2014) ActiveBrain: Online social platform for active and healthy ageing. *Procedia computer Science.* 27, 38-45
- Murua A, Valencia X, Carrasco E, Zimmermann G, Rosa B, Bund J, Alexandersson J (2010) Universally Accessible Task-Based User Interfaces. In 12th IEEE International Conference e-Health Networking Applications and Services (Healthcom)
- Hollender N, Hofmann C, Deneke M, Schmitz B (2010) Integrating cognitive load theory and concepts of human-computer interaction. *Computers in Human Behavior.* 26, 1278–1288
- Hsieh J C, Huang C (2013) Performance evaluation on simplified computer for the elderly people. In Seventh International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing. China
- Tuch A N, Roth S P, Hornbæk K, Opwis K, Bargas-avila J A (2012) Is beautiful really usable? Toward understanding the relation between usability, aesthetics, and affect in HCI. *Computers in Human Behavior.* 28, 1596–1607
- Hamano Y, Nishiuchi N (2013) Usability Evaluation of Text Input Methods for Smartphone among the Elderly. In International Conference on Biometrics and Kansei Engineering,
- Dongfang Z, Qiang S A (2009) Discussion Based on a Design of Cell Phones Usability by the Elderly in China. *Computer-Aided Industrial Design & Conceptual Design.* In IEEE 10th International Conference
- Kuo J-Y, Wu F-G (2011) The elder's discrimination of icons with color discrimination on the cell phone. In: Kaber, D.B.; Boy, G. pp. 176-185. *Advances in Cognitive Ergonomics*
- Fisk A D, Rogers W A, Charness N, Czaja S J, Sharit J (2009) *Design for older adults: principles and creative human factors approaches.* CRC Press, Boca Raton

CBO (Conselho Brasileiro de Oftalmologia). http://www.cbo.com.br/novo/publico_geral/idosos
(in portuguese)

Lean Office: a Systematic Literature Review

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Abstract Knowing that the administrative activities may represent up to 80% of the costs in attending the client, philosophy Lean was lead to administrative processes aiming to reduce the waste and maximize flow. The present work has as its goal to identify methodologies employed in Lean Office implementation, through a systematic literature review in Scopus and Scielo basis from 2010 to 2015. Analyzed data range from year and country of publication, methodology and tools used, company segment and rated flow. From these analyses, it was noticed that the Value Stream Mapping (VSM) is the most widespread tool in all countries and that the methodology presented by Tapping and Shuker (2010) is widely used in Brazil, country which stood out in the amount of published articles. Results show that seeking the decrease in waste and flow optimization, independently of the methodology employed, have positive outcomes.

Keywords: Lean Office; Waste; Value Stream Map.

1. Introduction

Aiming to identify and reduce the most the waste existing in manufacturing processes, concepts and tools were developed and applied by Shingo (1996) and Ohno (1997), originating the Toyota Production System (TPS).

To Womack, Jones and Roos (2004, p. 3), Lean Production or Lean Manufacturing, as it was named the TPS in the Occident, “matches advantages from craft and mass productions, avoiding the high costs of the first and the

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hardness of the second”. The expression “Lean Production” was established for using minor amounts of space to manufacture, effort of operators, stock, among others, in comparison to mass production (Womack et al., 2004). TPS presents practices implemented in Toyota Motors Company, nevertheless, it can be stated that Lean Production concepts are not applied only in manufacturing processes, but also which can be used as benchmarking in all sectors such as Civil Construction, Offices, Civil Aviation and the Health Sector (Ferro, 2005).

When used in administrative processes or provision of services, it can be named as Lean Office (Cardoso and Alves, 2013). With the same aim of eliminating waste over the value stream, Lean Office can be applied in administrative activities which, according to Tapping and Shuker (2010), represent from 60% to 80% of the cost involved to attend clients requests. Many organizations have already started using Lean Office in their administrative activities and some cases have also published them as articles or thesis. It is, through the review of this literature that the present article aims to conduct a systematic review of the literature to identify the main methodologies, techniques and tools used by companies in the implementation of Lean Office, using as a source 13 theses and articles published in the database Scopus and Scielo between 2010 and 2015. With this scenario traced, researchers and managers will be able to analyze the current situation of Lean Office so far and plan future applications according to the one raised.

2. Lean Office

Positive results of Lean implementation in productive areas have already been proved through several studies and publications about the topic “Lean Manufacturing”, what made that this philosophy was expanded to other areas in companies, such as environmental part (Lean Environment), services (Lean Service) and administrative (Lean Office). According to McManus (2005) in order to make this transition effective, it is required to adapt the Five Lean Principles of manufacturing process to suit them to administrative processes, as it is shown on Table 1. Some difficulties are found when regarding to identify the principles in the administrative processes, once this last has intangible stages and different from manufacturing processes. Another factor which hinders standardize and generates instability in the process is the high variability of activities in administrative processes (Locher, 2011; Tapping and Shuker, 2010). To McManus (2005), another common difficulty in applying Lean Office is mapping the value flow which, in this case, consists in analyzing information and knowledge, instead of products and materials, as it is made when mapping processes in the factory. Locher (2011) adds yet that a flawed information flow delays performing tasks and discourages workers, generating negative results for the company.

Table 1 Characteristic of Lean Principles in Manufacturing and Administrative Processes - adapted from McManus (2005).

Principles	Manufacturing Processes	Administrative Processes
Value	Goals set, visible in each stage.	Different goals, hard to be identified.
Value Stream	Materials and pieces.	Information and knowledge.
Flow	Interactions are waste.	Planned interactions must be efficient.
Pull	Guided by Takt Time.	Guided by the organization needs.
Perfection	Repetition of processes without mistakes.	Processes enable improvement in organization.

As important as clarifying the Lean Principles to all the involved ones in the continual improvement journey is to identify the waste existing in the work flow. As waste is known any activity which add cost or time without adding value to the client. Generally it is hard to identify for being “hidden” in the processes. Shingo (1996) defined the seven wastes found in the factory, however, according to Tapping and Shuker (2010), the identification of waste in offices is even more difficult due to the process characteristics.

Tapping and Shuker (2010) adapted the Seven Wastes of Lean Manufacturing to the Seven Administrative Wastes, which are: **Overproduction**: to produce information or paper more or before than the necessary time. For example: copies, reports, etc.; **Waiting**: to wait for anything or activity. For example: wait for signatures, machines, e-mails; **Over Processing**: it generally includes redundant activities as several signatures in only one document, review of the work done by someone else; **Stock or Inventory**: it refers to the excessive buildup of materials like unnecessary files, extra supply, excessive copies; **Motion**: any movement, unnecessary to the work or the service hired by the client. For example: inefficient layout among sectors; **Defects or Rework**: to produce a flaw work is clearly a waste, which includes the need of being remade (manpower), the resources involved (raw material) and the ordinary process breakdown to deal with the rework; **Transportation**: to transport, to shelve or to move excessively materials, information or papers wastes time and energy and still make them likely to breakage, theft or damage.

Nevertheless, Lean Office is considered as an excellent method to increase efficiency in administrative processes, through the identification of wastes and the elimination in variation of existing processes, making the flow more agile and with greater competitive advantages (Locher, 2011; McManus, 2005; Tapping and Shuker, 2010).

3. Methodology

To develop a work of research, particularly scientific research, it is required to observe some procedures which help to assure the reliability in results (Saunders et al., 2009). The current work aims, through performing systematic literature review, identify the methodology applied in companies that approach Lean Office implementation. According to Saunders, Lewis and Thornhill (2009), systematic review is a process of literature review that uses an embracing and preplanned strategy. Clear evaluation criteria are employed to select the articles, which are evaluated individually and in an investigative way and the results are impartially and comprehensively presented in tables. Biolchini et al. (2007) defend that the systematic literature review is a tool that enables the development of a synthesis about the research topic set, through mapping the existent knowledge and works already published.

To develop this paper, scientific databases Scopus (<https://www.scopus.com>) and Scielo (www.scielo.org/) were accessed within July and December 2015. Searches were performed under the words “lean office”, published between 2010 and 2015, without any filters, filter by location or language of the publications. This search presented five results from Scielo base and 14 in Scopus base, as shown in Table 2, although five of the results from Scopus base were not available to access and one was duplicated. Thus, an amount of 13 publications were selected to analysis, being five from Scielo and eight from Scopus.

Table 2. Amount of articles per database searched

Database	Articles Found	Articles Evaluated
Scielo	5	5
Scopus	14	8
Total	19	13

In possession of the selected articles, a reading was performed and data analysis started, using the following criteria: year of publication, origin of the material, methodology used in the application of Lean Office, company segment and evaluated flow.

4. Results

Through the selected publication reading, it was formulated a general table with information about the evaluation criteria established in the early stage of this research. Initially, publications were evaluated regarding to their origin, which showed that 5 articles had national origin (Brazil) and 8 articles had international origin (other countries). Table 3 presents the distribution of all the publications per year and per country. In this evaluation, reports about Lean Office are perceived in

North America, South America, Europe and Asia, showing that the philosophy Lean can generate results even when facing different cultures and people. The big participation of Brazil stands out, with about 38% of the articles evaluated, while the United States and England provide 15% of the publications in the period evaluated.

Table 3. Amount of publications per country per year

	2010	2011	2012	2013	2014	2015	Total
Brazil	0	1	1	2	0	1	5
USA	1	0	1	0	0	0	2
England	1	0	0	0	1	0	2
Estonia	0	0	1	0	0	0	1
Indonesia	0	0	0	0	0	1	1
Portugal	0	0	0	1	0	0	1
Sweden	0	0	0	1	0	0	1
Total	2	1	3	4	1	2	13

During the selection of the articles it was not applied any filter regarding to the activity of the company evaluated or the Lean tools application flow. This way, only after reading and tabulating the information was possible to notice the variety of activity hives of the companies which embrace the waste reduction in their administrative flows. The hive of activities of the companies studied, as well as their flow which was evaluated, are presented, respectively, in Tables 4 and 5.

Table 4. Segment of companies mentioned in the articles evaluated

Segment of the Company	Occurrences
Industry (specific departments)	4
Provision of services	4
Government	2
Construction	1
Softwares Development	1
Pharmaceutical Industry	1

Another analysis performed was regarding to the tools quoted in the articles and in some cases the same publications quoted the use of more than one tool employed in the case study. A clear example is the use of the 8 Steps to Lean Office, suggested by Tapping and Shuker (2010), whose methodology encompasses the use of VSM (Value Stream Mapping), the identification of the Seven Wastes and the performing of Kaizen. These were separately identified in Table 6. Aiming to verify if the use of any tool is more scattered in certain region, information were crossed as regarding to publication country and used tools.

Table 5. Flow evaluated in the articles

Flow evaluated	Occurrences
Customer Care	4
Product Development	2
Purchase	2
Accounting	2
Finance	1
Software Development	1
Administrative Process (technical documents)	1

In about 30% of the cases, Tapping and Shuker (2010) methodology was adopted. On the other cases some tools of Lean Production were used individually or together like VSM or Standard Work. It was also observed two registers of using quality tools to improve administrative processes, summing to reinforce Lean Office. Through observing the data, it can be suggested the preference for certain methodologies according to each country, because it has been observed that none of the countries with publications evaluated registered the use of more than two tools in their publications, except Brazil. In this case, it is observed the register of four different tools: 8 Steps, VSM, Kaizen and Standard Work; although, as referred previously, it is known that the VSM and the Kaizen are decisive steps of the 8 Steps of Tapping and Shuker. This way, it can be assured that Brazil follows the same characteristic of the other countries, it means, the register and use of two main tools in its records of Lean Office implementation. Another important note about the tools employed regarding countries is that all the records of the use of the 8 Steps proposed by Tapping and Shuker (2010) were in Brazilian publications.

Table 6. Tools Mentioned in the articles evaluated

Tool	Brazil	USA	Estonia	Indonesia	England	Portugal	Sweden
8 steps for Lean Office	4	0	0	0	0	0	0
VSM	1	0	0	1	0	1	0
Waste Reduction	0	2	0	0	2	0	0
Lead time	0	0	0	1	0	0	0
Quality Tools	0	0	1	0	0	1	1
Kaizen	1	0	0	0	0	0	0
Standard Work	1	0	0	0	0	0	0
Company Method	0	1	0	0	0	0	0

Last analysis performed in the articles was referring to improvements presented in the publications, which quote expressive reduction in Lead Time and significant increase in Adding Value Time in the flows evaluated, as well as an increase in information reliability and client satisfaction and gains in quality and productivity. In this regard, it was chosen not to relate tools used with gains obtained, as this finding could lead the reader to a wrong interpretation that one tool can be more efficient than another; whereas each evaluated flow could present different results in case there were used different tools.

4. Conclusion

The aim of this article was to perform a systematic literature review of publications which refer to the use of Lean Office through criteria like year of publication, origin of the material, methodology/tools employed, company sector and flow evaluated. Knowing that only two data bases were used, the amount of publications evaluated after proper ratings was limited to 13 works; which were basis for analysis performed throughout the research. Publications of several countries were noted, but Brazil participation in publications stands out, with 30% of the selected articles, what reveals that the country is engaged in the pursuit of reduction of the waste; once this country is considered as a producer of very low amounts of scientific contents, according to Czerniewicz (2013). It is noticed that the industry is ahead of the evaluated segments, possibly for presenting most historic in manufacturing sector through Lean Manufacturing. Among the tools used, VSM stands out, which has a vast using historic in all segments Lean for allowing to identify the current state and, in a systematic way, to propose the reduction of the wastes identified; and also the 8 Steps proposed by Tapping and Shuker (2010), methodology which implies the application of the VSM along with other techniques seeking the Lean Principles. It is important to notice that the companies which present their own methodologies or apply only one tool, draft problems found during the implementation trajectory. This same fact was not noticed in works developed through the other methodologies.

The articles evaluated showed the efficiency of using the philosophy Lean when applied to administrative areas, through the results obtained, such as addition of 380% in TAV or reduction of 77% in Lead time of the process evaluated; similar results to the ones found in industry, which confirms the idea that the wastes are, in fact, intrinsic to the processes and that it should be continuously worked in order to minimize the wastes and maximize the value flow.

For further works, it is suggested a new systematic literature review including another databases, for the purpose of having an increase in the amount of articles evaluated and the deepen regarding to the 8 steps proposed by Tapping and Shuker (2010), aiming to evaluate the efficiency of this methodology.

References

- Biolchini, J. C. A., Mian, P. G., Natali, A. C. C., Conte, T. U., & Travassos, G. H. (2007). Scientific research ontology to support systematic review in software engineering. *Advanced Engineering Informatics*, 21(2), 133-151.
- Cardoso, G. O. A., & Alves, J. M. (2013). Análise crítica da implementação do Lean Office: um estudo de casos múltiplos. *Gepros: Gestão da Produção, Operações e Sistemas*, 8(1), 23.

- Carraro, R. V. (2005). Avaliação de um Processo de Implantação da Mentalidade Enxuta e seu Desempenho no fluxo de valor: Um estudo de caso (Master dissertation, Universidade de Taubaté).
- Czerniewicz, L. Inequitable power dynamics of global knowledge production and exchange must be confronted head on. 2013 Apr 29 [cited 2014 Nov 22]. *The impact blog [Internet]. London: London School of Economics-LSE. Available from: <http://blogs.lse.ac.uk/im-pactofsocialsciences/2013/04/29/redrawing-the-map-from-access-to-participation>.*
- Ferro, J. R. (2005). Novas fronteiras de aplicação do sistema Lean em serviços. Lean Institute Brasil. Disponível em< <http://www.lean.org.br>>. Acesso em 21/02/2017.
- Liker, J. K. (2005). O modelo Toyota: 14 princípios de gestão do maior fabricante do mundo. Bookman Editora.
- Locher, D. (2011). *Lean office and service simplified: The definitive how-to guide*. CRC Press.
- Marchwinski, C., & Shook, J. (Eds.). (2003). *Léxico lean: glossário ilustrado para praticantes do pensamento lean*. Lean Institute Brasil.
- McManus, H. L. (2005). Product Development Value Stream Mapping (PDVSM) Manual Release 1.0.
- Ohno, T. (1997). *O Sistema Toyota de Produção Além Da Produção*. Bookman.
- Rosa, D. C. (2008). Aplicação do mapeamento do fluxo de valor em uma empresa do setor metal-mecânico. (Master dissertation, Universidade Federal de Santa Catarina).
- Rother, M., & Shook, J. (2004). *Aprendendo a enxergar: mapeando o fluxo de valor para agregar valor e eliminar o desperdício: manual de trabalho de uma ferramenta enxuta*. Lean Institute Brasil.
- Saunders, M.; Lewis, P.; Thornhill, A. (2009). Research methods for business students. *Harlow: Prentice Hall*.
- Shingo, S. (1996). O sistema Toyota de produção do ponto de vista da engenharia industrial.
- Tapping, D., & Shuker, T. (2010). LEAN OFFICE: gerenciamento do fluxo de valor para áreas administrativas-8 passos para planejar, mapear e sustentar melhorias Lean nas áreas administrativas. *São Paulo: Editora Leopardo*.
- Vieira, M. G. (2006). Aplicação do mapeamento de fluxo de valor para avaliação de um sistema de produção. (Master dissertation, Universidade Federal de Santa Catarina).
- Womack, J. P., Jones, D. T., & ROOS, D. (2004). A máquina que mudou o mundo: baseado no estudo do Massachusetts Institute of Technology sobre o futuro do automóvel. *Rio de Janeiro*.
- Womack, J., & Jones, D. (1998). A mentalidade enxuta nas empresas: elimine o desperdício e crie riqueza. Rio de Janeiro: Campus, 1998.

Planning capacities of facilities and human resources for seniors

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Abstract Physical environment, especially urban facilities that are age friendly can make a difference between independence and dependence for all individuals but are of particular importance for those growing older. Changes in the environment can lower the disability threshold. It influences the needs for care in each category of dependency measured by care dependency scale. Therefore the spatial interaction model developed individually for each group of functional capacity can be structured to forecast overall attractiveness and stickiness of municipalities for migration of older cohorts. The structure of cohorts, when disability thresholds are determined is calculated through a multi-state transition model where net migration of older cohorts is added for each year. The numerical example shows how we can plan the investments in facilities and education of human resources based on forecasted structure of care dependency categories and its dynamics.

Keywords: urban facilities, multi-state transition model, gravity model, human resources

1 Introduction

Multistate-transition modelling is a transparent approach of decision-analytic modelling, including Markov chain cohort simulation (Allignol et al, 2011), and one of the most widespread approach to clinical decision analysis, health technology assessment, and health-economic evaluation (Siebert et al, 2012). The applications range from personalized health care strategies to public health

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programs, but was never used for the joint program of investments in urban facilities and the human resource planning. How it could improve a spatial planning and construction development strategy in cities is subject of this paper. According to ageing report (EC, 2015) population projections share of cohorts 65+ will rise for more than 50% and cohorts 80+ will more than double in the period 2017- 2040. Therefore better methods for projection of needed facilities and education for human resources for Elder Care (EC) should be developed. In the context of EC and Long-Term Care (LTC), the scope of activities varies according to: (a) the basic daily tasks or services, provided usually in combination with basic health services such as health care, preventive medicine, rehabilitation and palliative care, and (b) support the daily tasks or services supportive care. In current categorization of these needs housing and logistic facilities are neglected, while human resources needed for servicing old people are considered partly only. The model suggested in this paper gives improved approach based on combination of our previous studies of the multistate transitions (Bogataj et al, 2015, 2016) and the structured gravity model (Drobne, Bogataj, 2014) to fill this gap.

2 The Model

2.1 Multiple decrements model

The care dependency of the older adults depends on their physical and mental abilities. In general, the degree of care dependency of elderly people is measured by Care Dependency Scale (CDS). Ranking CDS is based on fifteen (15) of basic human needs (sections A to O), which are estimated by Likert scale of 1 to 5 (Dijkstra et al., 2006). Care intensity is estimated for each criterion from totally dependent, partially dependent, almost independent, or completely independent of care (Dijkstra et al., 2012).

Regarding the level of reduced ability of self-sufficiency, it would be necessary to establish a unified categorization of the older citizens for their ability to self-care and self-care capacity and associate them with suitable or relevant types of dwellings and other facilities as well as intensity of care. Statistical monitoring of the level of self-sufficiency and related facilities as well as human resources for supportive activities would improve the proper planning of types of dwellings and other facilities as well as required education of human resources in the studied municipality. On this basis, we can observe and further forecast the period of life of inhabitants spending in each category. To this structure the appropriate type of accommodation and related facilities can be determined separately for each category. This means that we shall take LOSS scale and scoring for measuring the needs and dependence on others which is used in planning for assistance in social welfare institutions, and apply it to the entire population of persons older than 65 years who are more or less dependent on others. To this number of seniors in each category we shall add the results of the gravity model, structured by the same

categories. We have to develop further the projections according to the proper multistate transition model and adopt the program for building proper facilities and educating the human resources.

The model assumed that due to declining functional ability and, consequently, reduced the ability of self-sufficiency the residents move among the various types of housing and related facilities. The transitions are successive according to the intensity of care: $i = 0$: family housing unit without special facilities for seniors and with residents without need for care, where residents live with such functional capabilities that are fully capable of self-sufficiency; $i = 1$: Family housing unit with care at home (HC); $i = 2$: Adapted housing unit for the elderly with decreased functional capacity (AHC); $i = 3$: Assisted living facility (RC); and $i = 4$: Nursing home (NH); $i = 5$: Dead. Here we introduced the following notation: i is the type of facility in which the resident is currently residing ($i = 0$ to 4); j is the type of facility in which the resident moves due to declining functional ability (resettlement from the type of facility i to j) ($j = 1$ to 5);

The probability $q_x^{(i,j)}$ of moving from facility of type i to facility type j due to declining functional ability for occupant age x is written by:

$$q_x^{(i,j)} = \frac{M_x^{(i,j)}}{S_x^{(i)}}, j=1,2,3,4, j>i \quad (1)$$

Where $M_x^{(i,j)}$ is the number of residents that moves from i to j in past at the constant environment (given facilities) and $S_x^{(i)}$ is the total number of residents who were previously living in $i - 1$ or came from other municipalities to the cohort of size $S_x^{(i)}$. here $p_x^{(i)}$ is probability to stay in the dwelling with given other facilities. The final allocation of residents by type of facility for each cohort (x years old) in the year τ is described by the following matrix:

$$\mathbf{P}_{x,\tau} = \begin{bmatrix} p_x^{(0)} & q_x^{(0,1)} & q_x^{(0,2)} & q_x^{(0,3)} & q_x^{(0,4)} & q_x^{(0,5)} \\ 0 & p_x^{(1)} & q_x^{(1,2)} & q_x^{(1,3)} & q_x^{(1,4)} & q_x^{(1,5)} \\ 0 & 0 & p_x^{(2)} & q_x^{(2,3)} & q_x^{(2,4)} & q_x^{(2,5)} \\ 0 & 0 & 0 & p_x^{(3)} & q_x^{(3,4)} & q_x^{(3,5)} \\ 0 & 0 & 0 & 0 & p_x^{(4)} & q_x^{(4)} \end{bmatrix}_\tau \quad (2)$$

and vector $\mathbf{S}_{x,\tau}$ as sum of number of residents moving in the cohort from lower state in the facilities of this municipality ZS_x^i in the year τ plus net migration into i -th cohort NM_x^i in the same year is

$$\mathbf{S}_{x,\tau} = \begin{bmatrix} S_x^{(0)} & S_x^{(1)} & S_x^{(2)} & S_x^{(3)} & S_x^{(4)} \end{bmatrix}_\tau = \begin{bmatrix} ZS_x^{(0)} & ZS_x^{(1)} & ZS_x^{(2)} & ZS_x^{(3)} & ZS_x^{(4)} \end{bmatrix}_\tau + \begin{bmatrix} NM_x^0 & NM_x^{(1)} & NM_x^{(2)} & NM_x^{(3)} & NM_x^{(4)} \end{bmatrix}_\tau \quad (3)$$

Allocation of residents by type of facility for studied cohort in the year $\tau+1$ y (when they are $x+1$ year old) we can calculate:

$$\begin{aligned} \mathbf{S}_{x+1,\tau+1} &= \mathbf{S}_{x,\tau} \mathbf{P}_{x,\tau} = \\ &= \begin{bmatrix} S_x^{(0)} & S_x^{(1)} & S_x^{(2)} & S_x^{(3)} & S_x^{(4)} \end{bmatrix}_\tau \cdot \begin{bmatrix} p_x^{(0)} & q_x^{(0,1)} & q_x^{(0,2)} & q_x^{(0,3)} & q_x^{(0,4)} & q_x^{(0,5)} \\ 0 & p_x^{(1)} & q_x^{(1,2)} & q_x^{(1,3)} & q_x^{(1,4)} & q_x^{(1,5)} \\ 0 & 0 & p_x^{(2)} & q_x^{(2,3)} & q_x^{(2,4)} & q_x^{(2,5)} \\ 0 & 0 & 0 & p_x^{(3)} & q_x^{(3,4)} & q_x^{(3,5)} \\ 0 & 0 & 0 & 0 & p_x^{(4)} & q_x^{(4)} \end{bmatrix}_\tau = \\ &= \begin{bmatrix} S_{x+1}^{(0)} & S_{x+1}^{(1)} & S_{x+1}^{(2)} & S_{x+1}^{(3)} & S_{x+1}^{(4)} \end{bmatrix}_{\tau+1} \end{aligned} \quad (4)$$

Norms and standards of required human resources per capita of seniors in EC for given type of housing including other facilities is describe by vector \mathbf{H} :

$$\mathbf{H} = \begin{bmatrix} H^{(0)} & H^{(1)} & H^{(2)} & H^{(3)} & H^{(4)} \end{bmatrix}^T \quad (5)$$

The trade of between facilities and human resources can be subject of additional study. The dynamics of required human resources for EC in studied urban area we calculate according the following formula:

$$HR = \sum_{x=65}^{110} \left\{ \left[\begin{array}{ccccc} ZS_x^{(0)} & ZS_x^{(1)} & ZS_x^{(2)} & ZS_x^{(3)} & ZS_x^{(4)} \end{array} \right] + \left[\begin{array}{ccccc} NM_x^{(0)} & NM_x^{(1)} & NM_x^{(2)} & NM_x^{(3)} & NM_x^{(4)} \end{array} \right] \right\} \cdot \mathbf{H} \quad (6)$$

2.2 Spatial interaction model

The impact of attractiveness of regional centres on migration of different age cohorts can be studied using SIM model. For this purpose, we are grouping inhabitants according their functional capacities r and the age cohort x and for each of them we study migration factors in their ages from equation:

$$M_{ij} = k \cdot K(d(t))_{ij}^{\gamma} \prod_{s \in S} K(s)_i^{\alpha(s)} K(s)_j^{\beta(s)}, \quad (7)$$

where M_{ij} is migration flow from origin municipality i to the destination municipality j , k is proportional constant, $K(d(t))_{ij}$ is the coefficient of time-spending distance with the car from the centre of municipality of origin to the centre of municipality of destination, and $K(s)_i$ respectively $K(s)_j$ are coefficients of the analysed factor s which influence migrations in the municipality of origin (the factor of emissivity, also called factor of stickiness (Drobne and Bogataj, 2014)) respectively in the municipality of destination (of the factor of attractiveness). The coefficient of the analysed factor is the proportion between the value of the factor in the municipality and the value of the factor at the state level. The impacts of stickiness of the origin, the impacts of attractiveness of the destination and the impact of time-spending distance between origin and destination on the interactions can be analysed using the regression analysis with the regression coefficients according to the 5-10 years age cohorts and the level of the functional capacity r , therefore γ , $\alpha(s)$, and $\beta(s)$ we can get for each cohort. From here net migration for age cohorts x at all levels of functional capacities r in municipality j can be estimated by (8):

$$NM_x^{(r)}(j) = \sum_{i:i \neq j} M_{ij,x}^{(r)} - \sum_{m:m \neq j} M_{jm,x}^{(r)} \quad (8)$$

and introduced in formula (6). From our previous studies we recognised that different age cohorts can have very different values of γ , $\alpha(s)$, and $\beta(s)$, therefore the time interval for estimation of x must not be too wide and values of x

are very sensitive on income of municipalities (which influence investments in facilities and availability of human resources for EC).

3. Numerical example

According to the general demographic data, mortality tables and data reported from nursing homes the transition matrix could be written. Let us say that structure of residents 80 years old by type of facility for each cohort (x years old; x=80) is written by the following vector S_x as sum of internal reallocations and the net migrations of cohort:

$$S_x = \begin{bmatrix} S_x^{(0)} & S_x^{(1)} & S_x^{(2)} & S_x^{(3)} & S_x^{(4)} \end{bmatrix} = \begin{bmatrix} 21.510 & 390 & 230 & 436 & 71 \end{bmatrix} + \begin{bmatrix} 20 & 19 & 13 & 102 & 60 \end{bmatrix} = \begin{bmatrix} 21.530 & 409 & 243 & 538 & 131 \end{bmatrix}$$

$$\mathbf{P}_{80}^{2015} = \begin{bmatrix} p_x^{(0,\tau)} & q_x^{(0,1)} & q_x^{(0,2)} & q_x^{(0,3)} & q_x^{(0,4)} & q_x^{(0,5)} \\ 0 & p_x^{(1,\tau)} & q_x^{(1,2)} & q_x^{(1,3)} & q_x^{(1,4)} & q_x^{(1,5)} \\ 0 & 0 & p_x^{(2,\tau)} & q_x^{(2,3)} & q_x^{(2,4)} & q_x^{(2,5)} \\ 0 & 0 & 0 & p_x^{(3,\tau)} & q_x^{(3,4)} & q_x^{(3,5)} \\ 0 & 0 & 0 & 0 & p_x^{(4,\tau)} & q_x^{(4,5)} \end{bmatrix}_{2015} = \quad (3)$$

$$= \begin{bmatrix} 0,98164 & 0,00162 & 0,00167 & 0,00172 & 0,00176 & 0,01159 \\ 0 & 0,83415 & 0,04867 & 0,05111 & 0,05355 & 0,01252 \\ 0 & 0 & 0,9035 & 0,03993 & 0,04405 & 0,01252 \\ 0 & 0 & 0 & 0,76037 & 0,22711 & 0,01252 \\ 0 & 0 & 0 & 0 & 0,8344 & 0,16560 \end{bmatrix}$$

Allocation of residents by type of facility for studied cohort in the following year (when they are x+1 year old) we can calculate:

$$\mathbf{S}_{81}^{2015} = \mathbf{S}_{81}^{2015} \mathbf{P}_{81}^{2015} = \begin{bmatrix} S_{81}^{(0)} & S_{81}^{(1)} & S_{81}^{(2)} & S_{81}^{(3)} & S_{81}^{(4)} \end{bmatrix}_{2016}$$

Norms and standards of required human resources for elder care for each type of facilities is describe by vector H:

$$\mathbf{H} = [H^0 \ H^1 \ H^2 \ H^3 \ H^4]^T = [0 \ 0.1 \ 0.2 \ 0.3 \ 0.5]^T$$

The require human resources for eldercare in studied urban area we calculate according following formula:

$$\begin{aligned} HR(80) &= S_x \cdot H = [S_x^0 \ S_x^1 \ S_x^2 \ S_x^3 \ S_x^4]_{r+1} \cdot H \\ &= [21135 \ 376 \ 275 \ 476 \ 302] [0 \ 0.1 \ 0.2 \ 0.3 \ 0.5]^T = 387 \end{aligned}$$

It means that in such case 387 workers in EC will be needed for 80 years old inhabitants in the municipality. Summarizing the results for all age cohorts we can also calculate total number of required human resources for the next year and further gradually for all time horizon.

Using equation (7) and (8) we also can calculate what would be changes if we decide for new investments in municipality j.

4. Conclusion

Physical environment, especially urban facilities that are age friendly can make a difference between independence and dependence for all individuals but are of particular importance for those growing older. Investments in new housing and other facilities, better adopted to the needs of seniors can help to stay longer independent, which means also less human resources in eldercare needed for everyday health and social services for seniors. Changes in the environment, investment in the facilities, can lower the disability threshold. We found from our previous studies of spatial interaction models that investments in the facilities or more general income of municipality which is in strong correlation with investment, strongly influence attractiveness of municipality for different age cohorts, but this attraction is not same for all cohorts and all kind of functional capacities. It was surprising that municipality income which should influence investments in facilities for seniors in our previous study did not increase the net migrations for older population and was even less important for those 75+ than for 50+ or younger. From here we can conclude that investments in facilities for older citizens are not priority in studied municipalities. The realised investments in facilities also influences the needs for care in each category of dependency measured by care dependency scale. Therefore the spatial interaction model developed individually for each group of functional capacity can be structured to forecast overall attractiveness and stickiness of municipalities for migration of older cohorts. At planning the future needs of human resources and facilities for

seniors, the structure of the old residents according to the functional capacity and age cohort should be corrected by the structure of inflow and outflow of migrants. The structure of cohorts, when disability thresholds are determined is calculated through a multi-state transition model where net migration of older cohorts is added for each year. The numerical example shows how we can plan the investments in facilities and education of human resources based on forecasted structure of care dependency categories and its dynamics, which also depends on result of spatial interaction and factors, significant influencing it. When planning the investments in facilities and in education for human resources it is wise to make simulation for trade-off between these two dimensions of EC.

References

- Allignol, A., Schumacher, M., Beyersmann, J. (2011) Empirical Transition Matrix of Multi-State Models: The etm Package. *Journal of Statistical Software* 38(4): 1-15
- Bogataj, D., Ros McDonnell, D., Bogataj, M. (2016). Management, financing and taxation of housing stock in the shrinking cities of aging societies. *International Journal of Production Economics*, 181(SI:2-13)
- Bogataj, D., Ros McDonnell, D., Bogataj, M. (2015). Reverse Mortgage Schemes Financing Urban Dynamics Using the Multiple Decrement Approach. *Springer Proceedings in Mathematics & Statistics* Vol. 135: 27-47
- Dijkstra, A., Yönt, G. H., Korhan, E. A., Muszalik, M., Kędziora-Kornatowska, K. & Suzuki, M. (2012). The care dependency scale for measuring basic human needs. *Journal of advanced nursing*, 68 (10), 2341-2348
- Drobne, S., Bogataj, M.(2014) Regions for Servicing Old People : Case study of Slovenia. *Business systems research journal*, 5(3): 19-36
- Drobne, S., Bogataj, M.(2017) Migration flows structured by age cohorts to evaluate the impact of public investments in facilities, and potential housing market, *Facilities*,. 35(7/8):. 1-16. doi: 10.1108/F-09-2016-0091.
- Siebert, U., Alagoz, O., Bayoumi, A. M., et al. (2012). State-Transition Modeling: A Report of the ISPOR-SMDM Modeling Good Research Practices Task Force-3. *Medical Decision Making*, 32(5, SI): 690-700

Strategy and Entrepre- neurship

International Strategies Focused on Business Digitalisation and Technology Adoption

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Abstract In the fourth industrial revolution, some principles are introduced for realignment of operations management models, such as: interoperability, virtualization, real-time change capacity, service-oriented operations, modularity and decentralization. This new scenario leads to disruptive changes in business models, impacting on the establishment of specific international strategies for a trajectory analysis of different countries. This study aims to analyse the strategies focused on business digitalisation, adopted by countries like Germany, USA, China and Brazil, as well as the impact by technologies adoption. Therefore, this paper is based on an exploratory study and a comparative analytical framework of different international strategies focused on some principles of fourth industrial revolution.

Keywords: International Strategies; Industry 4.0; Business Digitalisation;

1. Introduction

The increasing digitization and interconnection of products, value chains and business models characterize the Fourth Industrial Revolution, making the Industrial Internet of Things (IoT) get more attention in practice and research over the last years. Thus, in the future, businesses will establish global networks incorporating machinery, warehousing systems and production facilities in Cyber-Physical Systems (CPS) (Hermann, M.; Pentek 2015). The application of these systems provides intelligence and communication to artificial systems known as "Smart Systems". According to Anderl (2014), "smart systems may be understood

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as a consequent successor technology of mechatronic and adaptronic systems. The main feature is the integration of cyber-physical systems for enabling inter-system communication and self-controlled system operation". Therefore, a decision-making can be made by the cyber-physical system based on production requisitions in real time. In addition, machines will not only receive commands, but will be able to provide information about their work cycle. Soon, the modules of the intelligent factory will work in a decentralized way, improving the production processes.

Venturelli (2016) points out that the technology behind such intelligent systems is the "Big Data", a large database with information for decision making, but with a big difference, the data in large quantity are dynamic, which analysis vary in real time according to external changes, for example, a relation of consumption according to a disclosure of a product on the internet, impacting on real time commercialization in. These new patterns of consumption press for a change in supply chain management involving new models of operations management, new forms of distribution, and supply of services.

Germany proposed intelligent manufacturing as "Industrie 4.0" (I.4.0); China also proposed "Made in China 2025", aims to change manufacturing industry (Wang 2016); in America, consortiums are investigating the possibility of further industrial development on end-to-end automation basis, with the Internet as central point (Bloem 2014). All of them belong to the transformation and upgrading of the manufacturing strategy, and include the digital, networked, intelligent as strategic support and strategic planning. Therefore, this study intends to approach the strategies adopted by countries as EUA, Germany, Brazil e China.

2. Global Initiatives in Industrie 4.0

Nowadays, industries must deal with increased competition, shifting market, increased complexity of products and processes, increasing customer expectations, as well as shorter technology and innovation cycles. Thus, flexibility and adaptability turn out to be success factors. In this context, several initiatives and investments are being made in various countries towards I. 4.0 and its technologies to maintain and strengthen global competitiveness.

The consultant Roland Berger shows in Figure 2 the list of investments and initiatives for each country based on fourth industrial revolution.



Figure 1. Investments and world initiatives in Industry 4.0 Source: Roland Berger (2016).

The first and with the largest investment is China, which will invest 2.2 billion dollars in 10 specific sectors; followed by the United States with two billion dollars earmarked for high-quality manufacturing creations and to improve high position in the global market; In third position is South Korea with 1.6 billion dollars reserved for creation of manufacturing ecosystems based on new technology: the Smart Factory; and fourth position is Japan with the goal of increasing the development of robotic technologies.

All these initiatives are being promoted in the medium term by 2020 and will involve both companies and industries as well as research centers, technology centers and universities

2.1 Germany

Since 2006, the German government has been pursuing a High-Tech Strategy geared towards interdepartmental coordination of research and innovation initiatives to secure Germany's strong competitive position through technological innovation. The current movement is known as the High-Tech Strategy 2020 and focuses on five priority areas: climate/energy, health/food, mobility, security and communication. The strategy revolves around several "strategic initiatives" through which the Industry-Science Research Alliance is addressing concrete medium-term scientific and technological development goals over a period of ten to fifteen years. The initiatives have formulated concrete innovation strategies and implementation roadmaps designed to make Germany a leader in supplying solutions to global challenges (Achatec 2013).

2.2 China

Known as "Made in China 2025 plan", it aims to remedy China's manufacturing problems with a comprehensive upgrading of the sector. The plan draws

inspiration from “Germany’s Industrie 4.0”, where China aims to make use of technologies like the Internet of Things, cloud computing and big data to upgrade its manufacturing within 10 priority sectors:



Figure 2. Strategic Sectors: priority sectors identified by Made in China 2025 plan. Source: CKGSB Knowledge, 2015.

As shown in figure 2, these priorities include new advanced information technology; automated machine tools and robotics; aerospace and aeronautical equipment; maritime equipment and high-tech shipping; modern rail transport equipment; new-energy vehicles and equipment; power equipment; agricultural equipment; new materials and biopharma advanced medical products (Lee 2015).

2.3 United States

In United States, in 2011, President Barack Obama announced the formation of AMP "Advanced Manufacturing Partnership", bringing together industry, universities and Federal government to invest in emerging technologies that will create high-quality industrial jobs and increase global competitiveness (Kurfuss 2014). Based on political opportunities and the needs of the United States (from an economic and national security point of view), the Director of the AMP, produced a final report entitled "Capturing Domestic Competitive Advantage in Advanced Manufacturing", which was adopted by "President's Council of Advisors on Science and Technology "(PCAST). The report has 16 key recommendations whose are divided into three key areas: (1) capacity building for innovations, (2) strengthening the talent chain, which focuses on the development of the workforce for the needs of the next (3) improving business environment, which addresses issues such as tax reform, rationalization of regulatory policy, improvement of

trade policies and the upgrading of energy policies (Report to the President - Accelerating U.S. Advanced Manufacturing, 2014)

2.4 Brazil

In Brazil, National Confederation of Industry (*Confederação Nacional das Indústrias - CNI*) concluded the first national survey on the adoption of digital technologies related to the I.4.0 approach (Afonso 2016). The survey - conducted with 2,225 companies of all sizes between January 4 and 13, 2016 - identified the adoption of ten types of digital technologies by companies and their use in different stages of the industrial chain. Seventy-three percent of those claim to use at least one digital technology at the process stage. Another 47% use in the development stage of the productive chain and only 33% in new products and new businesses. It is therefore necessary to identify the national industrial applications which could benefit from this technological advance and which strategic indicators must be put in practice. Increased use of technology systems means that the qualitative changes brought by I.4.0 are likely to be positive for the labor market. The number of physically demanding or routine jobs will decline, while the number of jobs requiring flexible responses, problem solving, and customization will increase. And for I. 4.0 to work effectively, workers will need a variety of skills. They will have to combine the know-how related to a specific work or process, such as techniques to work with robots or change the tools, in the machines, together with knowledge in the areas of Technology Information (TI) ranging from interfaces of use of basic plots to advanced programming and analytical skills. The need for multiple skills and the unprecedented reach of factory floor changes mean that soft-skills will become more important than ever. Employees should be even more open to change, have more flexibility to adapt to new roles and work environments and become accustomed to continuous interdisciplinary learning (Gerlitz 2016)

3. Comparative Analysis

Synthetically, the maturity level related to industry 4.0 is in descending order: Germany, USA, China and Brazil, the first not only as a pioneer of the subject, but with a large part of the industry already with operational projects. Although the investments are larger in the eastern country, North America comes after Germany, because it is in the forefront of four synergistic technological revolutions: innovation in energy production; advanced and digital manufacturing; biological sciences and information technology (industrial internet) (Schwab 2016). Manufacturers also note that regulatory uncertainty impacts their ability to both adopt new manufacturing technology innovations and to continue U.S.-based operations. Second, AMP2.0 encourages the further development of tax policies which are designed to encourage long-term establishment of capital-intensive and space-intensive manufacturing operations.

Per Staufen AG (2015), Chinese companies were near in the same position in 2015 as German companies were in 2014 compared to I. 4.0. Based on other data

from the consulting, 58% of Chinese companies are already focusing on smart factories and one in ten companies are already having individual operational projects in progress.

The consulting also interviewed German and Chinese entrepreneurs in order to relate them to their knowledge by questioning them: where is your company headed for smart factories? Is your company well prepared to become a smart factory? The data are shown in figure 4.

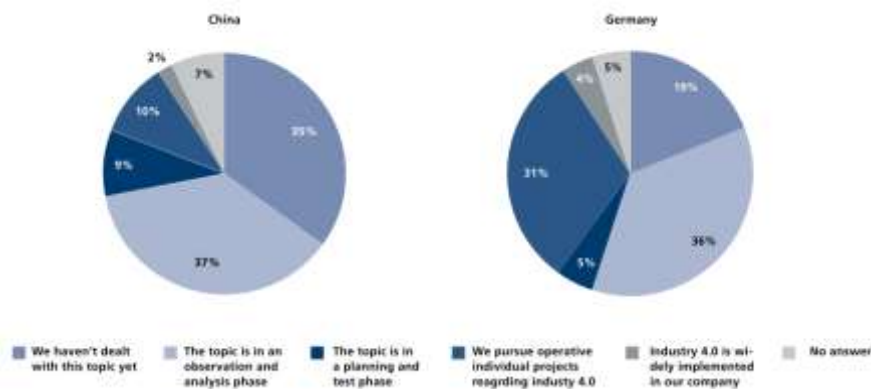


Figure 3. China x Germany Industry 4.0 maturity. Source: Staufen AG (2015)

Despite a higher level of maturity in I.4.0 approach of Germany compared to China, there is still great progress in China in recent years due continuously entering segments with higher aggregate values in global production and employing their important economies of scale to better compete in the world (Schwab 2016).

In Brazil, most of the efforts made by industry are at the stage of industrial processes, opening a huge disadvantage related to other countries. Also, having the high cost of implementation as the main internal barrier to the adoption of digital technologies, the National Confederation of Industry in Brazil conducted a survey of industrial companies and found that in order to accelerate the adoption of digital technologies in the country, it is fundamental to develop digital infrastructure (broadband, sensors, etc.), followed by new models of education and training programs and, finally, to establish specific financing lines (CNI 2016).

4. Relevance

This paper presents different strategies adopted by each selected country in this study (Germany, EUA, China and Brazil), based on I.4.0 approach. Therefore, those countries which can establish the best international norms for the future related to the main categories and fields of the new digital economy (Internet of Things, Advanced Manufacturing, Digital Health, Communications 5g, among

others) will have great economic and financial benefits. By contrast, countries that only promote their own rules to offer advantages to domestic producers, to prevent the entry of foreign competitors, and to reduce the royalties paid by domestic firms to foreign technologies will be in risk to be cut off from international standards and become the retards of the new digital economy (Schwab 2016). Finally, public policy choices will decide whether a given country will be able to capitalize on all the opportunities offered by the technological revolution.

Based on the I.4.0 approach, the general data of this research indicate that Germany has leadership in projects, China investment leadership and US intermediate stage between the two previous countries. The three countries mentioned present long-term strategies with establishments of predetermined goals and sectors, for a well-defined trajectory establishment. Unlike Brazil, which is still in a stage focused on industrial processes, which will require several investments and an industrial policy focused on the most competitive sectors related to Brazilian characteristics, as the same time to develop an appropriated infrastructure for this new scenario.

References

- ACHATEC, 2013. 001.Recommendations for implementing the strategic. , (April), pp.4–7.
- Afonso, I., 2016. Pesquisa inédita da CNI mostra cenário da indústria 4.0 no Brasil. Available at: <http://www.portaldaindustria.com.br/cni/imprensa/2016/05/1,88711/pesquisa-inedita-da-cni-mostra-cenario-da-industria-4-0-no-brasil.html> [Accessed August 24, 2016].
- Anon, 2014. Report to the President - Accelerating U.S. Advanced Manufacturing. *President's Council of Advisors on Science and Technology*, (2), p.108. Available at: https://www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/amp20_report_final.pdf.
- Bloem, J., 2014. The Fourth Industrial Revolution Things to Tighten the Link Between it and ot. *VINT research report*, pp.1–39.
- CNI, 2016. Indústria 4.0: novo desafio para a indústria brasileira. , p.13. Available at: http://www.portaldaindustria.com.br/relacoesdotrabalho/media/publicacao/chamadas/SondEspECIAL_Industria4.0_Abril2016.pdf [Accessed December 9, 2017].
- Gerlitz, L., 2016. Design Management as a Domain of Smart and Sustainable Enterprise: Business Modelling for Innovation and Smart Growth in Industry 4.0. *Entrepreneurship and Sustainability Issues*, pp.244–268. Available at: [http://jssidoi.org/dok/ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES/2016 Vol 3 No 3 March/3 Gerlitz 2016 March 3\(3\).pdf](http://jssidoi.org/dok/ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES/2016 Vol 3 No 3 March/3 Gerlitz 2016 March 3(3).pdf) [Accessed September 1, 2016].
- Hermann, M.; Pentek, T., 2015. Design principles for industrie 4.0 scenarios: a literature review. , (1).
- Kurfuss, T., 2014. Industry 4.0: Manufacturing in the United States. *OSTA - Office of Science and Technology Austria Washington DC*. Available at: <http://ostaustria.org/bridges-magazine/item/8310-industry-4-0> [Accessed November 1, 2016].

- Lee, X.E., 2015. Made in China 2025: a New Era For Chinese Manufacturing. Available at: <http://knowledge.ckgssb.edu.cn/2015/09/02/technology/made-in-china-2025-a-new-era-for-chinese-manufacturing/>.
- Schwab, K., 2016. *A Quarta Revolução Industrial*, Edipro.
- STAUFEN AG, 2015. China – Industry 4.0 Index 2015.
- Venturelli, M., 2016. INDÚSTRIA 4.0 - A Quarta Revolução Industrial – Uma Visão da Automação Industrial. Available at: <https://mhventurelli.wordpress.com/industria-4-0/> [Accessed September 12, 2016].
- Wang, L., 2016. Comparative Research on Germany “ Industrie 4 . 0 ” and “ Made in China 2025 . ”, (Ichssr), pp.27–30.
- Zuehlke, D., 2010. SmartFactory-Towards a factory-of-things. *Annual Reviews in Control*, 34(1), pp.129–138.

Institutional relationship on smart cities approach: the Brazilian case

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Abstract: the increase of urban agglomerations results in several problems in structuring cities and in the quality of life of the individuals. The scarcity of natural resources for structuring cities and the insecurity due the increase of violence in an urban conurbation conduct challenges for a new concept in the academic and industrial milieu: “the smart cities”. Therefore, the objective of this paper is to quantify Brazilian and international research institutions related to intelligent cities and to analyze the relationship between them.

Keywords: Smart Cities; Institutes; Universities; Brazil.

1. Introduction

A United Nations Organization survey for Rio +20 pointed out that by 2030 almost 60% of the world's population will live in urban areas and in Brazil this figure is expected to reach more than 90% (UN, 2012). Despite the small area of the planet effectively occupied by urban areas these centers consume almost 75% of the planet's natural resources (BOUSKELA, et al, 2016). The increase in urban areas does not only mean a future shortage of resources but also brings with it all the difficulties of living in urban areas, including insecurity. Brazil is the country where the sensation of insecurity is the largest in the world and reaches about 70%

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of Brazilians (UN, 2016). From these problems emerged the concept of intelligent cities that aims to unite technology, innovation and communication to improve the quality of life in urban agglomerations (KOMNINOS, 2002). It is believed that only with the use of intelligence will it be possible to maintain urban clusters and increase their quality for the next generations.

2. Methodology

This paper consists on quantifying the main national and international institutions and universities which research the theme “smart city”. Subsequently, within this theme, it will be separated those whose purpose is the security theme.

3. Results and discussion

There were found at least seven Brazilian institutions studying “smart city” theme, sixteen international institutions belonging to the most diverse countries and areas of activity, four Brazilian universities and nine international universities, observed in Table 1. Some of Brazilian institutes are linked with another international institutes as demonstrated in Table 1. Institutions linked to universities will be described in topic 3.4.

Table 1 Main Brazilian and international institutions regarding the “Smart City”

Brazilian institutes	International institutes	país da instituição internacional
Instituto Smart City Business Latin America	Smart City Business Institute	Spain, Barcelona
WRI Brasil	World Resources Institute (WRI)	USA, Washington DC
Instituto Planet	PLANET The Smar City	Italy, Torino
iCities	Smart Circle	Netherlands, Eindhoven
Instituto das Cidades Inteligentes		
Instituto do Futuro		

Instituto Igarapé		
Instituto Brasileiro da Qualidade e Produtividade		
SB-LAB – Sustainable Business Laboratory, FCA-UNICAMP		
	Smart City.Institute	Germany, Ludwigsburg
	IEEE Smart Cities	USA, New Jersey
	Israel Smart Cities Institute	Israel, Tel Aviv
	International Telecommunication Union (ITU)	Switzerland, Geneva (UN)
	International Community Forum (ICF)	USA, New York
	Global Institute	USA, Ohio
	Industrial Technology Research Institute (ITRI)	Taiwan, Hsinchu
	Digital Government Society	USA, California
	Urban Land Institute Foundation (ULIF)	USA, Washington DC
	Institute For The Future	USA, California
	Institution of Engineering and Technology (IET)	England, Hertfordshire

The analyzes of the institutions mentioned in table 1 will be detailed below

3.1 Main Smart City institutes in Brazil

3.1.1 Instituto Smart City Business America

The Instituto Smart City Business America is an organization that aims to build discussions about the smart cities scenario in the world throughout Latin America. Created in 2013, the institute aims to create a solid foundation to promote the

development of smart cities and encourage innovative ideas, it has the support of the Smart City Business Institute which is a global portal that gathers information on the development of knowledge in smart cities around the world.

3.1.2 WRI Brasil

WRI is an international non-profit research organization focused on climate, sustainable cities and forests. Through research and knowledge production in sustainable cities WRI helps governments to implement projects for a more sustainable world. WRI's main job is to develop strategies to conserve natural resources and improve the quality of life on the planet.

3.1.3 Instituto das Cidades Inteligentes

The Instituto das Cidades Inteligentes is a non-profit social organization that is a reference in information and communication technology development throughout Brazil and that invests all its financial returns in researches to transform Brazilian cities in Smart cities. In this way, the institute has revolutionized the Brazilian market for information and technology services, contributing to a broadening of the horizons in smart city.

3.2 Main international institutions in smart city

3.2.1 Smart City Business Institute

The Smart City Business Institute is an online platform that converge information about the initiatives of all companies, institutions, city halls and professionals who are dedicated to the possibilities of Smart Cities.

3.2.2 IEEE Smart Cities

IEEE is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity. This organization nurtures, develops and promotes global technology improvement through a full cycle approach, including the study of non-standard technologies, standards development, and implementation in the marketplace.

3.2.3 Smart City Institute

Smart City Institute is an organization that conducts research on the topic of smart cities. Their work focuses on the fields of energy, mobility and urban development. In addition, the institute provides consulting services for cities. Furthermore, it builds networks to promote the intersectoral exchange of knowledge and cross-industrial collaboration in order to support the creation of real smart city solutions.

3.3 Safety Smart City institute

3.3.1 Instituto Igarapé

The Instituto Igarapé is a non-profit institution that aims to integrate security and development programs, while acting as a bridge between decision makers and

social movements. In this way, the institute acts as a channel to propose innovative solutions to social challenges through research, new technologies, political influence and articulation. The Institute works with five macro topics: national and global drug policy; citizen security; peace-building; safe cities; and cyber security.

3.4 Universities focused on smart city in Brazil and in the world

3.4.1 Brazil

- SB-LAB – Sustainable Business Laboratory, Faculdade de Ciências Aplicadas, Universidade Estadual de Campinas, FCA-UNICAMP
- Instituto de Matematica e Estatística (IME) - Universidade de São Paulo
- FGV PROJETOS - Fundação Getúlio Vargas
- Instituto Metropole Digital (IMD) - Universidade Federal do Rio Grande do Norte
- Instituto LabCHIS - Universidade Federal de Santa Catarina

3.4.2 International

- Smart City Institute HEC Liege – Université de Liege
- Data Science Institute – Columbia University
- Global Cities Institute - University of Toronto
- Mississippi State University Extension Service Intelligent Community Institute (MSUES-ICI) - Mississippi State University
- Center for Technology in Government - University at Albany (State University of New York)
- California Institute for Smart Communities - San Diego State University
- Institute for Smart Communities - San Diego State University
- Macau Smart City Institute - Macau University of Science and Technology
- Massachusetts Institute of Technology

4. Conclusion

Institute with the greatest national repercussion is the Smart City Business America focused on consultancy in developing projects on intelligent cities in many aspects. WRI Brazil is leader on sustainability and research for intelligent solutions in water resources. The both institutions have a relationship with the Smart City Institute whose focus is on energy, mobility and urban development while, also addressing overarching issues such as digitization, sustainability and resiliency, and represents the institute of greatest international repercussion and consequently a reference to the national institutes.

References

- Bartoli, G., Fantacci, R., Gei, F., Marabissi, D. & Micciullo, L., 2013, 'A novel emergency management platform for smart public safety', *International Journal of Communications Systems* 28, 928-943. <http://dx.doi.org/10.1002/dac.2716>
- CAMPBELL, Tim. Learning cities: Knowledge, capacity and competitiveness. *Habitat International*, [s.l.], v. 33, n. 2, p.195-201, abr. 2009. Elsevier BV. <http://dx.doi.org/10.1016/j.habitatint.2008.10.012>.
- City of Dublin, Ohio, USA (2016). Disponível em: <<http://globalinstitute.dublinohiousa.gov/>>. Acesso em: 14 de fevereiro de 2017.
- Columbia University, Data Science Institute (2017). Disponível em: <<http://datascience.columbia.edu/>>. Acesso em: 14 de fevereiro de 2017.
- D. Junkes; C. S. Teixeira, 2016, “Modelo brasileiro de maturidade para cidades inteligentes: Análise do municípios da cidade de santa catarina”. REAVI Revista mantida pela UDESC.
- Digital Government Society (2017). Disponível em: <<https://dgsociety.org/>>. Acesso em: 14 de fevereiro de 2017.
- FGV Projetos (2017). Disponível em: <<http://fgvprojetos.fgv.br/home>>. Acesso em: 13 de fevereiro de 2017.
- Global Cities Institute (2013). Disponível em: <<http://www.globalcitiesinstitute.org/>>. Acesso em: 14 de fevereiro de 2017.
- IBQP - Instituto Brasileiro da Qualidade e Produtividade. Disponível em: <<http://www.ibqp.org.br/>>. Acesso em: 15 de fevereiro de 2017.
- ICI, Instituto das Cidades Inteligentes (2017). Disponível em: <<http://www.ici.curitiba.org.br/>>. Acesso em: 14 de fevereiro de 2017.
- iCities (2016). Disponível em: <<http://www.icities.com.br/>>. Acesso em: 15 de fevereiro de 2017.
- HEC Liège (2017). Disponível em: <<http://www.hec.ulg.ac.be/en/hec-liege/remarkable-projects/smart-city-institute>>. Acesso em: 13 de fevereiro de 2017.
- IEEE Smart Cities (2017). Disponível em: <<http://smartcities.ieee.org/>> . Acesso em: 12 de fevereiro de 2017.
- IMD, Instituto Metropole Digital. Disponível em: <<http://portal.imd.ufrn.br/>>. Acesso em: 14 de fevereiro de 2017.
- Intelligent Community Forum (2015). Disponível em: <<http://www.intelligentcommunity.org/>>. Acesso em: 13 de fevereiro de 2017.
- Intelligent Community Institute - Mississippi State University Extension Service (2017). Disponível em: <<http://ici.msucare.com/>>. Acesso em: 14 de fevereiro de 2017.
- Institute for the Future (2017). Disponível em: <<http://www.iff.org/home/>>. Acesso em: 13 de fevereiro de 2017.
- Instituto de Matemática e Estatística da Universidade de São Paulo (2017). Disponível em: <<https://www.ime.usp.br/>>. Acesso em: 13 de fevereiro de 2017.

- Instituto do Futuro. Disponível em: <<http://www.institutodofuturo.com.br/>>. Acesso em: 15 de fevereiro de 2017.
- Instituto Igarapé (2017). Disponível em: <<https://igarape.org.br/>>. Acesso em: 14 de fevereiro de 2017.
- Instituto PLANET (2016). Disponível em: <<http://institutoplanetsmartcity.com.br/>>. Acesso em: 13 de fevereiro de 2017.
- Instituto SmartCity Business America (2016). Disponível em: <<http://smartcitybusiness.com.br/home/>>. Acesso em: 12 de fevereiro de 2017.
- Israel Smart Cities Institute NGO (2015). Disponível em: <<https://www.smartcitiesisrael.org/background>>. Acesso em: 15 de fevereiro de 2017.
- ITRI, Industrial Technology Research Institute (2017). Disponível em: <<https://www.itri.org.tw/eng/index.aspx>>. Acesso em 15 de fevereiro de 2017.
- ITU (2017). Disponível em: <<http://www.itu.int/en/about/Pages/default.aspx>>. Acesso em: 13 de fevereiro de 2017.
- Massachusetts Institute of Technology. Disponível em: <<http://web.mit.edu/>>. Acesso em: 15 de fevereiro de 2017.
- Organização das nações unidas, Rio +20 (2012). Disponível em: <<http://www.onu.org.br/rio20/cidades.pdf>>. Acesso em 15 de fevereiro de 2017.
- Palmer, A. (2016). SMART SAFETY. Successful Meetings, 65(4), 14-14,16,18,20. Retrieved from <https://search.proquest.com/docview/1781762929?accountid=8113>
- PLANET. The smart city (2016). Disponível em: <<http://www.planetsmartcity.com/>>. Acesso em: 13 de fevereiro de 2017.
- San Diego State University (2017). Disponível em: <<https://www.sdsu.edu/>>. Acessado em: 14 de fevereiro de 2017.
- SmartCity.institute, by THINK and GROW consult (2014). Disponível em: <<http://smartcity.institute/sci/>>. Acesso em: 14 de fevereiro de 2017.
- Smart Circle, an initiative of Euroforum (2015). Disponível em: <<http://www.smart-circle.org/>>. Acesso em: 15 de fevereiro de 2017.
- Smart City Business Institute (2015). Disponível em: <<http://www.smartcbi.org/index.php/en/>>. Acesso em: 12 de fevereiro de 2017.
- T. Nam, and T.A Pardo, “Conceptualizing Smart City with Dimensions of Technology, People, and Institutions”, Proceedings of the 12th Annual International Conference on Digital Government Research, New York, pp.282-291, 2011.
- The Institution of Engineering and Technology (2017). Disponível em: <<http://www.theiet.org/>>. Acesso em: 13 de fevereiro de 2017.
- The Macau University of Science and Technology (2016). Disponível em: <<http://www.must.edu.mo/en/news-en/15460-article09260707-e>>. Acesso em: 15 de fevereiro de 2017.
- The Research Foundation of State University of New York, CTG (2016). Disponível em: <http://ctg.albany.edu/>>. Acesso em: 14 de fevereiro de 2017.

- Universidade Federal de Santa Catarina (2017). Disponível em: <<http://ufsc.br/>> . Acesso em: 14 de fevereiro de 2017.
- Université de Liège - Relations extérieures et Communication (2015). Disponível em: <<http://labos.ulg.ac.be/smart-city/>>. Acesso em: 13 de fevereiro de 2017.
- World Resources Institute (2017). Disponível em: <<http://www.wri.org/>> . Acesso em 15 de fevereiro de 2017.
- WRI Brasil (2017). Disponível em: <<http://www.wribrasil.org.br/pt>>. Acesso em: 12 de fevereiro de 2017.

The Contribution of the Process of Materiality to the Evolution of the Field of Sustainability Performance Measurement

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Abstract The aim of this study is to validate the cycle of sustainability performance measurement in the context of materiality. The study examines whether materiality contributes to the progress of the area through the framework proposed by Andy Neely. To do so, the paper explores the five questions that could guide future field research. One of the limitations is that the topic addressed was explored from the viewpoint of the performance measurement GRI, more specifically in its latest G4 version. The guideline perceives materiality as the key element for sustainable reporting, so the principle should be studied to see how important it is to industries. Results show that materiality contributes to the maturity of the topic by providing the necessary support for the theory introduced by Neely, more specifically the framework of the article “The evolution of performance measurement research: Developments in the last decade and a research agenda for the next”. Consequently, Neely’s future agenda was debated with the concepts of materiality applied in the practical environment of business. This document meets the identified need to explore the materiality tool, since the field needs future research due to little literature found.

Keywords: Materiality; Performance Measurement; Sustainability; Global Reporting Initiative (GRI); Andy Neely

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1. Background

Despite the existence of previous work the area of performance measurement has spread after the influence of the Balanced Score Card before the industry (Neely et al. 2005a; Neely, 2005b). Since then the topic has been part of the research agenda of the academic community that seeks to develop issues ranging from the design process to the study of implementation and management of indicators (Neely, 2005b).

This study is based on the work of Andy Neely (2005b) entitled “The evolution of performance measurement research: Developments in the last decade and a research agenda for the next”. Briefly it sought to sum up the contents of a decade of study on performance measurement. Results allowed the author to project trends for the ten subsequent years. Even though this time scale has recently been closed, the mentioned topics have been debated to this day.

One of the great contributions of Neely’s paper (2005b) was the proposal of the evolutionary cycle of the performance measurement field. The framework represents the development of the subject through simple connections, setting a virtuous sequence of improvement.

These stages are the origin of this article. The aim is to show from the viewpoint of sustainability how materiality is helping companies to measure their sustainable performance, and consequently contributing to the progress of performance measurement.

2. The perspective of materiality

The term materiality initially designated accounting activities, in particular auditing techniques. The definition in sustainability acquired new perspectives, giving rise to a new concept (Jones et al. 2016c).

According to Global Reporting Initiative (GRI), a Dutch institution that gives its name to its sustainable reports, materiality can be defined as “the threshold at which Aspects become sufficiently important that they should be reported. Beyond this threshold, not all material aspects are of equal importance and the emphasis within a report should reflect the relative priority of these material aspects” (GRI, 2015b).

Despite efforts by GRI to adopt the principle of materiality in older versions of its report it was only in G4 – in 2013 – that materiality became the key element of the document, guiding all selection procedures, application, and especially the way to report the applied components.

2.1 Architecture

The definition process of materiality is based on the premise of relevance (Whitehead, 2016). When designing the sustainability strategy, the company must put together a continuous action plan so that the strategic actions are always in connection with materiality, ensuring correct alignment with all operational flows.

In addition to being the base of the operation the economic, environmental, and social pillars ensure constant information exchange between the strategic process and the definition of material aspects. Thus, it is possible to observe that both the company and the stakeholders have different materials – i.e. different priorities.

This conflict between the parties gives rise to materiality. Materiality is composed of the intersection between the aspects of the company and the aspects of its stakeholders. The proposed framework, Figure 1, simply demonstrates the mechanism of the definition.



Figure 1. Proposed framework for the definition of materiality.

GRI has a tool capable of crossing such information, called materiality matrix. Basically, sustainability is divided into two axes. Axis X is responsible for the importance of economic, environmental, and social impacts. Axis Y represents the influence of stakeholders on evaluations and decisions (Jones et al. 2016c; Bellantuono et al. 2016).

3. Materiality and the future of performance measurement

The progress of performance measurement introduced by Neely (2005b) shows the evolutionary cycle of the area. Materiality used by the sustainability indicators, more precisely GRI in the G4 guideline, is based on this framework for updating. Figure 2 shows how the theory of materiality relates to the evolutionary cycle proposed by Neely.

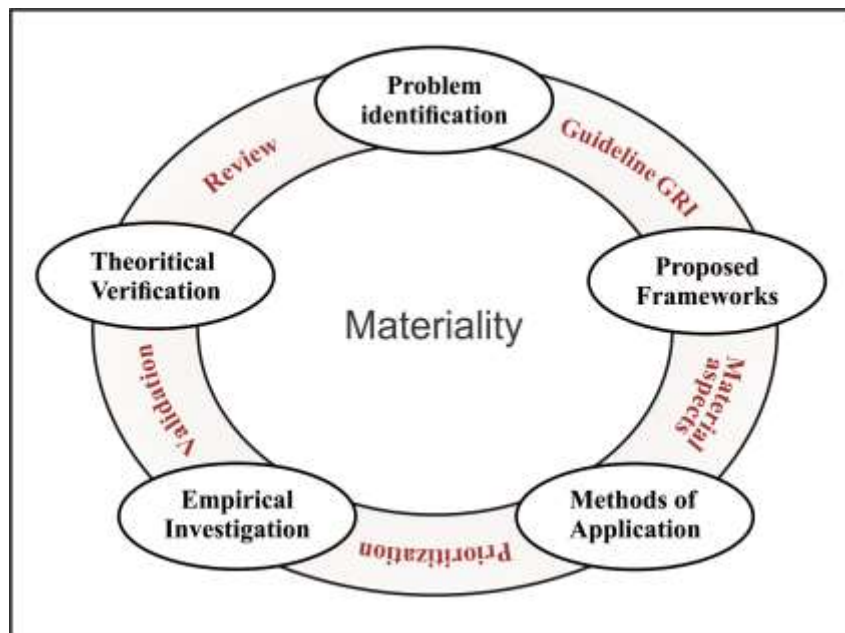


Figure 2. Adapted from Neely (2005b). The evolution of the field of measurement of performance through the materiality.

Some questions were posed by Neely (2005b) to drive the future of performance measurement. They will be answered based on the theory of materiality (aiming sustainability).

“How to design and deploy enterprise performance management rather than measurement systems?”

Utility is one of the inherent concepts of materiality. By analyzing materiality, it is possible to measure only the relevant aspects of the company and its stakeholders.

By adopting the materiality theory, the company seeks to achieve operational efficiency. Since sustainability has several applications, materiality seeks to identify which criteria are essential for the company. Thus, it is possible to customize the sustainable actions according to each type of business.

By determining which practices are relevant it is possible to manage business performance. Thus, the company creates, implements, and manages consolidated actions for the inserted market. These factors eliminate the mistake that many companies make: to control performance measures that are not necessary for that type of business.

“How to measure performance across supply chains and networks rather than within organizations?”

Among various types of performance measurement systems materiality is one of the principles that empower stakeholders. Materiality does not seek to measure the sustainable performance of only one “tip of an iceberg”, but the performance of all elements.

That’s why supply chains – along with the other elements of the process – are important for the process of definition of material aspects and their influence is accepted in the variable control.

The process is carried out jointly between the company and its stakeholders. Due to this fact, the stage is usually time-consuming, because the demands of all interested parties must be unified.

“How to measure intangible as well as tangible assets for external disclosure as well as internal management?”

Materiality analysis seeks to measure the assets by the order of importance. Regardless of whether it is tangible or intangible the material will only be reported if it influences the company and its stakeholders.

A long period of internal and external verification is required for this to happen. Managers and strategic members cooperate to carry out this stage, as they have the know-how of the process. The knowledge of each operational stage, or focal point, allows the company to measure the variables inherent to the organizational cycle.

Materiality is not only a measurement resource, but also a management tool due to the constant monitoring of the assets. The external disclosure is carried out by the materiality matrix, which shows only the assets relevant to business continuity.

“How to develop dynamic rather than static measurement systems?”

One of the great attributes of materiality is the uninterrupted analysis of verifications. The process provides flexibility in establishing that each company will measure its aspects individually, as each industry has its peculiarities.

As organizational strategies change, the means of measuring materiality follow the change. The movement becomes more complex as it increases the continuous imposition of stakeholders, because factors are part of a permanent change process, such as the internal environment.

While GRI guidelines provide several fill standards, it is optional to fill in all items. The customization criteria allow companies to be capable of changing the dynamism of performance measurement every year, or even earlier. GRI, the institution that gives its name to its indicator, is concerned with the agenda addressed in providing support for updating its index, as in the case of the last update, the G4 guideline, which considers materiality to be the key element for sustainability performance measurement.

“How to enhance the flexibility of measurement systems so they can cope with organizational changes.”

One of the main stages of the materiality cycle is its analysis. With each cycle feedback, it is possible to improve the actions undertaken, fixing process failures, and reaching excellence in the application of factors.

It is usually done during preparation of the following reports, since materiality is a continuous learning process. This gives companies flexibility, as it adjusts to the market according to the current requirements of society.

The business environment is dynamic, therefore it is critical for business continuity to learn from mistakes. With materiality, the company has a culture of renewal while trying to be efficient.

4. Conclusion

Materiality is changing the performance measurement field. Its application contributes to the evolution of measurement systems and consequently to the theory proposed by Neely in 2005.

Despite being a unique element of sustainability, materiality tends to be applied in other areas. It is necessary to understand how the variable interacts with other factors and minimizes the subjectivity in its application (Calabrese et al. 2016). For future work the application of statistical tools is recommended to justify the material choice.

This paper contributes to the advancement of science by relating the future of performance measurement to materiality. The resolution of Neely's research agenda (2005b) was made, and it was pointed out how materiality assists in the development of performance measurement.

One of the main findings of this article was to verify that materiality fully answers to future Neely's questions. The synchronization with the proposed framework results in new contributions to the evolution of the area of performance measurement.

References

- Bellantuono, N, Pontrandolfo, P, Scozzi B (2016) Capturing the stakeholders' view in sustainability reporting: A novel approach. *Sustainability*. 8 (4), pp.379
- Calabrese A, Costa R, Levaldi N, Menichini T (2016) A fuzzy analytic hierarchy process method to support materiality assessment in sustainability reporting. *Journal of Cleaner Production*. 121, pp.248-264
- Calu A, Negrei C, Calu D. A, Avram V (2015) Reporting of non-financial performance indicators - A useful tool for a sustainable marketing strategy. *Amfiteatru Economic*. 17 (40), pp.977-993
- Elkington J (2001) *Canibais com garfo e faca*. Makron Books, São Paulo
- Fonta X, Guixb M, Bonilla-Priegoc M (2016) Corporate social responsibility in cruising: Using materiality analysis to create shared value. *Tourism Management*. 53, pp.175-186
- GRI (2002) Diretrizes para relato de sustentabilidade G1 e G2. <http://www.epeat.net/documents/EPEATreferences/GRIguidelines.pdf>. Accessed in Oct/2016
- GRI (2011a) Diretrizes para relato de sustentabilidade G3. <https://www.globalreporting.org/resourcelibrary/G3-Guidelines-Incl-Technical-Protocol.pdf>. Accessed in Oct/2016
- GRI (2011b) Diretrizes para relato de sustentabilidade G3.1. <https://www.globalreporting.org/resourcelibrary/G3.1-Guidelines-Incl-Technical-Protocol.pdf>. Accessed in Nov/2016
- GRI (2015a) Diretrizes para relato de sustentabilidade G4, PARTE 1. <https://www.globalreporting.org/resourcelibrary/Brazilian-Portuguese-G4-Part-One.pdf>. Accessed in Dec/2016
- GRI (2015b) Diretrizes para relato de sustentabilidade G4, PARTE 2. <https://www.globalreporting.org/resourcelibrary/Brazilian-Portuguese-G4-Part-Two.pdf>. Accessed in Dec/2016
- GRI (2015c) FAQ. <https://www.globalreporting.org/resourcelibrary/G4-FAQ.pdf>. Accessed in Dec/2016
- GRI (2017) Database. <http://database.globalreporting.org/>. Accessed in Jan/2017
- Hřebíček J, Faldík O, Kasem E, Trenz O (2015) Determinants of sustainability reporting in food and agriculture sectors. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*. 63 (2), pp.539-552
- Jones P, Comfort D, Hillier D (2015) Materiality and external assurance in corporate sustainability reporting: An exploratory study of UK house builders. *Property Management*. 33 (5), pp.430-450
- Jones P, Comfort D, Hillier D (2016a) Managing materiality: a preliminary examination of the adoption of the new GRI G4 guidelines on materiality within the business community. *Journal of Public Affairs*. 16 (3), pp.222-230
- Jones P, Comfort D, Hillier D (2016b) Materiality and external assurance in corporate sustainability reporting: An exploratory study of Europe's leading commercial property companies. *Journal of European Real Estate Research*. 9 (2), pp.147-170

- Jones P, Comfort D, Hillier D (2016c) Materiality in corporate sustainability reporting within UK retailing. *Journal of Public Affairs*. 16 (1), pp.81-90
- Neely A, Gregory M, Platts K. (2005a) Performance measurement system design: A literature review and research agenda. *International Journal of Operations & Production Management*. 25 (12), pp.1228-1263
- Neely A (2005b) The evolution of performance measurement research: Developments in the last decade and a research agenda for the next. *International Journal of Operations & Production Management*. 25 (12), pp.1264-1277
- Neely A (1999) The performance measurement revolution: why now and what next? *International Journal of Operations & Production Management*. 19 (2), pp.205-228
- Norris C, Dettling J, Couture J, Norris G, Parent J (2014) Assessing the materiality of various sustainability issues in the agrifood sector with LCA-based tools: 3 case studies. *Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food Sector*
- United Nations (1987) *Our Common Future - Brundtland Report*. Oxford University Press. pp.204
- Whitehead J (2016) *Prioritizing Sustainability Indicators: Using Materiality Analysis to Guide Sustainability Assessment and Strategy*. Business Strategy and the Environment

Benefits and Obstacles in the implementation of Sustainable Public Procurement (SPP): Literature Review

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Abstract The following article revisits previous studies on the benefits and obstacles in the implementation of Sustainable Public Procurement (SPP), aiming to contribute towards both the theoretical approach and practical applications. A qualitative research of an explorative and descriptive nature has been undertaken as the means of investigation. The article develops integrated review frameworks in order to understand the challenges of implementing SPP. The results point to the adoption of SPP is a new paradigm. The benefits of SPP were identified in the literature, as well as the obstacles for its implementation. The scientific literature under study points to the necessity of replacing criteria through procurement systems for choosing suppliers based solely on the cheapest price and proposes that the added value (the meeting of sustainability requirements) be weighed in. The contributions identified in this paper are located in the practical and academic fields, respectively in the application of the knowledge produced and in the support of future research.

Keywords: sustainable public procurement; sustainability; public organizations; sustainable development

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1. Introduction: Research theme context

The challenge posed by the dynamic balance between the economic, environmental and social dimensions is known as sustainable development. Brazil has put in great efforts in the editing of regulatory benchmarks towards fostering the practice of SPP in state-owned organizations. The objective of this article is to identify the main benefits and obstacles in the literature, for the implementation of SPP.

This study aims to contribute to the body of knowledge concerning the implementation of SPP and offer information which facilitates the maturation of this procurement system.

An observational study of the bibliographical type (Goldim, 1997) has been chosen, from which the methodological strategy has been developed through exploratory and selective reading of research material on the benefits and obstacles of implementing SPP. The descriptors of the bibliographical research were: sustainable management in public organizations, sustainable development; sustainable public procurement, sustainability in the supply chain of public organizations. Criteria were adopted in selecting the articles. The following parameters were analyzed: a) The year of 2000 until 2016; b) Portuguese, English and Spanish languages; c) Articles which address the benefits and obstacles in the implementation of sustainable procurement; and d) Articles in their complete version. The articles and scientific documents were sorted by the standards defined by Mello (2014), in order to facilitate viewing of the bibliographical integration with the benefits of SPP implementation.

2. Literature Review

Roos (2012) states that public contracts account for 15 up to 25% of developing countries' GDP. Public procurement is seen as a public policy instrument for generating relevant economic, environmental and social benefits. Roos (2012) presents an overview of SPP initiatives in developing countries. Hayes and Wheelwright (1984) suggest that sustainable development could be a new competitive priority, to be jointly considered along other traditional priorities: quality, cost, reliability, timeliness, flexibility and innovation. The conclusions of Krause et al. (2009) indicate that some organizations will adopt sustainability unilaterally, as part of their business strategy, while others will be pressured for integrating sustainability through clients, suppliers or legislation. Some may opt for focusing their efforts on the economic and environmental dimensions, while others may include the social and cultural ones.

According to Santos *et al.* (2010), sustainable procurements are the integrating mechanism in the economic, environmental, cultural and social dimensions in the

procurement system. The practice of sustainable procurements makes it possible to meet specific necessities through acquiring products and services which offer reduction of costs and of environmental impact, strength to local culture, and which benefits society through more jobs, generation of income and improvement mechanisms for life quality. These are known as eco acquisitions, environmentally friendly procurements, responsible consumption or positive bidding. The concept of SPP is described by Schneider & Wallenburg (2012) and integrates the economic, social and environmental spheres.

3. Results

3.1 Benefits of implementing sustainable public procurement

The literature presents evidence for improving efficiency in implementing public procurement. According to Hegenberg, J. T. (2013) and Brammer, S.; Walker, H. (2011), there is a correlation in the suppliers concerning increases of productivity and efficiency and of waste, pollutants and emissions. According to SILVA (2012), the SPP represent a new concept through which suppliers align themselves with the rational and intelligent use of natural resources, increasing the value of their products and services.

The achievement of results in the procurement or supplier spheres, which derive from the adoption of SPP, demand the existence of clear perception of the relation between costs and benefits, familiarity and comprehension of concepts and policies related to the theme, as well as qualification of public procurers and information (Brammer and Walker, 2011; Hegenberg, 2013). According to Santos (2016), the implementation of sustainable procurement in public organizations establishes a commitment of the supplier with sustainable development, and improves quality of life for users, with decreased environmental impact. According to the same author, the insertion of sustainable criteria must be stressed in the procurement of goods and services provided by public organizations. Guidelines for sustainability begin to spread through the various stages of the procurement and procurement processes of public organizations, aiming to provide users wider possibilities and variety of products and services with better benefits for the environment and for society.

Concerning the Risk Reduction (both human and environmental) derived from the implementation of SPP: the human risks comprise the work itself and internal risks of organizations which are part of the supply chain. The human risks consist in exposure to dangerous materials and contamination, while environmental risks are faced while depositing waste in the environment or while utilizing dangerous materials, which may include high environmental risk in its production (Mahler et al, 2007). They report that leading organizations in their sustainable supply chains

are the ones which update their procurement systems concerning supplier monitoring in TBL (*Triple Bottom Line*).

As a result of implementing SPP, there is great contribution towards a stronger economy, for market development for sustainable products and services; Incentive to innovation through the creation of partnerships between suppliers for developing products and services which generate less impact; Reduction of costs in energy and materials, facilitating financial resources for other uses. It produces more knowledge of the production process of services and products, which allows the organizations to be able to implement critical criteria in the manner in which their products and services are produced and in their waste material. These crucial concerns, added to the market pressure, originates possibilities of product innovation, which consume fewer non-renewable resources, are less aggressive to the environment, and include renewable resources which are likewise less aggressive, or processes which utilize renewable raw materials, with greater efficiency, less waste, and decreased environmental impact.

As for the increase in social welfare, SPP provides support to suppliers and establish a commitment with local communities, social and environmental responsibilities; They promote the development of local suppliers; Identify and acknowledge suppliers which meet international conventions related to work conditions; establish the guarantee of safety for suppliers as well as workers' safety and health. A healthier environment is created, due to the reduction of waste production; the utilization of more efficient raw materials; the reduction of elimination of emissions to air and water; the reduction of environmental impact of products and services throughout their lifecycle, with benefits acknowledged both locally and globally.

On the strengthening of the organizational image, the implementation of SPP facilitates the understanding and satisfaction of stakeholders' needs, emphasizing the quality of the relationship with communities, society in general, other components of the supply chain, concerning sustainability; it demonstrates the commitment of the organization with a policy of sustainability; improves working conditions for collaborators and the community environment involvement through the reduction of air and water emissions, decreasing of natural resource consumption and promoting local economic development.

Table 1 presents results in an integrated manner (benefits and bibliographical reference), grouping article and scientific document citations set out by Mello (2014).

Table 1. Benefits deriving from the Implementation of Sustainable Public Procurement.

1. Results improvement. Scientific Literature: BETIOL <i>et al.</i> , 2012, BIDERMAN <i>et al.</i> , 2008, BRAMMER <i>et al.</i> , 2011, HEGENBERG, 2013, SILVA <i>et al.</i> , 2012, SANTOS, 2016.
2. Risk reduction. Scientific Literature: BETIOL <i>et al.</i> , 2012., BIDERMAN <i>et al.</i> , 2008., BRAMMER <i>et al.</i> , 2011., HEGENBERG, 2013., SILVA <i>et al.</i> , 2012., SANTOS, 2016.
3. Stronger economy. Scientific Literature: COUTO <i>et al.</i> , 2011., MOTA, 2004.

4. Social welfare improvement. Scientific Literature: LARYEA <i>et al.</i> , 2013., SECO, 2013.
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5. Strengthening of image. Scientific Literature: BURJA, 2009., MARQUES <i>et al.</i> , 2014.
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3.2 Obstacles for the implementation of SPP

Aside from identifying the benefits, this study also aimed to describe the obstacles which restrict the implementation of SPP. Such implementation of sustainable procurement is troublesome in various sectors, due to factors which can be either internal or external to public organizations.

The success of the implementation of sustainable procurement finds in the lack of leadership its main challenge, as well as in the absence of clarity in policies and guidelines which establish necessities of resources and internal synergy. The literature studied suggests that the participation of the public sector in raising environmental awareness is essential, as well as in the promotion of collaborative and imposing public procurement policies.

There is also a lack of data banks for products and services, and the operational aspect of companies which compromises the quality and success of the implementation of sustainable procurement is the deficit of reliable data and maintenance records of products and services demanded by the organization's processes.

One of the present obstacles in the identified literature is the corruption risk. This concern includes the notion that SPP reduce competitiveness, resulting in higher public spending, which may result in an increase in corruption. This obstacle can be mitigated by applying governance, transparency and mechanisms for preventing against fraud or conflict of interests. Roos (2012) reports an analysis of 20 sustainable procurement programs in developing countries. It provides evidence about areas in which reforms are more advanced. These evidences include: 1) Law, regulations, procedure and standard tender documents; 2) Creation of a procurement regulatory body; 3) Education and training in procurement; 4) Procurement inspection, internal control systems, public access to information; and 5) Provisions concerning the fight against corruption, fraud, or conflict of interests.

In the studied literature, the unavailability of necessary resources was one of the main obstacles for implementing sustainable procurement. The economic factor stands as the main challenge and hampers the adoption of structural technology and solutions. There is also an absence of sources of internal and/or external knowledge, which hinders access to information of how to act in sustainable procurement implementation processes; the absence of informational structure which aids managers in evaluating potential economic, social and environmental benefits.

As for the obstacles related to acquisition costs, it is evidenced by the pressure of the contract system for buying at the lowest cost. There is a perception about sustainable products and services of them being more expensive. To address

sustainable procurement, it is necessary to expand the concept of “value” to financial resource, utilized in procurement systems, and to integrate this concept while evaluating the range of costs and benefits related to the economic, environmental, cultural and social aspects.

The scientific literature presents evidence of lack of competence in procurement professionals. The following obstacles were found: lack of knowledge and technical limitations of workers who may be involved in the implementation of sustainable procurement, as well as deficiency in training for employees in the operational level in order to maintain efficiency of the measures adopted. It is important that procurers in the public sector be intimate with the legal possibilities for including environmental conditions for their tendering processes.

The literature reports a lack of adaption by the supplying market, an absence of guidelines concerning sustainable development, and the need for sustainable products and services in the supplying market, turning this into a complex obstacle. It is necessary to know the capacity of suppliers and the demand of the public sector for sustainable services and products. The literature reports that the adoption of SPP does not occur in a planned manner, nor subsidized by some specific methodology. Isolated actions take place, without SPP policies or action completely defined action strategies to guide them.

The main obstacles found in the literature are listed within Table 2 and classified according to Jesus (2014); afterwards, an analysis of these obstacles is conducted.

Table 2. Obstacles for implementing Sustainable Public Procurement

1. Lack of leadership support, planning and proper environmental policies, resulting in difficulties when identifying the benefits of SPP. Scientific Literature: BETIOL <i>et al.</i> , 2012, HEGENBERG, 2013, BRAMMER <i>et al.</i> , 2011.
2. Absence of data banks for products and services. Scientific Literature: BRAMMER <i>et al.</i> , 2011, BELÁUSTEGUI, 2011.
3. Risk of corruption. Scientific Literature: ROOS, 2012.
4. Lack of financial, human, management, technological, informational and monitoring resources. Scientific Literature: BETIOL <i>et al.</i> , 2012, BELÁUSTEGUI, 2011, ROOS, 2012.
5. Aquisition costs. Scientific Literature: HEGENBERG, 2013, BRAMMER <i>et al.</i> , 2011, BELÁUSTEGUI, 2011, ROOS, 2012.
6. Lack of competence in procurement professionals. Scientific Literature: BETIOL <i>et al.</i> , 2012, BELÁUSTEGUI, 2011, ROOS, 2012.
7. Lack of adaptation to supplier’s market. Scientific Literature: HEGENBERG, 2013, BELÁUSTEGUI, 2011, BRAMMER <i>et al.</i> , 2011, ROOS, 2012.
8. Increase in complexity and the absence of specific and structured methodology for analyzing and implementing SPP. Scientific Literature: HEGENBERG, 2013, ROOS, 2012.

4. Conclusion

The analysis of the studied literature results in the ascertainment that it is inexorable that public organizations demand suppliers to prioritize the integration of sustainability in services and products. Some suppliers will adopt sustainability as part of their business strategy. The decisions of a procurement system which prioritizes and incorporates sustainability aspects in the acquisition of services and products consist in essential elements for implementing sustainable supply chains.

The information and results derived from the research are deemed relevant in the academic environment, as well as for public organization managers which seek to inform themselves on the benefits which may be achieved as well as on elaborating an obstacle mapping.

The authors of this article point out the need of perfecting the criteria and legislation which regulates the choice of suppliers in the public procurement sphere, based on the cheapest price and elaborates a proposal which includes value (meeting the sustainability requirements) through the procurement system. As for the obstacles of implementing SPP, the risk of corruption exists, in the light of the inclusion of criteria solely based on cheapest price, for choosing suppliers of services and products.

This research has limited itself to the identification of the main obstacles for the implementation of SPP, and it presents a reference of researchers and public managers. It may be stated that it possesses the deficiency of not researching and providing structured solutions for the identified obstacles. It does not provide further details concerning the benefits deriving from the implementation of SPP. Further research is necessary for healing such deficiencies.

References

- Beláustegui V (2011) Las compras públicas sustentables en América Latina. Estado de avance y elementos clave para su desarrollo. Red Interamericana de Compras Gubernamentales: n. 3
- Betiol L S, Uehara T H K, Laloë F K, Appugliese G A, Adeodato S, Ramos L e Monzoni Neto M P (2012) *Compra Sustentável: A força do consumo público e empresarial para uma economia verde e inclusiva*. São Paulo: Editora FGV
- Biderman R L, Betiol L M M, Monzoni R M (2008) *Guia de compras públicas sustentáveis. Uso do poder de compra do governo para a promoção do desenvolvimento sustentável*. RJ: Editora FGV
- Brammer S, Walker H (2011) Sustainable procurement in the public sector. *International Journal of Operations & Production Management*, Vol. 31, 4. ed. pp.452 – 476.
- Burja A (2009) Using green public procurement (GPP) for sustainable consumption and production. *Journal for European Environmental & Planning Law*; 6(3): 319-338

- Couto H L, Ribeiro H L G, Ribeiro F L (2011) *Compras Públicas sustentáveis: mecanismo para a promoção do consumo sustentável no Brasil*. IX Encontro Nacional Daecoeco. Brasília
- Goldim J R (1997) *Pesquisa em saúde: leis, normas e diretrizes*. Porto Alegre: HCPA
- Hayes R H, Wheelwright S C (1984) *Restoring our Competitive Edge-Competing Through Manufacturing*. Jhon Wiley & Sons, Inc., USA
- Hegenberg J T (2013) *As compras públicas sustentáveis no Brasil: um estudo nas universidades federais*. Dissertação (Mestrado em Planejamento e Governança Pública). UTFP. Curitiba
- Jesus C S (2014) *Compras Sustentáveis nas Universidades Federais: Aspectos e Propostas a partir do caso Itaipu Binacional*. Dissertação de Mestrado em Tecnologia. CEFET/RJ
- Krause D R, Vachon S, Klassen R D (2009) Special topic forum on sustainable supply chain management. *Journal of Supply Chain Management* , 18–25
- Laryea S, Alkizim A, Ndlovu T (2013) The increasing development of publication on sustainable procurement and issues in practice. *ARCM*, 1285-1294, UK
- Mahler D, Callieri C, Erbard A (2007) Chain reaction: your firm cannot be "sustainable" unless your supply chains become sustainable first. Disponível em: <http://www.atkearney.com/Chain_Reaction_S.pdf>. Acesso em: 12 Jan. 2017.
- Marques C S, Guarnieri P (2014) *Seleção de fornecedores considerando fatores socio-ambientais e impacto na imagem corporativa*. *Gestão e Saúde, Brasília, DF*. Brasil, 3415 - 3434
- Mello T M (2014) *Gestão de Portfólio de Itens de Alavancagem para Sustentabilidade em Contratações*; Dissertação (Mestrado em Logística-Opção Profissional) – PUC/RJ
- Mota J A (2004) *Economia, meio ambiente e sustentabilidade: as limitações do mercado onde o mercado é o limite*. Escola Superior do Ministério Público da União, ano 3, n. 12, p. 67-87
- Roos R (2012) *Sustainable Public Procurement: Briefing Note*. United Nations Procurement Capacity Development Centre and the United Nations Environment Programme
- Santos B S E, (2016) *Compras Públicas Sustentáveis: Incorporação de Critérios de Sustentabilidade na Contratação de Mobiliário no âmbito da Caixa Economia Federal*. ENAP. Brasília. DF
- Santos R S, Foresti L F, Santos Neto, A M V (2010) *Guia de Compras Públicas Sustentáveis para a Administração Federal*. Brasília.
- Seco - Swiss State Secretariat for Economic Affairs (2013) *Iseal Alliance. Buying for Tomorrow*. United Kingdom.
- Schneider L, Wallenburg C M, (2012) Implementing sustainable sourcing-Does purchasing need to change? *Journal of Purchasing and Supply Management*, v.18, no.4, pp.243-257
- Silva R C et al (2012) *Compras Públicas Compartilhadas: a prática das licitações sustentáveis*. *Revista do Serviço Público*, v. 63, p. 157

Strategy consolidation level and its effects in organizational variables

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Abstract This paper presents the impact of strategy in the organizational variables in the construction sector. The goal is to demonstrate that the more consolidated and better defined the strategy is the best is the organization development, based on the empirical study of the variables associated with the strategy. The research was based on a Survey that collected data from 125 companies. The data related to nine variables divided into two groups and three categories were analysed by descriptive statistics analysis. The results showed the more highly defined vision and strategic positioning, the better the company's growth rates and its position in relation to competitors. In this sense, the article encourages the development of strategy to create business sustainability by improving results in the construction sector.

Keywords: construction industry; strategic; organization theory; construction management; competitive environment.

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1. Introduction

Given the fluctuating market conditions that take place from a period of growth to a period of recession, many companies find it difficult to decide which strategies are most effective at the corporate level to sustain growth in conditions that change rapidly (Jung et al., 2012).

Unlike other industries sectors that had a strong impact on external competition, firms in the construction industry did not suffer the same competition experienced by others, even after the post-dictatorship economic and technological opening in Brazil. Previously, the competition in this sector was restricted to the domestic market and in an inexpressive way, so that the sale was always fulfilled. This made the entrepreneurs focus on meeting the technical and marketing requirements, with little concern for other variables of the organization (Vieira, 2006). However, in the face of a scenario of political uncertainties, reduced confidence, economic recession, rising unemployment and inflation, with Gross Domestic Product (GDP) falling by 7.6% in 2015 (CBIC, 2016), the construction industry situations require better results.

With these conditions of uncertainty, the pressure of these companies on the need to achieve better performance in shorter times has been challenging (Contador, 2010, p.457). For this reason, given the importance of this subject in the market, the article analyses the strategy influence and its consolidation in the company performance of the civil construction sector. This article aims to demonstrate that the more consolidated and better defined the strategy the better the organization development, measured by the variables presented throughout the work through descriptive statistical analysis. In this sense, the article contributes to the improvement of the organizations management performance, collaborating with the business sustainability in order to generate better results in the civil construction sector.

2. Studies related to the construction industry

Construction is an important industry in any economy. Therefore, competitive strategy must also be modified according to the variety of firms and changing environments (Ho, 2016). Given the global financial crisis and other free market conditions in 2008, the international construction market shifted from growth to recession. Many international contractors still find it difficult to decide on strategies that are most effective during volatile market conditions. Jung et al. (2012), studied 31 Korean contractors seeking to identify the strategies before and after the Asian recession of 1998-2002. The results of the strategies indicated that diversification in international markets is considered the most effective strategy to overcome a recession.

Zuo et al. (2015), interviewing 35 industry senior managers, concluded that the impacts of the 2008 global financial crisis on Australia's construction market has led many companies to reduce profit margins and expectations, and the need to retain people with skills needed to respond quickly to new opportunities in the future. In Malaysia, according to Lai et al. (2014), the results indicate that the crisis directly affected the profitability of the public construction companies studied, causing a sharp increase in the price of construction materials and fuel, requiring more prudent financial management and the strategy was to use internal diversification and expansion abroad to improve performance.

From this point of view, the development of corporate strategies is increasingly essential for sustainable growth in changing markets (Jung et al., 2012). The analysis of the literature on the subject shows that the common aspect of these publications is the clear relationship between the strategy and sustainability of construction companies. The need to analyse the market and seek strategic positioning is evident where markets are showing signs of recession.

3. Survey Planning

The methodological basis of the research used was the survey allied to the descriptive statistical analysis. The survey seeks to obtain information from a particular group of people or target population, by means of a predefined research instrument, usually a questionnaire (Hair Jr. et al., 2005).

The research consisted of companies with activities related to civil construction, located in Curitiba and metropolitan region in Brazil. About 450 companies were previously contacted and invited to participate in this research and 125 companies responded. Data collection lasted eight months, from November 2013 to July 2014. By the number of respondents we chose the non-probabilistic sampling method, involving the selection of sample elements that are more available to provide the necessary information for the study (Hair Jr. et al., 2005). Thus, because this sample is not representative of the target population, it is not possible to extrapolate and generalize about the results.

In this research, the work of Porter (1989) was taken into account. In order to simplify the analysis, these variables were divided into two homogeneous groups and three constructs, as shown in Table 1. The first group of variables is formed by the independent variables. In this group, the "value" of the variables is the result of a choice made by those who have power within the companies. This group is formed by Strategy and Strategic Management. The second group, which represents the dependent variables, is formed by the result of the strategy, that is, the variables resulting from the strategies and management strategies adopted. These variables sought to reflect the level of definition of the strategy, how the strategic management is done and the results obtained by the way the organization operates. With respect to the quantitative measurement of the characteristics, the

semantic differential scale was adopted (Osgood, 1952), where each evaluated item is polarized by two opposite terms at the ends, distanced by seven points. In the example case presented in Figure 1, the closer to result 1 to question 1, the more centralized the organizational structure of the company.

Table 1. Variables related to the characteristics of the organization

Group	Construct	Variables
Independent variables	Strategy	60 - Company has vision and strategic positioning
	Strategy management	58 - Performs environmental analysis
		59 - Performs analysis of customer needs
		61 - Performs internal performance analysis based on targets and / or indicators
Dependent variables	Result of strategy	90 - Management of the organizational performance strategy through performance evaluation and benchmarking processes
		38 - Company growth rate in the last three years
		44 - Position of the company in relation to the currents
		50 - Level of knowledge of employees in relation to management strategies adopted by the company
		55 - Alignment of the characteristics of the enterprises, products and services in relation to the strategy

The semantic differential method is easy to answer and understand, but the use of these scales has subjectivity depending on how the question is asked and the importance of the questions to the respondents (Samartini, 2006) and on the difficulty of finding opposing adjectives (Hair Jr et al., 2013). Thus, the final results obtained should be analyzed as trends and not as absolute values.

Question	Scale
1 What is the level of centralization of the company's organizational structure?	Centralized 1 2 3 4 5 6 7 Decentralized

Figure 1. Example of the semantic differential scale

4. Results

The objective is to analyse how the consolidation of the strategy affects the company's management and its result through the variables listed in the previous chapter. The reference variable used to analyse the level of strategy consolidation was item 60 of the questionnaire (Does the company have a well-defined strategic vision and position?), in which it is possible to verify if the definition and

consolidation of the strategy guide and influence the other variables analysed in the study.

4.1 Analysis of independent variables

The group of independent variables is determined by decision of each company. This group is subdivided in two constructs: Strategy and Strategic Management, and the study relate the Strategic Management of the company in function of the Strategy.

In the research, the Strategy Management construct is defined by analysing the environment in which it operates, analysing the clients' needs, analysing their internal performance with strategic indicators and goals, and strategically managing their organizational performance through evaluations performance and benchmarking. Figure 2 show the boxplot graph of performance analysis and customer need analysis, respectively, as a function of strategy consolidation, with the minimum strategic position 1 (non-existent process - no strategy defined) to the maximum strategic position 7 (highly defined process - clear definition of vision and strategic positioning).

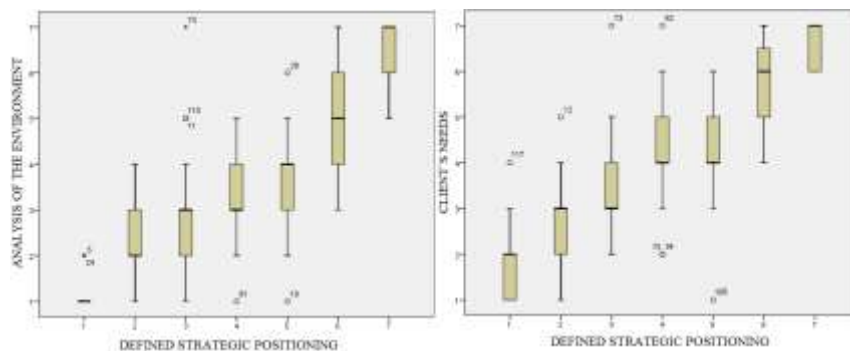


Figure 2. Boxplot of analysis of the environment and the analysis of the client's needs, respectively, as a function of strategy consolidation

The graphs show that as the consolidation of the strategic position increases, the organization tends to carry out analyses of the environment in which it operates and to analyse the customers' needs. In organizations where strategic positioning is highly developed, the median reaches its maximum value in relation to environmental and customer analyses.

It can be noticed that the most divergent results regarding the hypothesis of study were those of companies 19 and 81 that, despite having developed vision and strategic positioning, do not do any analysis of environment. Regarding the analysis of customer needs, the most divergent results, considering the general trend, were those of companies 34, 75 and 108 that have a strategic process developed, but do not analyse the clients' needs.

Following the analyses, Figure 3 demonstrates the analysis of internal performance based on goals and / or indicators and organizational performance

through performance evaluation and benchmarking, respectively, as a function of strategy consolidation. The graphs show a strong trend of concern with performance as the strategic position becomes more defined.

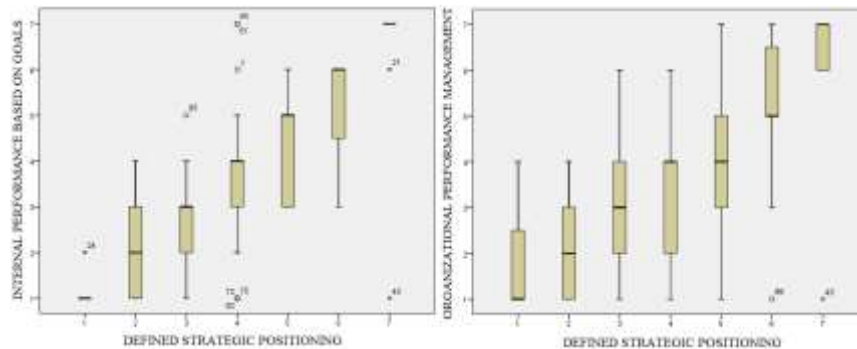


Figure 3. Boxplot of analysis of internal performance based on goals and / or indicators and organizational performance through performance evaluation and benchmarking, respectively, as a function of strategy consolidation

The most divergent results were those of companies 43, 72, 75, 82 and 88, in which the 43, despite having highly developed vision and positioning, did not use indicators and goals and did not evaluate organizational performance.

4.2 Analysis of dependent variables

The group of dependent variables is formed by organizational factors that reflect the decisions made by the company in relation to its organization and functioning. In the research, the Result of strategy construct is defined by the company's growth rate, the company's position in relation to its competitors, the level of knowledge of the employees in relation to the management strategies adopted and the alignment of the characteristics of the enterprises, products and services in Strategy.

The data show that the more defined the vision and the strategic positioning, the greater the growth trend of the company. This conclusion can also be observed by Figure 4, boxplot graph. This result emphasizes the importance of strategy in organizations, bringing positive financial returns to well-positioned companies.

In the same way, Figure 5 show that for companies with more consolidated strategies, better align the characteristics of the projects, products and services with the strategy adopted. This underscores the competitive advantage importance and the difference between a positioned organization and an organization that has no defined strategy, with the possibility of market gain.

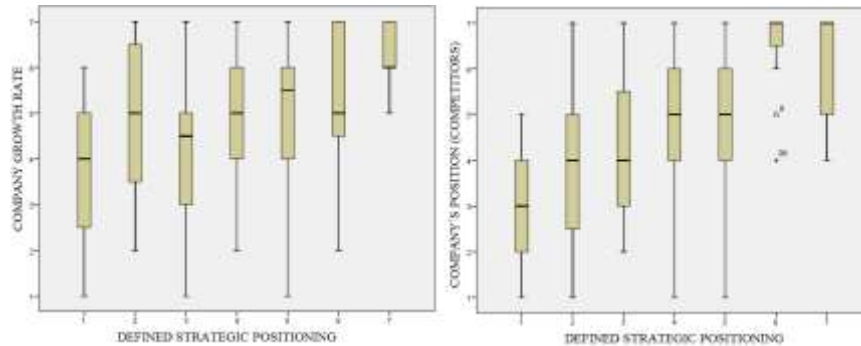


Figure 4. Boxplot of company growth rate and company's position in relation to its competitors, respectively, as a function of strategy consolidation

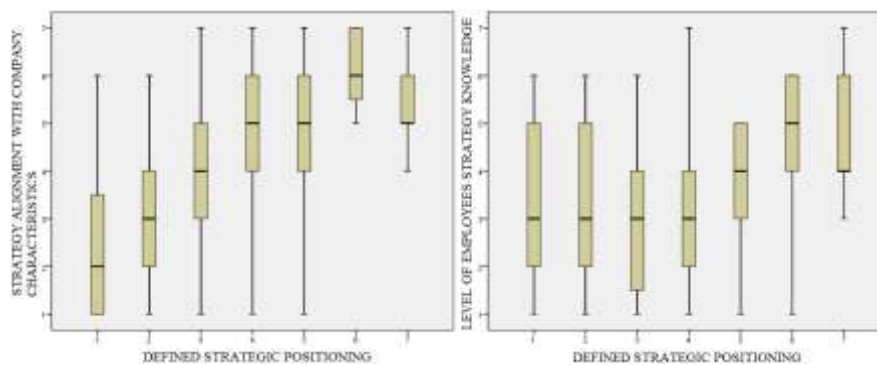


Figure 5. Boxplot of strategy alignment with the company characteristics and level of employees' strategy knowledge, respectively, as a function of strategy consolidation

However, in the case of Figure 5, it is not possible to determine that the strategy position has a clear relation with the level of knowledge of the employees in the company strategy. The graph demonstrates a slight trend in employee knowledge to companies with better strategy definition, but it is not a clear conclusion, demonstrating that there is room for change and disclosure of goals for better financial results and organizational performance. According to Camargos and Dias (2003), considering that the strategy evolves continuously, it must be known to all employees ensuring participation in its implementation.

5. Conclusions

Regarding the strategy, the analysis of the independent variables made it possible to conclude that the more highly defined the vision and the strategic positioning, the higher are the analyses of both the environment in which the company operates and the analyses of the clients' needs. There are also more developed analyses of goals and / or indicators and strategic management of organizational

development. The behaviour of the dependent variables shows that the highly developed strategy position generates great results in the growth rate of the company, its position in relation to its competitors and in the alignment of the characteristics of the enterprises, products and services. However, in relation to the level of knowledge of the employees about the strategy, there is little relationship between a consolidated strategic position and the knowledge of the employees, generating a possibility of gaining results if goals are better disclosed.

References

- Camargos, M. A. de e Dias, A. T. (2003) *Estratégia, administração estratégica e estratégia corporativa: uma síntese teórica*. Caderno de Pesquisas em Adm, São Paulo, v. 10, nº 1.
- CBIC – Câmara Brasileira da Indústria da Construção Civil (2016) PIB 2015. Available on: <<http://www.cbicdados.com.br/menu/home/pib-2015>>. Accessed in April 2016.
- Contador, José Celso (2010) *Gestão das Operações – A Engenharia de Produção a serviço da modernização da empresa*. São Paulo. Edgard Blücher Ltda.
- Hair, Jr., J. F.; Babin, B.; Money, A. H. Samouel, P. (2005) *Fundamentos de métodos de pesquisa em administração*. Porto Alegre: Bookman.
- Ho, P. H. K. (2016) Analysis of Competitive Environments, Business Strategies, and Performance in Hong Kong's Construction Industry. *J. Manage. Eng.*, 32(2): 04015044.
- Jung, W.; Han, S. H.; Koo, B. Jang, W. (2012) Which Strategies Are More Effective for International Contractors during Boom and Recession Periods? *Journal of Management in Engineering*, July.
- Lai, H. Y.; Aziz, A. R. A. Chan, T. K. (2014) Effect of the global financial crisis on the financial performance of public listed construction companies in Malaysia. *Journal of Financial Management of Property and Construction*, Vol. 19 ISS 3, pp. 246 – 263.
- Osgood, C. E (1952) The nature and the measurement of meaning. *Psychological Bulletin*. University of Illinois. Vol 49, No 3.
- Porter, M. (1989) *Vantagem competitiva: criando e sustentando um desempenho superior*. Rio de Janeiro: Elsevier.
- Samartini, A.L.S (2006) *Comparação entre métodos de mensuração da importância de atributos em produtos e serviços*. GV – pesquisa. São Paulo.
- Vieira, Helio Flavio (2006) *Logística Aplicada à Construção Civil – como melhorar o fluxo de produção nas obras*. São Paulo: Editora Pini.
- Zuo J.; Zillante, G.; Xia, B.; Chan, A. Zhao, Z. (2015) How Australian construction contractors responded to the economic downturn. *International Journal of Strategic Property Management*. Volume 19(3), pp 245–259.

Technology and science investments, universities, and intellectual property analysis on the Brazilian South região

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Abstract This paper sheds light on the current scenario of technology-based incubators in South Brazil from a socioeconomic and intellectual perspective. The objective was achieved by drawing upon correlation analysis with the following variables: higher education institutes with *stricto sensu* graduate programs, intellectual property rights and investments in science and technology. The study focused on the Brazilian South region since it presents some of the best social indicators in the country when compared with other Brazilian regions. Based on correlation analysis, it was possible to investigate an outstanding scenario in developed nations, the technology-based entrepreneurship.

Keywords: Technology-Based Incubators; Socioeconomic Indicators; Intellectual Property; Investments in Science and Technology.

1. Introduction

Since the middle of the last century, people and organizations have faced technological, cultural, social and economic changes (Scarano et al., 2014). In this context, there are markets that need to adapt to these new conditions in order to maintain competitiveness, such as the technology-based firms (TBFs). These enterprises aim to adopt new technologies available in Research and Development (R&D) institutions to make them useful for other agents, particularly the

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potentially motivated entrepreneurs who have clear projects for creating new industrial enterprises or services in TBFs (Lasrado et al., 2016).

The primary objective of incubators fits within their general purpose, which is to stimulate innovation and regional development, by providing entrepreneurs with basic infrastructures, financial resources, and different types of services and information necessary for creating start-ups (Mas-Verdú et al., 2015). Furthermore, incubators have the potential to provide TBFs with a competitive advantage and to bring economic growth to the country through institutionalized networks and efficient entrepreneurship education programs (Marvel et al., 2016). Thereby, universities and research centers have been the key to the development of technology similar to that of large companies in terms of technological upgrading.

Thus, this paper aims to shed light on the current scenario of technology-based incubators (TBIs) in South Brazil by arguing that better socioeconomic indicators and a high level of intellectual production play a crucial role in shaping the growth and survival prospects of a firm as it progresses through its life course. For that, correlations were obtained among TBIs and the following aspects: Higher Education Institutes (HEIs) with *stricto sensu* graduate programs, intellectual property rights granted and investments in science and technology. The study focuses on the Brazilian South region which is composed of the following states: the Rio Grande do Sul, Santa Catarina, and Paraná, because this region presents some of the best social indicators in the country, with the best health indicators, the second biggest per capita income, and the highest index of human development.

2. Technology-based incubators

Technology-based incubators (TBIs) have spread around the world as a tool to accelerate the growth and survival of high-tech companies (Lasrado et al., 2016). They must be attentive to the specificities of each enterprise involved since they constitute a physical site where critical business resources are concentrated and made accessible to new venture owners for exploitation (Patton, 2014).

These organizations support the enterprises and make the connection between science, technology, education, knowledge, talent and business capital, embedding stakeholders such as universities, industries, research laboratories and investors (Mcadam M et al., 2016). In this sense, business incubators should stimulate technology transfer and disseminate products to develop innovative local companies in their early stages, creating and capturing value from them (Cesaroni; Piccaluga, 2016). Given that innovation is seen to play an important role in current economic policy and is the basis of technology-based firms (TBFs), the presence

of these companies in a region is important and needs to be supported in order to generate jobs and benefits for the communities (Deligianni et al., 2015).

3. Higher Education Institutes with *stricto sensu* graduate programs

Universities are a vital source of scientific knowledge and are strongly linked to public research institutes, providing knowledge and resources to innovative business, such as TBFs. These institutions can promote sustainable economic development even in structurally weak regions with poor financial performance (Löfsten, 2016). In Brazil, according to *Sistema de Informações Georreferenciadas* (2015), there are 3.302 higher education institutions with *stricto sensu* graduate programs, those that only include masters and doctoral degrees. From this total number, 708 are located in the southern states of the country, accounting for approximately 21,5% of Brazilian institutions with this profile.

Consequently, local economic interests are likely to develop connections to a university in hopes of benefiting from the human capital, innovation, and other resources it provides to the community. Similarly, the connections are positive for universities and serve as relevant assets to create TBIs (Lasrado et al., 2016). This information induces the belief that there is a positive relation between the existence of TBIs and the presence of HEIs with *stricto sensu* graduate courses in the municipalities belonging to South Brazil. Therefore, the following hypothesis is created:

Hypothesis 1. The existence of technology-based incubators (TBIs) is positively related to the presence of higher education institutes with *stricto sensu* graduate programs.

4. Intellectual Property

Intellectual Property (IP) is a bundle of legally recognized rights when ideas or inventions are protected. Among the several different types of legal rights for intangible assets, the most common list includes copyrights, patents, trademarks, and trade secrets (Oh; Matsuoka, 2016). In Brazil, according to the National Institute of Intellectual Property (Brasil, 2015), in the period between 2000 and 2012, 505.206 intellectual property rights were granted, including patents of invention, utility models, certificates of addition, trademarks, industrial designs, licenses of technology, and computer programs. Intellectual property rights are recognized for contributing to the dissemination of new technologies, stimulating

the diffusion of knowledge and raising the competitive strategy of firms (Brüggemann et al., 2016).

The national average of intellectual property rights granted in the same time interval is 1.439, while the average presented by the South of the country is 2.828. This index indicates that the states of the South region had a level of IP rights approximately 97% higher than the other Brazilian states (Brasil, 2015). Specifically, in South Brazil, 21,83% of the concessions are distributed among its three states as follows: 7,65% in Rio Grande do Sul, 6,22% in Santa Catarina and 7,95% in Paraná. In this sense, it is inferred that there is a positive relation between the existence of TBIs and production of intellectual property in the municipalities of the South region of the country. Therefore, the following hypothesis is made:

Hypothesis 2. The existence of technology-based incubators (TBIs) is positively related to high levels of intellectual production.

5. Investments in science and technology

A company must continually restructure its administrative organization and cooperate with the government, universities and research institutes to remain competitive (Jiao et al., 2016). Also, technology is an important asset for many firms, sustaining growth and retaining competitive advantages. It is articulated through research and development, which plays a significant role in determining a firm's technology position in the intense and competitive market (Wang J et al., 2015).

The Ministry of Science, Technology and Innovation (MCTI), with the incorporation of two of the most famous Brazilian development agencies – Financing of Studies and Projects (FINEP) and National Council for the Scientific and Technological Development (CNPq) – began the implementation of programs and actions that consolidate the National Science, Technology and Innovation Policy (Mendes et al., 2013). In addition, the government has encouraged cooperation between companies and research institutions through the Brazilian Enterprise for Research and Industrial Innovation (EMBRAPII, 2015), which focuses on business demand, using the infrastructure of research institutions.

The average of investment by FINEP, CNPq, and EMBRAPII during the period from 2000 to 2015 amounts to R\$ 1.454.261.945,67 in Brazil, while in the South this amount is about R\$ 292.851.600,00 (Brasil, 2016; EMBRAPII, 2015). These data indicate that the Southern region receives investments in science and technology from these development agencies corresponding to 20,14% of the amount invested in the country. Therefore, a positive relation can be seen between investments in science and technology and the existence of institutions that aim to

develop these new ideas that arise from research and development. Hence, to elucidate this consideration, the authors hypothesize the following relation:

Hypothesis 3. States that receive more investments in science and technology have a positive relation with the existence of technology-based incubators (TBIs).

6. Methodology

This empirical research is classified as correlational because it summarizes results expressing the relation between two variables (Rovine; Eye, 1997), and recognizing the intrinsic linearity of the method. Figure 1 demonstrates the research steps.

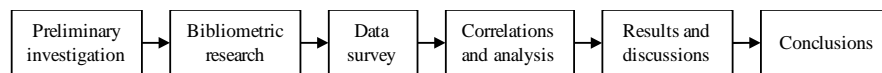


Figure 1. Research steps.

The study started with a preliminary investigation about the theme, by conducting searches in online journals and platforms, to identify current publications about TBFs associated with socioeconomic indicators and intellectual production.

The second part consisted of filtering information through keyword searches, based on the research issues. Through this approach, bibliometric selection and analysis of the articles were made in referenced databases such as ScienceDirect and Web of Science, with the keywords “technology-based incubators; technology-based firms; socioeconomic indicators; correlation; incubated firms; intellectual property; post-graduation; investment in science and technology”, as well as combinations of these terms. The considered period was from 2011 to 2016, taking into account the most relevant papers and co-occurrences of the terms in the title and abstract. The selection process generated a final database of 67 articles.

The third part consisted of a search of higher education institutes and courses on the e-MEC register, an electronic system for monitoring processes that regulate higher education in Brazil, to verify which HEIs are recorded, where they are located, and lastly, the technology-based incubators linked to these institutions were identified. Besides that, a survey on the website of EMBRAPPII and in the Aquarius Platform of MCTI was made. The survey was about the investment in science and technology made by CNPq, FINEP, and EMBRAPPII in all Brazilian states, especially in the Rio Grande do Sul, Santa Catarina, and Paraná.

On the National Institute of Intellectual Property (INPI) website, the number of IP rights granted to all the municipalities of the South region was researched from 2000 to 2012. On the Sucupira platform, supported by Coordination of Improvement of Higher Education Personnel (CAPES), HEIs with *stricto sensu*

graduate programs (with masters and doctorate programs) in South Brazil and in the other Brazilian states were searched.

In the fourth step, the Statistica software was used and, from the database, matrices and correlation graphs were generated to analyze the variables association, considering 95% of reliability. Correlations were made relating the number of TBIs to the following aspects: the number of HEIs, the index of IP rights granted and the investments in science and technology by FINEP, CAPES, and EMBRAPPII - all variables related to the cities with TBIs in the South Brazilian region.

The fifth step refers to correlation analysis, which consists of statistical estimates of the linear coefficient of association, a measure of the relationship degree between two variables. The correlation was considered positive when the phenomena varied in the same sense, whereas it was negative when the phenomena varied in the opposite direction, regarding confirm or reject the hypotheses.

7. Results and discussions

In the H1 hypothesis, the correlation degree found was 0,87344. It demonstrates a strong relation between the existence of TBIs and HEIs with *stricto sensu* graduate programs. Fritsch and Aamoucke (2013) state that universities collect, generate, and store knowledge and make it available in the region, by providing innovation-related services and by cooperating with private firms. This correlation association indicates that the TBIs in South Brazil make use of universities resources available. However, after decades of research, it seems that many business faculties and most business Ph.D. students know considerably more about academic publishing and sophisticated statistical techniques than problems of the workplace, which are deeply related to the entrepreneurial activity (Marvel et al., 2016).

For the H2 hypothesis, the correlation analysis between TBIs and the levels of IP activity resulted in a positive and strong degree (0,76376). Based on the assumptions that: (a) the government in developing countries is responsible for designing appropriate policies for the development of their countries and their people (Salami; Soltanzadeh, 2012), such as Brazil, and (b) governments are responsible for the creation and modification of the constituent structures in an innovation system (Padilla-Pérez; Gaudin, 2014), e.g. universities, it is necessary to mention that the discussions on this topic tend to be politically biased. At the same time, it is important to highlight that Brazil has diverse regional characteristics, caused by its large territorial extension and lots of different actors involved, including from the private initiative. These actors collaborate effectively to obtain a good performance in TBIs projects on universities.

The H3 hypothesis resulted in a positive very strong correlation degree (0,97293) between TBIs and investments in science and technology. That is, cities with TBIs are very highly related to higher investments in science and technology. According to Marvel et al. (2016), investments in science and technology foster technological changes, which lead to regulatory changes, and alter the *status quo* of subjects and objects involved in the context - in this case, positively. The available infrastructure for R&D activities in HEIs, such as TBIs, is the driving force of business and regions development capacity (Minguillo et al., 2015), reflecting the importance of public and private investment in science and technology.

8. Conclusions

The level of academic activity in *stricto sensu* graduate programs and the level of IP show strong correlation degrees with TBIs, and this implies considerations related to human capital and commercial affairs. The idea of commercialization is sometimes associated to that of raising additional funds, a recurrent gap on these enterprises but in spite of that, there are the technological transfer agencies, which aim to provide local and regional economic development (Cesaroni; Piccaluga, 2016). For the authors, universities should facilitate the implementation and operation of agencies for the transfer of knowledge through bilateral agreements with TBIs because these agencies only gain some financial profit from the commercialization of their inventiveness, which facilitates the negotiation with TBFs.

While human capital impacts entrepreneurial outcomes, the ability to acquire appropriate human capital and the turbulence of the environment are important considerations (Marvel et al., 2016). Such assertion indicates that negotiations are based on a high level of human capabilities, expertise, and intuition. If negotiations are being conducted, it is because there is enough human capital and technological standards being developed in the Brazilian South region.

The very strong correlation between investments in science and technology and TBIs agrees that, in recent years, Brazil has been able to play an increasingly important role in international trade, production, and innovation (Lasrado et al., 2016). The study also ratifies Ponomariov and Toivanen (2014)'s affirmation that a central theme in the analysis of emerging economies is the importance of cultivating enhanced internal capacities in science, technology, and innovation.

References

- Brasil. Instituto Nacional da Propriedade Intelectual – INPI (2015) Anuário Estatístico de Propriedade Industrial: 2000-2012. Available via <http://www.inpi.gov.br/estatisticas/anuario-estatistico-de-propriedade-industrial-2000-2012-pc2#pc>. Cited 21 Sept 2016
- Brasil. Ministério da Ciência, Tecnologia e Inovação – MCTI (2016) Plataforma Aquarius. Available via <http://aquarius.mcti.gov.br/app/home/>. Cited 04 Oct 2016.
- Brüggemann J, Crosetto P, Meub L, Bizer K (2016) Intellectual property rights hinder sequential innovation: Experimental evidence. *Research Policy*, doi: 10.1016/j.respol.2016.07.008
- Cesaroni F, Piccaluga A (2016) The activities of university knowledge transfer offices: towards the third mission in Italy. *The Journal of Technology Transfer*, doi: 10.1007/s10961-015-9401-3
- Deligianni J, Voudouris I, Lioukas S (2015) Growth paths of small technology firms: The effects of different knowledge types over time. *Journal of World Business*, doi: 10.1016/j.jwb.2014.08.006
- Empresa Brasileira de Pesquisa e Inovação Industrial – EMBRAPPI (2015) Plano Diretor 2014-2019. Available via <http://embrappi.org.br/categoria/institucional/quem-somos/>. Cited 04 Oct 2016
- Fritsch M, Aamoucke R (2013) Regional public research, higher education, and innovative start-ups: an empirical investigation. *Small Business Economics*, doi: 10.1007/s11187-013-9510-z
- Jiao H, Zhou J, Gao T, Liu X (2016) The more interactions the better? The moderating effect of the interaction between local producers and users of knowledge on the relationship between R&D investment and regional innovation systems. *Technological Forecasting and Social Change*, doi: 10.1016/j.techfore.2016.03.025
- Lasrado V, Sivo S, Ford C, O’Neal T, Garibay I (2016) Do graduated university incubator firms benefit from their relationship with university incubators? *The Journal of Technology Transfer*, doi: 10.1007/s10961-015-9412-0
- Löfsten H (2016) Business and innovation resources. *Management Decision*, doi: 10.1108/MD-04-2015-0139
- Marvel M R, Davis J L, Sproul C R (2016) Human capital and entrepreneurship research: a critical review and future directions. *Entrepreneurship Theory and Practice*, doi: 10.1111/etap.12136
- Mas-Verdú F, Ribeiro-Soriano D, Roig-Tierno N (2015) Firm survival: The role of incubators and business characteristics. *Journal of Business Research*, doi: 10.1016/j.jbusres.2014.11.030
- Mcadam M, Miller K, Mcadam R (2016) Situated regional university incubation: A multi-level stakeholder perspective. *Technovation*, doi: 10.1016/j.technovation.2015.09.002
- Mendes D R F, Oliveira M A C, Pinheiro A A (2013) Política Nacional de Ciência, Tecnologia e Inovação: avaliação do marco regulatório e seus impactos nos indicadores de inovação. *Revista de Empreendedorismo e Gestão de Pequenas Empresas*, 2/1: 22-46
- Minguillo D, Tijssen R, Thelwall M (2015) Do science parks promote research and technology? A scientometric analysis of the UK. *Scientometrics*, doi: 10.1007/s11192-014-1435-z

- Oh C, Matsuoka S (2016) Complementary approaches to discursive contestation on the effects of the IPR regime on technology transfer in the face of climate change. *Journal of Cleaner Production*, doi: 10.1016/j.jclepro.2015.09.050
- Padilla-Pérez R, Gaudin Y (2014) Science, technology and innovation policies in small and developing economies: the case of Central America. *Research Policy*, doi: 10.1016/j.respol.2013.10.011
- Patton D (2014) Realising potential: The impact of business incubation on the absorptive capacity of new technology-based firms. *International Small Business Journal*, doi: 10.1177/0266242613482134
- Ponomariov B, Toivanen H (2014) Knowledge flows and bases in emerging economy innovation systems: Brazilian research 2005-2009. *Research Policy*, doi: 10.1016/j.respol.2013.09.002
- Rovine M J, Eye A (1997) A 14th way to look at a correlation coefficient: correlation as the proportion of matches. *The American Statistician*, doi: 10.2307/2684692
- Salami R, Soltanzadeh J (2012) Comparative analysis for Science, Technology and Innovation policy; Lessons learned from some selected countries (Brazil, India, China, South Korea and South Africa) for other LdCs like Iran. *Journal of Technology Management & Innovation*, doi: 10.4067/S0718-27242012000100014
- Scarano T F, Siluk J C M, Nara E O B, Neuenfeldt Junior A L, Da Fontoura F B B (2014) Diagnóstico do desempenho organizacional em empresas do setor metal mecânico. *Espacios*, 35/3: 18
- Sistema de Informações Georreferenciadas (2015). Distribuição de Programas de Pós-graduação no Brasil por Estado. Available via <http://geocapes.capes.gov.br/geocapes2/>. Cited 27 Sept 2016
- Wang J, Wang C-Y, Wu C-Y (2015) A real options framework for R&D planning in technology-based firms. *Journal of Engineering and Technology Management*, doi: 10.1016/j.jengtecman.2014.12.001

Frequency and Quality of Vertical Communication in New Product Development

Felekoglu B¹

Abstract Vertical communication between management and project team in developing new products is important. This study investigates the frequency and quality of the vertical communication in new product development (NPD) projects. Data is collected for 86 NPD projects using a survey. Findings indicate that different means of communication are used in different frequencies between managers and team members. The majority of respondents reported a high quality communication between top management and NPD team. However, some NPD projects were reported to suffer from poor timing, reliability and accuracy of this communication. On average, communication between top management and NPD team more included topics which were relevant to both parties than it was timely. Change in quality and frequency of communication between top management and NPD team by company size and NPD process structure are also reported.

1. Introduction

Developing successful new products is an important strategic issue for many firms today. One of the success factors of new product development is effective communication not only within the new product development (NPD) team members but also between the NPD team and management. Most studies exploring communication in NPD focus on the relationships between functional groups or the relationships within the NPD team. However, vertical communication between top management and NPD team has not been investigated in detail.

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2. Vertical Communication in NPD and Aim of this Study

Past research on internal interactions in NPD investigated communications in a functional group such as R&D, between dyadic functional groups such as R&D and marketing (e.g. Gupta et al., 1985; Griffin and Hauser, 1996; Perks et al., 2010), R&D and manufacturing (e.g. Crittenden et al., 1993); and between a variety of functions (e.g. Brettel et al., 2011; Pinto and Pinto, 1990; Song et al., 1997). However, there are also vertical communications in NPD between top management and NPD team members. Further work is needed to better understand the complex communications between senior management and employees (Pincus et al., 1991). However, very few studies focused on this critical communication boundary in NPD (e.g. Ancona and Caldwell, 1992; Richtner and Ahlstrom, 2010).

This study focuses on this vertical communication boundary and aims to investigate the communication between top management and NPD team using cross-sectional data by looking at the frequency and quality of this communication since these two parameters are frequently considered as dimensions of managerial communication.

3. Methodology and Findings

Data was collected for 86 NPD projects using a survey and analyzed using descriptive statistics and ANOVA. Quality of communication between the NPD team and the top management was measured with seven items which were adapted from Sarin and O'Connor (2009). To measure the frequency of communication between the NPD team and the top management, a comprehensive list of communication mechanisms was generated based on Felekoglu and Moultrie (2013)'s study. Respondents were asked to base their answers on a new product development project that has been completed within the last three years where they were the project manager.

Descriptive Information: Descriptive questions were included in the survey to get information on the size (in terms of full-time employees), turnover, sector and NPD process structures of the companies.

Company size and turnover: Respondents were asked to indicate the number of full-time employees in their companies (or strategic business units). The size bands used were small and medium sized companies (SME) (less than 249 employees) and large companies (more than 250 employees). Among the sample, 64 companies (75 %) were SMEs having less than 250 full-time employees and 21 companies (25 %) were large companies with equal to or more than 250 full-time employees (See Table 1). The annual sales volume of the 38 companies (45 %)

were less than £10 million and 47 companies (55 %) were equal to or more than £10 million (See Table 1).

Table 1. Descriptive information on the company size and turnover

	Company Size (Full-time employees)	Turnover (M£)
Distribution	Less than 50	28
	50 --- 249	36
	250 --- 499	11
	More than 500	10
	Less than 3	20
	3 --- 9	18
	10 --- 49	24
	More than 50	23

Sector: The sample covered a range of sectors including industrial equipment and machinery (27 companies); high-tech (25 companies); chemicals, pharmaceuticals, biotech & medical (11 companies); consumer products (12 companies); aerospace and automotive (7 companies) and others (3 companies) (See Fig. 1).

NPD process structure: The project managers were asked to indicate if the NPD team followed a formally documented NPD process in the given project. The percentage distribution of the responses is shown in Fig. 2.

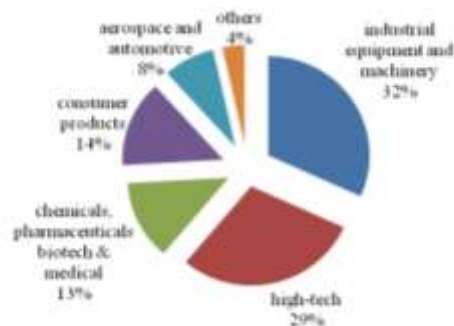


Figure 1. Distribution of companies by sector

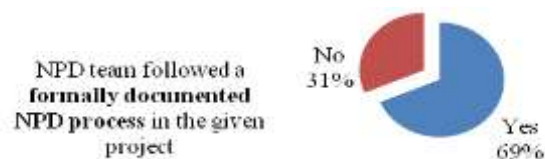


Figure 2. Distribution of companies by NPD process structure

Frequency of communication between top management and NPD team: Communication between top management and NPD team is important in NPD projects. One of the attributes of this communication is its frequency. In this study, the following question was asked to obtain information on the frequency of communication between top management and NPD team: *Please indicate how frequently top management and your team communicated using the following*

mechanisms over an average three month period in this project: (Never, Rarely, Once in 3 Months, Monthly, Weekly, Every 2-3 Days, Daily)

- Face-to-face ad-hoc conversations
- Regular review meetings
- Written documents (e.g. project plans, reports, authorisation forms)
- Telephone
- E-mail
- Instant message
- Video conference
- Project website
- Company Intranet
- Physical notice board
- Company newsletter
- Other (Please specify)

Fig. 3 shows the frequency of communication between top management and NPD team. As shown in this figure, e-mail is mostly used daily, face-to-face communication happens mostly in every 2-3 days, telephone is mostly used weekly, regular review meetings and written documents mostly used monthly.

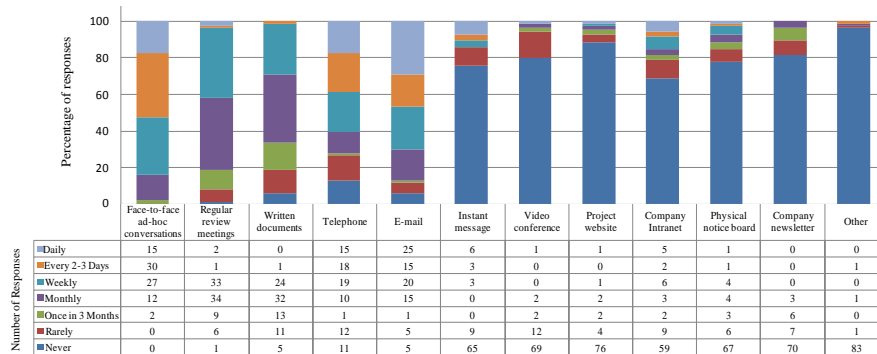


Figure 3. Frequency of communication between top management and NPD team

Fig. 4 shows the average frequency of use of different communication mechanism between top management and NPD team. As seen in this figure, there is a relative frequency of the use of five mechanisms such as face-to-face ad-hoc conversations, e-mail, telephone, regular review meetings and written documents, when top management and NPD teams communicate.

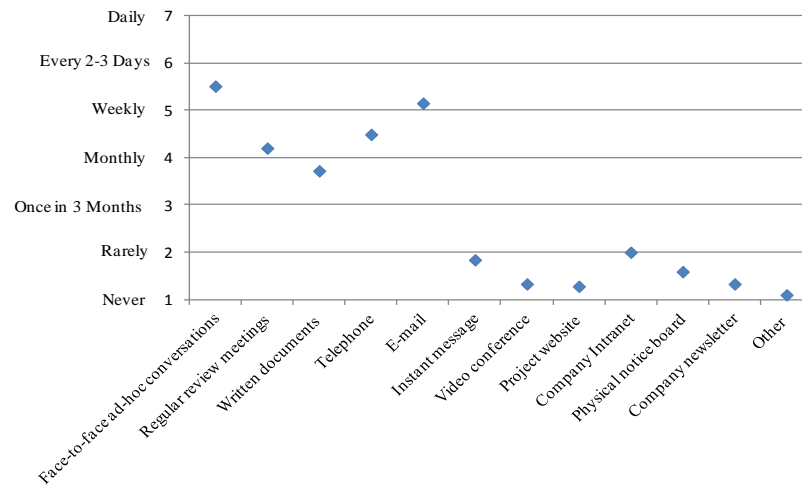


Figure 4. Average frequency of use of different communication mechanisms between top management and NPD team

Quality of communication between top management and NPD team: Quality is another important attribute of the communication between top management and NPD team. In this study, the following question was used to obtain information on the quality of communication between top management and NPD team on a five-point Likert scale: *Communication / information exchanged between our team and top management...*

- *was reliable*
- *was easy to comprehend*
- *was detailed enough to be useful*
- *was accurate*
- *was “actionable”*
- *was timely*
- *included topics which were of relevance to both our team as well as top management*

Fig. 5 shows the quality of communication between top management and NPD team from seven aspects. As seen in this figure the majority of the respondents reported a high quality communication between top management and NPD team. However, some NPD projects were reported to suffer from poor timing, reliability and accuracy of this communication. Fig. 6 illustrates that on average, the communication between top management and NPD team more included topics which were relevant to both parties than it was timely.

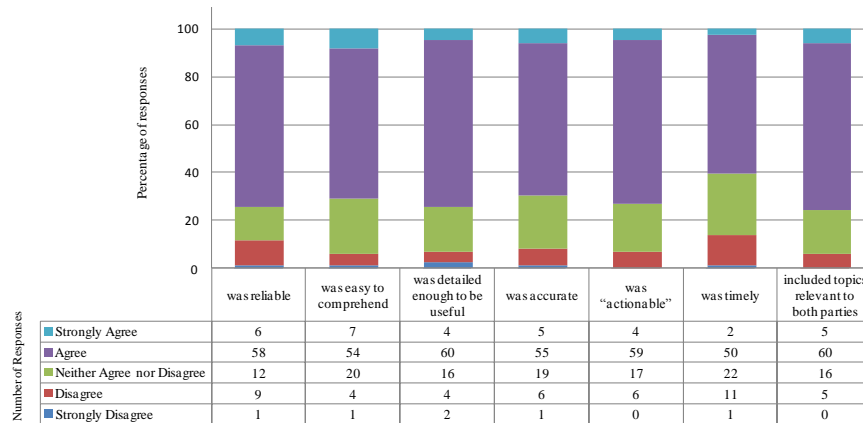


Figure 5. Quality of communication between top management and NPD team

Quality and frequency of communication between top management and NPD team by company size and NPD process structure: The quality and frequency of communication between top management and the NPD team in SMEs and large companies is compared. A comparison for the frequency of communication between companies, which followed a formally documented NPD process and those, which did not, is also performed.

Company size: For a better understanding of the difference between SMEs and large companies in terms of the nature of communication between top management and NPD team, group comparisons were performed. Fig. 7 shows the average quality of communication between top management and NPD team in SMEs and large companies. As seen in this figure, in large companies, the average quality of communication between top management and NPD team in terms of reliability, usefulness, and relevance is slightly higher than in SMEs. Fig. 8 shows the average frequency of use of different communication mechanisms between top management and NPD team in SMEs and large companies. From the most frequently used two communication mechanisms, e-mail comes first in large companies, while face-to-face conversations comes first in SMEs.

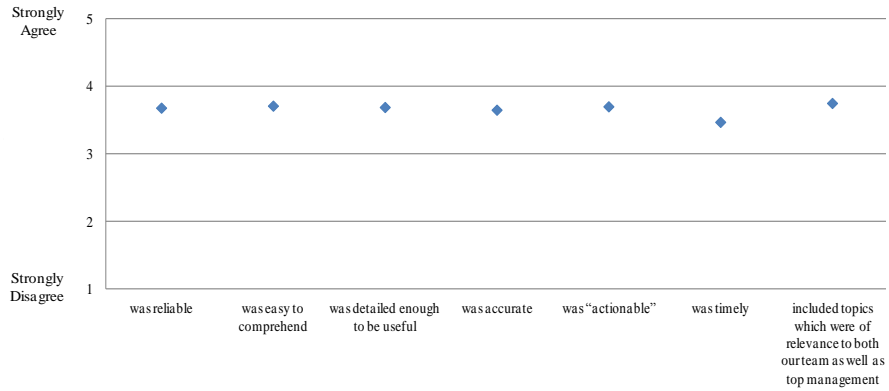


Figure 6. Average quality of communication between top management and NPD team

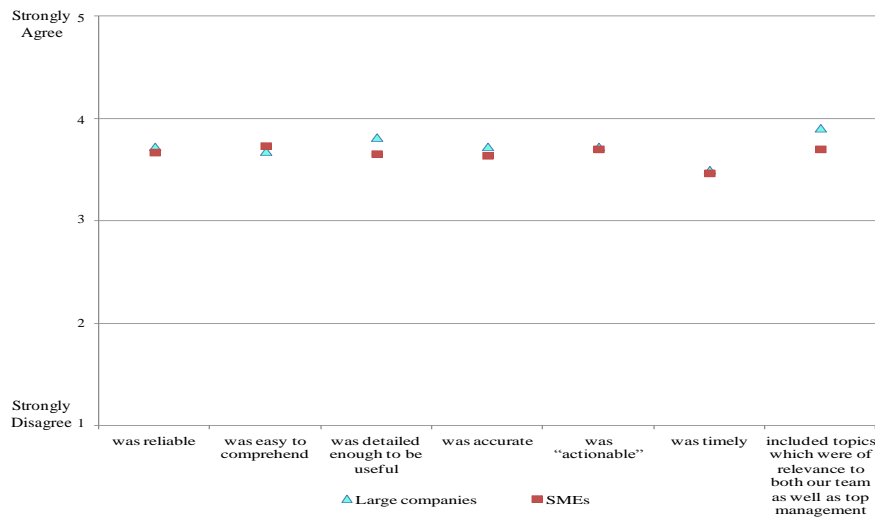


Figure 7. Average quality of communication between top management and NPD team in SMEs and large companies

Additionally, average frequency of use of written documents in large companies is higher than in small companies. Subsequent ANOVA analysis showed significant mean differences in the frequency of use of project website ($p < 0.05$) and company newsletter ($p < 0.05$) between SMEs and large companies.

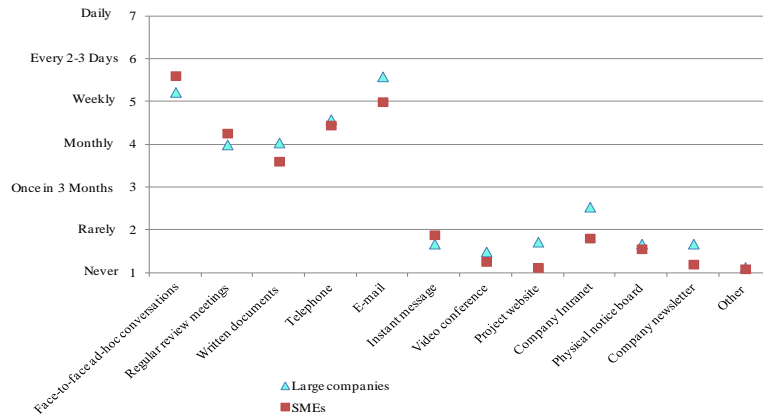


Figure 8. Average frequency of the use of communication mechanisms between top management and NPD team in SMEs and large companies

NPD process structure: NPD projects that followed a formally documented process and those that did not are compared in terms of the average use of various mechanisms in top management and NPD team communication. As shown in Fig. 9, in projects where a formally documented NPD process was not followed, on average, face-to-face ad-hoc conversations between top management and NPD team is higher than those where a formal process was followed. Additionally, the average use of written documents in projects where a formally documented NPD process was followed is higher than those where a formal process was not followed. Subsequent ANOVA analysis showed significant mean differences in the use of face-to-face ad-hoc conversations ($p < 0.1$), written documents ($p < 0.05$) and company newsletter ($p < 0.05$) between the NPD projects which followed a formal process and those which did not.

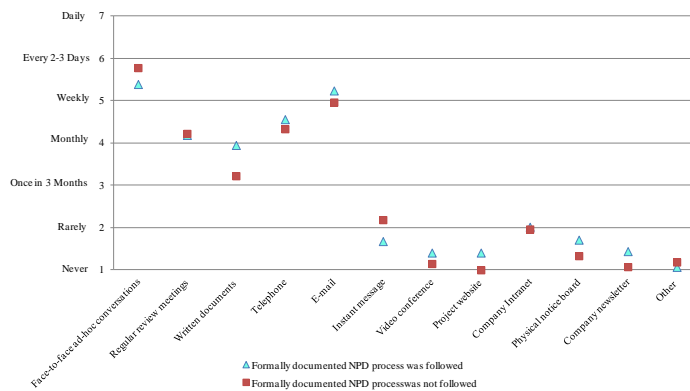


Figure 9. Average frequency of use of communication mechanisms between top management and NPD team in projects that followed a formally documented NPD process and those that did not.

4. Conclusion

In this study, frequency and quality of the vertical communication in new NPD projects using various communication mechanisms is investigated. It is seen that while the frequent use of e-mail and telephone is reflective of the advances in technology, face-to-face communication between the NPD team and top management still remains to be very important. Particularly, e-mail comes first among the most frequently used communication mechanisms in large companies, while face-to-face conversations comes first in SMEs. Additionally, there is evidence that the communication between top management and NPD team is not necessarily timely but tend to include topics which are relevant to both parties. In large companies, the average quality of communication between top management and NPD team in terms of reliability, usefulness, and relevance is slightly higher than in SMEs. In the case a formal NPD structure is followed, use of written documents is higher while face-to-face communication is lower than the case of not following a formal NPD structure.

References

- Ancona, D.G. and Caldwell, D.F. (1992). Bridging the Boundary - External Activity and Performance in Organizational Teams. *Administrative Science Quarterly* 37(4), 634-665.
- Brettel, M., Heinemann, F., Engelen, A. and Neubauer, S. (2011). Cross-Functional Integration of R&D, Marketing, and Manufacturing in Radical and Incremental Product Innovations and Its Effects on Project Effectiveness and Efficiency. *Journal of Product Innovation Management* 28(2), 251-269.
- Crittenden, V.L., Gardiner, L.R. and Stam, A. (1993). Reducing conflict between marketing and manufacturing. *Industrial Marketing Management* 22(4), 299-309.
- Felekoglu B. and Moultrie J. (2013) Interactions in New Product Development: how the nature of the NPD process influences interaction between teams and management. *Journal of Engineering and Technology Management*. 30(4), 384-401
- Griffin, A. and Hauser, J.R. (1996). Integrating R&D and Marketing: A Review and Analysis of the Literature. *Journal of Product Innovation Management* 13(3), 191-215.
- Gupta, A.K., Raj, S.P. and Wilemon, D.L. (1985). R-and-D and Marketing Dialog in High-Tech Firms. *Industrial Marketing Management* 14(4), 289-300.
- Perks, H., Kahn, K.B. and Zhang, C. (2010). The Nature of R&D-Marketing Integration in Chinese High-Tech Companies. *International Journal of Innovation Management* 14(1), 19-40.
- Pincus, D.J., Rayfield, R.E. and Cozzens, M.D. (1991). The Chief Executive Officer's Internal Communication Role: A Benchmark Program of Research *Journal of Public Relations Research* 3(1-4), 1-35.

- Pinto, M.B. and Pinto, J.K. (1990). Project Team Communication and Cross-Functional Cooperation in New Program-Development. *Journal of Product Innovation Management* 7(3), 200-212.
- Richtner, A. and Ahlstrom, P. (2010). Top management control and knowledge creation in new product development. *International Journal of Operations & Production Management* 30(10), 1006-1031.
- Sarin, S. and O'Connor, G.C. (2009). First among Equals: The Effect of Team Leader Characteristics on the Internal Dynamics of Cross-Functional Product Development Teams. *Journal of Product Innovation Management* 26, 188-205.
- Song, X.M., Montoya-Weiss, M.M. and Schmidt, J.B. (1997). Antecedents and Consequences of Cross-Functional Cooperation: A Comparison of R&D, Manufacturing, and Marketing Perspectives. *Journal of Product Innovation Management* 14(1), 35-47.

Motivating Factors for the Merger Process among Automotive Industry Organizations

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Abstract Faced with the economic changes, the organizations need to redefine their strategies in order to provide better market positioning. Among the strategies adopted by them, the strategic alliances, such as merger and acquisitions, allow the value proposition and reformulation of the business. One of the economic sectors that is most affected by cooperation processes is the automotive industry. Considering the importance of merger and acquisitions strategies for the Brazilian automotive sector, the aim of this research is to identify the motivating factors that determined the merger process, specifically, between two organizations of this sector. The research was carried out through a case study. Key findings are presented, that demonstrate that the merger strategy is driven by the joining of forces, overcoming obstacles, taking advantage of opportunities in order to achieve operational and economic efficiency.

Keywords: strategic alliances; merger; acquisitions; automotive sector.

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1. Introduction

The industrial scenario is undergoing intense transformations associated with globalization and, consequently, competitiveness. It deals with diversification challenge, improvement of service and product quality, cost reduction and technology development (Klotzle, 2002).

Cooperation strategies among organizations are applicable in that scenario. The practices related to this allow competitive advantages concerning cost reduction, investment optimization, innovation, flexibility and strengthening of companies in the market (Galerani, 2003). In this context, the strategies of feasibility and fundraising guide organizations to adopt strategic alliances as a way of developing themselves. Among the strategic alliances adopted by organizations, such as short- and long-term contracts, equity interest and joint ventures, mergers and acquisitions strategies allow efficiency gains and strategic rationality (Neary, 2004).

Merger and acquisitions are strategic alliances that guarantee the value proposition in order to reformulate the business environment of companies (Pessanha et al., 2012). From the merger and acquisition processes, organizations are able to acquire new assets, improve the managerial and technological base, increase liquidity for owners and shareholders, and seek opportunities for cost savings and greater profits (Ross et al., 2009).

An economy sector that is encouraged by cooperation agreements in pursuit of the competitiveness is the automotive industry (Techemayer, 2001). According to Vale; Pudo (2012), this industry is important in the economic scenario due to investments in productive structures, sectorial participation of the product, generation of employment and the consequent development of society. Saturation in developed markets drives organizations of this sector to seek new opportunities in emerging countries, such as Brazil (Senhoras, 2005), where merger and acquisition processes provide economic and business benefits.

Considering the importance of merger and acquisition strategies for the Brazilian automotive sector, the following question arises: what are the motivating factors for the establishment of merger and acquisition processes among organizations of automotive industry?

In order to contribute with the aforementioned issue, the aim of this paper is to identify the predominant factors that determined the merger process, specifically between two companies of the automotive sector located in Brazil. Thereby, this research seeks to verify the indicative aspects of value creation, performance and investment rationalization in the organizations involved.

The paper is structured as follows. Section 2 presents the background about merger and acquisition strategies. The third section presents the research methodology. Section 4 describes the outcomes of this research. Finally, section 5 presents concluding remarks.

2. Merger and Acquisition Strategies

Dhawan (2009) states that the merger and acquisition strategies are often conceptualized indistinctly. However, Santos et al. (2013) argue that they involve distinct operations and, therefore, it is important to differentiate the concepts of “merger” and “acquisition”.

The merger is a strategic combination between two or more organizations in order to attain only one legal entity, in which one of the organizations controls the new business (Tanure; Cançado, 2005). Mergers consist of a legal agreement between organizations that are subject to a common control by renouncing their autonomy and some peculiarities (Nakamura, 2005).

The acquisition is an operation in which one organization acquires the other that ceases to exist legally, i.e. the buying organization remains with its legal entity and the purchased organization is absorbed (Tanure; Cançado, 2005).

In accordance with Ross et al. (2009), the merger and acquisition process can be classified in four categories: horizontal - union among firms operating in the same industry; vertical - results from the union among firms that are part of the same production chain with potential or actual buyer-seller relationships; conglomerate - it involves firms operating in different industry; congener - the firms are from the same industry, but do not operate in the same business.

Merger and acquisition strategies can enable the companies to enter into new lines of activities, as it allow access to assets and additional knowledge that can be applied in different sectors (Pessanha et al., 2012).

3. Research Methodology

In order to achieve the aim of this research, a case study was carried out, which encompassed two organizations of the Brazilian automotive sector. One of them is the automaker (organization “X”) and the other is a first tier supplier of welded components (organization “Y”).

The case study adopted was unique and it had a quality-descriptive approach. Besides, the study had an exploratory approach. By means of that, the merger process between two companies could be analyzed and described in order to identify the main motivating factors which contributed to the cooperation strategy.

The case study was carried out by means of the documentary analysis of the economic and technical feasibility project related to the merger process. The analysis was performed in loco. For the analysis of data, the content-based analysis was applied to group the information and identify the predominant factors that guided the merger strategy. The steps of content-based analysis adopted were

based on the proposal of Bardin (2011). Thus, an interpretative analysis of the data was performed.

First, the reasons that led to study of the merger process were detected. Then, the scope of the project related to the merger process was analyzed. A comparative analysis of the budget before and after the merger was carried out, as well as the estimated return on investment. By means of that evaluation, the motivating factors were identified. Finally, the findings obtained were validated by the project manager responsible for the merger process of the organizations.

4. Results and Discussion

The merger strategy began to be considered by the organizations in 2015, when the economic crisis had a significant impact on business and resulted in falling sales of vehicles in Brazil. Through the partnership, it was verified the possibility of restructuring the planning process, supply, logistics, production and use of technologies. Also, the companies needed to increase profits with lower investments. The economic and technical feasibility project related to the merger process was initiated in 2015, and the changes in physical structures of companies, the alteration of fiscal flows, production scheduling, inventory process and other activities began to be carried out in 2016.

The main purpose of the project scope was to transfer the production operations performed in organization “Y” (first tier supplier) to the facilities of organization “X” (automaker). The operations of body welding, chassis welding and components welding that were performed in different installations, were relocated to a unique organizational structure. Besides the productive process, other processes impacted were: supply, logistics, industrial maintenance, information technology, work safety and the processes related to providing services. The main deliveries of the merger process included: transfer of facilities needed to the production and logistic processes, transfer of equipment for performing administrative activities (such as computers), and systemic adaptation concerning the data flows. Thus, it was necessary the integration of operational and administrative processes.

Basic premises were defined, such as the complete transfer of production operations in accordance with the project schedule and the production discontinuation of one of the models manufactured by the automaker. Strategic alliances also entail risks to the businesses. The main risks involved in the merger process between the organizations studied were related to the approval of new vehicle projects and the impact on vehicle projects in progress.

In the case study, the incorporation between the organizations was integral. For this reason, the estimated budget was analyzed considering two scenarios: without the merger and with the merger strategy, in which the results are presented in Fig. 1 and 2, respectively.

Department	May	June	July	August	September	October	November	December
Industrial	1.030.963	1.032.688	1.022.971	1.078.792	1.073.013	1.094.462	1.097.912	825.857
	1.911.065	1.982.953	1.973.020	1.995.877	1.953.612	1.892.454	1.889.722	1.958.123
	37.635	50.916	54.608	48.578	50.916	71.905	49.078	34.784
Supply	491.321	491.056	477.014	495.446	491.466	500.441	500.350	491.923
	60.374	65.397	67.374	68.284	66.440	78.646	77.339	50.288
	23.085	23.085	23.085	23.085	23.085	23.085	23.085	11.840
	5.009	5.009	5.009	5.009	5.009	5.009	5.009	5.608
Financial Management	854.485	846.937	849.869	856.531	857.361	865.740	891.768	1.480.641
	37.753	64.753	34.753	34.753	34.753	33.753	47.753	36.068
	26.502	26.502	23.533	25.204	24.388	26.502	26.502	20.585
	49.839	45.799	35.053	50.039	45.899	50.139	50.489	55.206
Total	4.528.033	4.635.095	4.566.289	4.681.599	4.625.941	4.642.137	4.659.009	4.970.923

Figure 1. Budget without the merger, in real.

Department	May	June	July	August	September	October	November	December
Industrial	969.952	934.419	919.429	995.340	988.523	1.001.340	1.005.366	736.853
	1.911.465	1.973.606	1.920.805	1.957.735	1.917.792	1.886.107	1.855.685	1.895.640
	37.235	48.197	50.497	48.178	50.516	71.505	48.678	44.584
Supply	437.936	437.491	430.390	442.278	437.737	447.123	446.586	433.379
	60.374	66.203	67.374	69.090	66.440	78.646	79.757	49.691
	23.753	23.753	23.753	23.753	23.753	23.753	23.753	10.634
	6.101	6.101	6.101	6.101	6.101	6.101	6.101	6.101
Financial Management	822.488	816.225	819.159	825.831	826.662	835.052	861.082	1.458.154
	37.753	49.753	29.253	29.253	27.753	26.753	40.753	26.753
	21.294	18.331	16.451	17.033	16.217	18.331	18.331	12.780
	49.805	45.765	34.918	49.905	45.765	49.805	50.355	50.155
Total	4.378.157	4.419.844	4.318.131	4.464.497	4.407.259	4.444.516	4.436.448	4.724.723

Figure 2. Estimated budget with the merger, in real.

Comparing the budgets shown in Fig. 1 and 2, it is identified the feasibility of financial synergy, since there is saving in each month. The accounting data shows that the operational and financial synergies allow the productive restructuring and, consequently, a better performance in cost management. With the integration among the operational and administrative processes and logistical control, the investments rationalization leads to a greater profits and the value creation to the owners and shareholders of the organizations. In this sense, the results of the budget feasibility project demonstrated that the cost and expenses reduction and savings can be achieved, as well as the entailing operational synergies.

In this perspective, the value creation can be delimited by the optimization and better allocation of resources. It will be higher when the return on investment reward the business directing, also, to improve the economic performance of organizations. Fig. 3 presents the return on investments that can be achieved by the merger process.

Based on Fig. 3, the merger process leads to a positive return on investments. From the month #4, the investment of month #0 has already been recovered. This demonstrates that the merger strategy is competitive in cost, leading to the minimization of operating and administrative costs. With this, one can reduce the price of the product offered to the consumer or increase the profit for the shareholders.

Therefore, the merger strategy provides the operational and financial efficiency, as well as the investment rationalization, creating value based on the better use of resources and leads to a return on investment that impact positively on the business.

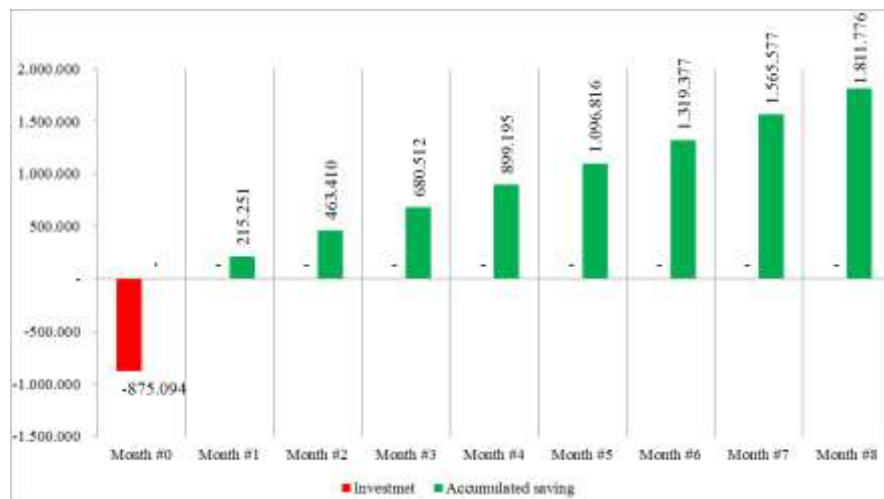


Figure 3. Return on investment, in real.

5. Conclusions

This paper contributes to knowledge by the demonstration of practical importance of the merger strategy between organizations of Brazilian automotive sector. By means of the findings, the main motivating factors for the merger strategy among organizations are: operational efficiency, cost reduction and value creation for owners and shareholders. The merger process encompasses not only the transfer of facilities or equipment, but it also guarantees a positive return on investments, impacting on cash flow of companies. Thus, the findings demonstrate that the merger strategy is driven by the joining of forces, overcoming obstacles, taking advantage of opportunities in order to achieve operational and economic efficiency.

But, it is highlighted that the organizations had initiated the merger process driven by a market condition in the face of the economic crisis. So, they must consider their particularities and learning in order to achieve the effective consolidation of the merger process. The experience and management of operational and financial synergies are differential for future strategic decision making.

The next steps of this study are related to the analysis of the motivating factors for the merger strategy in other industry sectors. Besides that, the results concerning

the logistic flow after the consolidation of the merger process between the two organizations studied will be consolidated and evaluated.

Acknowledgements

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References

- Bardin L (2011) *Análise de Conteúdo*, São Paulo: Ed.70
- Dhawan S (2009) Merger and Acquisition in Global Context. *Kindler* 4:7-16
- Galerani J (2003) Formação, estruturação e implementação de aliança estratégica entre empresas cooperativas. *Rev Adm Emp [online]* 2:1-16
- Klotzle MC (2002) Alianças estratégicas: conceito e teoria. *Rev Adm Contemp* 6:85-104
- Nakamura AA (2005) Desempenho de processos de fusões e aquisições: um estudo sobre a indústria petrolífera mundial a partir da década de 90. Available via ANP http://www.anp.gov.br/CapitalHumano/Arquivos/PRH21/Akio-Assuncao-Nakamura_PRH21_UFRJ_M.pdf Cited 13 Feb 2017
- Neary P (2004) *Cross-border mergers as instruments of comparative advantage*. Oxford, University College Dublin and CEPR
- Pessanha GRG et al (2012) Influências das fusões e aquisições no valor de mercado das instituições bancárias adquirentes. *Cont Gest e Gov* 17:145-158
- Ross SA et al. (2009) *Administração Financeira*. São Paulo, Atlas
- Santos TA et al. (2013) Fusões e aquisições na Indústria Manufatureira: uma análise econométrica das cias de capital aberto no período de 2001 a 2011. In: SEMEAD. Available via <http://sistema.semead.com.br/16semead/resultado/trabalhospdf/1052.pdf> Cited 14 Feb 2017
- Senhoras EMA (2005) A indústria automobilística sob enfoque estático e dinâmico: uma análise teórica. In: SEMEAD. Available via <http://sistema.semead.com.br/8semead/resultado/trabalhosPDF/226.pdf> Cited 14 Feb 2017
- Tanure B, Caçado VL (2005) Fusões e aquisições: aprendendo com a experiência brasileira. *Rev Adm Emp* 45:10-22
- Techemayer CA (2001) O processo de formação e gestão de aliança estratégica: um estudo de caso numa empresa do setor automotivo da região Sul. Available via <http://www.lume.ufrgs.br/handle/10183/2586> Cited 11 Feb 2017
- Vale CP, Pudo PB (2012) O Mercado automobilístico no cenário econômico brasileiro. *Rev Interf [online]* 4:69-75.

A Performance Management Model for Third Mission of Brazilian Public Universities

Maximiano M¹, Rosa M², Cabral J³

Abstract: The development of tools for the evaluation and performance management of public universities is a field of growing interest in Brazil and in other countries, stimulated, among other factors, by the need to improve organizational management in a context of reduced public resources and growing accountability impositions by different stakeholders, which demand institutions to demonstrate their social relevance. This paper presents the results of a research developed with the purpose of proposing a performance management model for the Brazilian public universities' third mission. The research was conducted in 2016 with the final contribution of 89 academic specialists working in the area of extension in 54 institutions from the 5 regions of Brazil. Guided by the Delphi technique two rounds of consultation and validation of a set of performance indicators were conducted. The indicators were proposed taking as reference model the Balanced Scorecard (BSC) management system. The results obtained are relevant since the proposed model establishes a reference base that universities can use to support themselves when thinking and planning the management of the activities they perform in relation with the society.

Keywords: Public Universities; Third Mission; University Extension; Performance Management; Balanced Scorecard.

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1. Introduction

Public Higher Education Institution (HEI) face nowadays a significant number of challenges, some of them related with the way they manage their relation with the external environment. It is possible to observe the growing interest of different countries in the establishment of methodologies to evaluate this relationship and improve the way it is managed (Pineiro, Langa and Pausits 2015). Based on this, the following research question emerged: *Which indicators are relevant to evaluate and strategically manage Brazilian universities' third mission activities in order to improve their performance?*

2. Objectives

The objective of the research was then to propose and validate a model of indicators for the evaluation and strategic management of the performance of the Brazilian public universities' third mission.

3. Methods

In the design of the initial set of performance indicators, the BSC strategic map structure was adopted (Kaplan and Norton 1992, 1996). The starting point for the formulation of the strategic map was the observation of the university extension's purpose, described as "... to promote the transformative interaction between the university and other sectors of society" (Forproex, 2012). Then perspectives of evaluation, strategic objectives and performance indicators able to reflect the university extension purpose were defined. For the extended consultation of the universities, the Delphi technique was selected, with two rounds of electronic surveys being conducted with the Survey Monkey software. The participants were professors and technicians from the universities members of the Pro-Rectors Forum Extension of Public Institutions of Higher Brazilian Education. Respondents were asked about the relevance of a set of strategic objectives and indicators for the evaluation and the performance management of third mission activities.

4. Results

65 Brazilian HEIs participated in the first round of the research. As there were 3 invited specialists by institution, 130 valid answers were obtained. In the second

round the participation was of 54 institutions and 89 answers were collected. In the individual characterization of the respondents by function related to the university's third mission, 32 (36%) identified themselves as managers (pro-rector, director or equivalent), 33 (37%) as teachers and 24 (27%) as administrative technicians. Respondents had to provide their answers (relevance attributed to the set of strategic objectives and performance indicators proposed to them) using a 5-point Likert-scale. The data obtained was subjected to statistical analysis, being calculated the medians and means of the answers obtained for each variable (questions proposed for objectives and indicators). At the end of the two Delphi rounds the validation of the starting model was obtained with 4 evaluation perspectives and 16 associated strategic objectives, some of which were redefined throughout the process. Also 52 performance indicators were approved, from the initial 58, which is still a high number for management purposes (the final model is presented in the annex). In addition, a factorial analysis was performed over the indicators' answers with the goal of further grouping and reducing their number.

5. Conclusion

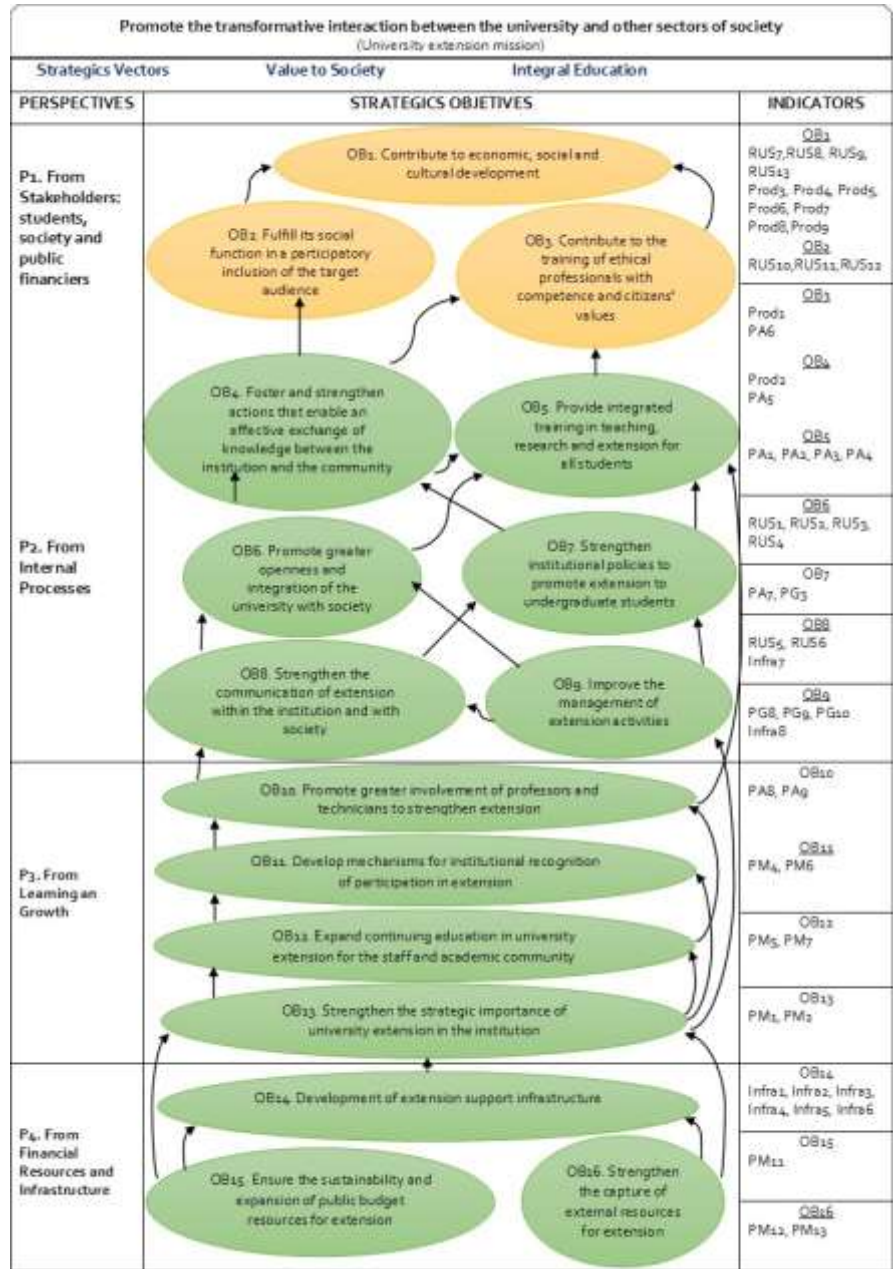
Assuming that organizations in general, and universities in particular, have multiple peculiarities that make each one of them unique, the purpose of this research was to establish a base of reference for them to manage their relationship with the external environment, able to be used by different institutions to support their third mission activities strategic management under their particular environmental context.

References

- Bouckaert G, Halligan J (2008). *Managing Performance: International Comparisons*. New York: Routledge.
- Caldeira J (2010). *Implementação do Balanced Scorecard no Estado*. Edições Almedina.
- Chen S, Yang C, Shiau J (2006). The application of balanced scorecard in the performance evaluation of higher education. *TQM Magazine* n°. 18 (2):190-205
- E3M Project (2012a). "The Green Paper: Fostering and Measuring Third Mission in Higher Education Institutions". 24. Accessed 2014 march. <http://e3mproject.eu/docs>.
- FORPROEX (2012). *Política Nacional de Extensão Universitária*. Manaus/AM. Acessado dezembro 2016. <http://www.renex.org.br/>.
- Kaplan R, Norton D (1992). *Strategy Maps: Converting Intangible Assets Into Tangible Outcomes*. Boston, MA: Harvard Business School Press.

- Kaplan R, Norton D (1996). *The Balanced Scorecard: Translating Strategy Into Action*. Boston, MA: Harvard Business School Press.
- Molas-Gallart J, Salter A et al (2002). *Measuring third stream activities*. Final report to the Russell Group of Universities. Brighton: SPRU, University of Sussex.
- Pinheiro R, Langa P, Pausits A (2015). One and two equals three? The third mission of higher education institutions, *European Journal of Higher Education*, 5:3, 233-249.

Annex - BSC strategic map for Brazilian university extension performance management



The trade relationship between Brazil and Algeria in the import of oil and its derivatives in the period 2010-2016

Oliveira F¹, Silveira A², Vilena M³

Abstract: The Brazilian choice on the energy matrix, which established as a priority the exploitation of oil and consequently its derivatives for energy generation, had consequences for its foreign trade relations. It is important to clarify that the choice of the energy matrix involves strategic variables and decisions about investment, consumption and demand projected for the next thirty years, for example. Thus, this paper intends to analyze the trade balance between Brazil and Algeria (Country of North Africa, with a strong movement of oil and its derivatives), in the period 2010-2016, focusing even on the period in which Brazil began its periods of recession (2015). The research problem is, therefore, "during the period of 2010-2016, what is the situation of the trade balance between Brazil and Algeria?". Therefore, the hypothesis formulated is that, because it does not have enough supply to supply Brazilian domestic demand for oil and, consequently, derivatives, Brazil has imported these products from other continents. During the period analyzed, Brazil did not have a favorable balance. The reason why Algeria was chosen for analysis, and not another country since Brazil has trade relations with more than seventy countries is that the African continent is the main supplier surpassing the percentage of 71%, and Algeria has significant representativity. The methodology used was a bibliographical research, based on the analysis of recent data from the Brazilian trade balance, including in the context of recession, starting in 2015. Among the results obtained are: (1) the Brazilian energy matrix is diversified, but still shows a majority of non renewable energies, different from what happens with other emerging countries; (2) it is necessary to revise the demand for oil and its derivatives for the next 30 years, as a matter of urgency. (3) the investment volume defined by the Brazilian government for the energy matrix is not sufficient for the established demand.

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Keywords: Foreign trade; Exploitation of oil; Energy matrix.

1. Introduction

For being an emerging economy, Brazil has been facing in the last thirty years many changes in its international trade relations, as well as in its internal development.

In this search for development, the definition of the energy matrix imposes itself as a special condition.

Energy matrix means in this context, a set of energy sources offered in the country to capture, distribute and use energy in the commercial, industrial and residential sectors. The source of this energy may be from renewable or non-renewable sources.

In this way, the definition of the energy matrix will impact industrial development and employment policy as well as the trade relations involved.

Important to clarify that the global energetic matrix, have undergone significant changes in the last ten years, mainly. For the most part, this global energy matrix consisted of non-renewable energy sources, it means fossil fuels - oil, coal and natural gas - which have been replaced relatively quickly by renewable energy sources.

The Brazilian energy matrix has been strengthening its position in two areas: hydroelectric and oil.

If on the one hand, we have renewable energy - hydroelectric - on the other side, we have the strengthening of non-renewable energies - oil.

This puts us in front of two diametrically opposed strategies, and that will have consequences for the other relations of development of the country.

The Brazilian choice on the energy matrix, which established as a priority the exploitation of oil and consequently its derivatives for energy generation, had consequences for its foreign trade relations. It is important to clarify that the choice of the energy matrix involves strategic variables and decisions about investment, consumption and demand projected for the next thirty years, for example.

Thus, this paper intends to analyze the trade balance between Brazil and Algeria (Country of North Africa, with a strong movement of oil and its derivatives), in the period 2010-2016, focusing even on the period in which Brazil began its periods of recession (2015). The research problem is, therefore, "during the period of 2010-2016, what is the situation of the trade balance between Brazil and Algeria?". Therefore, the hypothesis formulated is that, because it does not have

enough supply to supply Brazilian domestic demand for oil and, consequently, derivatives, Brazil has imported these products from other continents.

2. Brazilian Energy Matrix

The national energy matrix was analyzed in the period 2010-2015 given the availability of data. The table below shows the structure of the domestic energy supply based on the non-renewable and renewable energy specifications.

Table 1. Brazilian Energy Matrix

Type of Energy	% In Use
Renewable	41,1
Hydraulics and Electricity	11,3
Firewood and Charcoal	8,2
Sugarcane Derivatives	16,9
Others	4,7
Non Renewable	58,9
Oil and Derivatives	37,3
Natural gas	13,7
Coal Mining and Derivatives	5,9
Uranium and Derivatives	1,3
Others	0,7
Total	100

Fonte: Ministry of Mines and Energy (2017)

From Table 1, we see that non-renewable energies are still the largest percentage in the Brazilian Energy Matrix. In this way, investigating the origin, and trade agreements involving the country's oil supply, is a pertinent issue. The Trade Agreements are important because Brazil imports oil from North Africa, particularly from Algeria, a major trading partner. The inter-that in investigating these trade relations is to ensure the supply of this product, and not to threaten the development of the country.

3. Trade between Brazil and Algeria

According to the Business Guide of the Ministry of Foreign Affairs, we have a brief overview of the trade relationship between Brazil and Algeria. In 2010, total imports from Brazil were US \$ 2 billion and in 2016 fell to US \$ 1.5

billion, showing a sharp drop that may be justified by the crisis Brazil is facing. Imports from Brazil in this commercial relationship are concentrated in crude oil and Nafta, a petroleum derivative used in the petrochemical industry.

Table 2. Statement of turnover between Brazil and Algeria (2010-2016)

Trade Balance	Imports	Exports	Balance
2010	\$2.053.269.914,00	\$598.243.283,00	\$-1.455.026.631,00
2011	\$2.770.090.193,00	\$-	\$-
2012	\$2.867.978.839,00	\$834.961.044,00	\$-2.033.017.795,00
2013	\$2.862.919.081,00	\$870.027.177,00	\$-1.992.891.904,00
2014	\$2.751.511.323,00	\$786.704.488,00	\$-1.964.806.835,00
2015	\$1.693.723.904,00	\$599.623.556,00	\$-1.094.100.348,00
2016	\$1.543.797.934,00	\$-	\$-

Fonte: MDIC (2017)

Exports in 2010 were only US \$ 598 million, where they are primary products such as sugar cane and beef. Exports of Brazilian products to Algeria are concentrated in semi-manufactured products and imports are directed at manufactured goods.

The trade balance between these two countries shows a balance unfavorable to Brazil, as can be seen in the table above that in all years analyzed except in 2011 and 2016 (\$ -) because we did not have the values data, Brazil has imported many products and ex-small doors.

To understand the context of this trade relationship, Brazil and Algeria signed a Trade Agreement on February 8th, 2006 with the main objective being to strengthen and develop trade between the two countries, adopting measures to stimulate Bilateral Relations.

4. Methods

The methodology used was a bibliographical research, based on the analysis of recent data from the Brazilian trade balance, including in the context of recession (2015 -).

On the Brazilian energy matrix, the survey was conducted across the data available by the Mines and Energy Ministry in its official website.

Thus, the data surveyed for the period 2010-2015 were tabulated and consolidated and represented in Table 1.

Similarly, the balance of turnover between Brazil and Algeria is shown in Table 2, and was obtained by accessing the official website of the Ministry of Development, Industry and Foreign Trade, tabulated and consolidated for presentation.

From the tables presented, it was possible to make the necessary analyzes for conclusion and results obtained.

5. Results

The results obtained (1) the Brazilian energy matrix is diversified, but still shows a majority of non renewable energies, different from what happens with other emerging economies. It is important to clarify that Brazil is investing on non renewable energies (like oil, for example), instead of invest on other renewable energies. It goes on a different way, looking for “green product”. If we are talking about correct development, Brazil has to move forward on renewable energies; (2) it is necessary to revise the demand for oil and its derivatives for the next 30 years, as a matter of urgency. If we consider that research on renewable energy sources takes at least twenty years, Brazil would take only ten years to invest and start with other alternatives. That is the reason, we consider the decision is urgent. This urgency has to be considered on economic policy; (3) the investment volume defined by the Brazilian government for the energy matrix is not sufficient for the established demand. The demand for development has to be increased based on actual volume. This method has to be considered if Brazil wants to be on competitiveness level.

6. Conclusion

During the period analyzed, Brazil did not have a favorable balance. The reason why Algeria was chosen for analysis, and not another country since Brazil has trade relations with more than seventy countries is that the African continent is the main supplier surpassing the percentage of 71%, and Algeria has significant number. Brazil depends on imports of oil and do not export too much products. Two actions has to be combined: (1) less imports of oil (using another renewable energies) and (2) increase on exports, by using different ways to offer different products.

Considering infrastructure investments needs a minimum of ten or fifteen years, Brazil has to review some foreign trade policies immediately.

References

Grieger, M. (2003) In: Electronic Marketplaces: A literature review and a call for supply chain management research. *European Journal of Operational Research*, v. 144, nr.02, 280-294.

- Halldorsson, A., Kotzab, H., Mikkola, J. H., & Skjøtt-Larsen, T. (2007) In: Complementary theories to supply chain management. *Supply Chain Management: An International Journal*, v. 12, nr. 04, 284-296.
- Ministry of Industry, Foreign Trade and Services, *Trade balance: January-December 2010*, available at: www.mdic.gov.br/index.php/comercio-exterior/estatisticas-de-comercio-exterior/balanca-comercial-brasileira-acumulado-do-ano?layout=edit&id=1180 (accessed 1 may 2017)
- Ministry of Industry, Foreign Trade and Services, *Business guide – Algeria*, available at: <https://investexportbrasil.dpr.gov.br/arquivos/Publicacoes/ComoExportar/GNArgelia.pdf> (accessed 01 may 2017)
- Ministry of Mines and Energy (2013), *Brazilian energy review - financial year 2012*, available at: www.abce.org.br/downloads/ResenhaEnergetica2012.pdf (accessed 02 may 2017)
- Ministry of Mines and Energy (2014), *Brazilian energy review - financial year 2013*, available at: [www.mme.gov.br/documents/10584/3597128/01+-Resenha+Energ%C3%A9tica+Brasileira+2014+-+Ano+Base+2013+\(PDF\)/a54f22a2-e5bd-46af-8a28-949934244cb2;jsessionid=EA174D8159C21B7C94B25A59F05C52EC.srv155?version=1.4](http://www.mme.gov.br/documents/10584/3597128/01+-Resenha+Energ%C3%A9tica+Brasileira+2014+-+Ano+Base+2013+(PDF)/a54f22a2-e5bd-46af-8a28-949934244cb2;jsessionid=EA174D8159C21B7C94B25A59F05C52EC.srv155?version=1.4) (accessed 2 may 2017)
- Ministry of Mines and Energy (2015), *Brazilian energy review - financial year 2014*, available at: www.mme.gov.br/documents/1138787/1732840/Resenha%2BEnerg%25C3%25A9tica%2B-%2BBrasil%2B2015.pdf/4e6b9a34-6b2e-48fa-9ef8-dc7008470bf2 (accessed 2 may 2017)
- Ministry of Mines and Energy (2016), *Brazilian energy review - financial year 2015*, available at: [www.mme.gov.br/documents/10584/3580498/02+-Resenha+Energ%C3%A9tica+Brasileira+2016+-+Ano+Base+2015+\(PDF\)/66e011ce-f34b-419e-adf1-8a3853c95fd4;version=1.0](http://www.mme.gov.br/documents/10584/3580498/02+-Resenha+Energ%C3%A9tica+Brasileira+2016+-+Ano+Base+2015+(PDF)/66e011ce-f34b-419e-adf1-8a3853c95fd4;version=1.0) (accessed 2 may 2017)
- Rohit B, Amrik S Sohal (2005) In: Supply chain competitiveness: measuring the impact of location factors, uncertainty and manufacturing practices. Available via <http://sciencedirect.com>, *technovation* 443-456

Technology Roadmapping as a methodology for fostering Corporate Sustainability

Machado C¹

Abstract: Technology Roadmapping - TRM is a methodology for the identification, definition and mapping of technological strategies, objectives and actions related to innovation. Organizations that can structure their strategies based on emerging technologies are more likely to gain competitive advantage. Corporate Sustainability - CS is a strategic and profit-driven response for companies, translating into benefits for companies and businesses. The benefits refer to the construction and increase of competitive advantages and the opportunity to explore new markets. The present study sought to identify in companies of the machinery and agricultural implements sector the main demands for the development and application of the TRM methodology. It was possible to verify that the application of the TRM methodology contributes to the promotion of SC insofar as it generates benefits related to the increase of competitive advantages and innovation.

Keywords: Technology Roadmap; TRM, Corporate Sustainability.

1. Introduction

Technology Roadmapping - TRM is a methodology that aims to help with technology planning. It is used for strategies, definition of future plans, planning of gains, overcoming of barriers and definition of the actions necessary to follow the technological advances, identification, definition and mapping of technological strategies (Daim et al, 2012; Lee et al, 2009; Farrukh, Phaal E Probert, 2003; Groenveld, 1997; Phaal, Farrukh E Probert, 2004; Phaal Farrukh E Probert, 2007).

Corporate Sustainability -CS, a strategic response oriented to the profits of the companies translating into benefits for these and the businesses. The benefits refer to the construction and increment of competitive advantages (Porter, Kramer

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2002, 2006; J. G. Stead, Stead 2013; Lozano, 2015; Lozano, Nummert, Ceulemans, 2016) and the opportunity to explore new markets (Hart, Milstein, Caggiano 2003).

The present study addresses the application of methodology TRM as a practice to foster the integration of CS in the strategic management of companies (Engert, Rauter, Baumgartner 2016; Bach et al. 2016; Neugebauer, Figge, Hahn, 2016; Xie, 2016).

2. Objectives

The objective of this study was to identify the demands of the manufacturers of machines and agricultural implements for the development and application of the TRM.

3. Methods

The research question that guides the present study is inductive and demands the execution of multiple case studies. The case studies provide unique ways of developing the theory, deepening the resulting elements of empirical phenomena and their contexts (DUBOIS; GADDE, 2002). The research protocol contained semi-structured questions and the evidence collected was divided into two units of analysis: (i) 5 multinational companies and 5 national manufacturers of agricultural machinery and implements and (ii) 10 suppliers of machinery and agricultural equipment manufacturers.

4. Results

Among the main findings it is worth highlighting that in order to make a sustainable business it is necessary to increase productivity, to execute the actions indicated by the technological roadmap as those capable of increasing the competitiveness of the business, not only via technological innovation, but also through new models Of business. The TRM application enables organizations to integrate, build and reconfigure skills, better coping with rapid environmental changes. As an immediate benefit, we highlight the understanding, the competitors and the technological directions of their field of activity. In a second moment, the understanding of what technologies would be necessary for the viability of new products or services to be introduced in the market. It covers the identification of opportunities (or needs) that can generate competitive advantages, generating SC.

5. Conclusion

It was possible to verify that the application of the TRM methodology can contribute positively to the CS's promotion through the visualization of a new technological innovation level and, in turn, competitive for the business.

References

- Bach, V, Berger, M, Henßler, M, Kirchner, M, Leiser, S, Mohr, L, Finkbeiner, M (2016). Integrated method to assess resource efficiency – ESSENZ. *Journal of Cleaner Production*, 137. arti-cle. <http://doi.org/10.1016/j.jclepro.2016.07.077>
- Daim TU, Ammer M, Brenden R. (2012) Technology Roadmapping for wind energy: case of the Pacific Northwest. *Journal of Cleaner Production*. Volume: 20. Edição: 1. Páginas: 27-37. Publicado: Janeiro 2012.
- Dubois, A, Gadde, LE (2002) Systematic combining: an abductive approach to case re-search. *Journal of business research*, 55(7), 553-560.
- Engert, S, Rauter, R, Baumgartner, RJ (2016) Exploring the integration of corporate sustainability into strategic management: A literature review. *Journal of Cleaner Production*, 112, 2833–2850. <http://doi.org/10.1016/j.jclepro.2015.08.031>
- Farrukh C, Phaal R, Probert D. (2003) Technology roadmapping: linking technology resources into business planning. *Int. J. Technology Management*. Volume: 26. Edição: 1. Páginas: 2-19. Publicado: 2003.
- Groenveld P. (1997) Roadmapping integrates business and technology. *Research Technology Management*. Volume: 40. Edição: 5. Páginas: 48-55. SET-Out 1997.
- Hart, SL, Milstein, MB, Caggiano, J(2003) Creating sustainable value *Academy of Management Executive*. Disponível em: <<http://www.scopus.com/inward/record.url?eid=2-s2.0-0038269808&partnerID=tZOtx3y1>>
- Lee S, Yoon B, Lee C, Park J (2009) Business planning based on technological capabilities: Patent analysis for technology-driven roadmapping. *Technological Forecasting & Social Change*. Volume: 76. Edição: 8. Páginas: 1130-1131. Publicado: Out 2009.
- Lozano, R, Nummert, B, Ceulemans, K (2016) Elucidating the relationship between Sustainability Reporting and Organisational Change Management for Sustainability. *Journal of Cleaner Production*, 125. article. <http://doi.org/10.1016/j.jclepro.2016.03.021>
- Lozano, R. (2015) A Holistic Perspective on Corporate Sustainability Drivers. *Corporate Social Responsibility and Environmental Management*, 22(1), 32–44. article. <http://doi.org/10.1002/csr.1325>
- Neugebauer, F, Figge, F, Hahn, T (2016) Planned or Emergent Strategy Making? Exploring the Formation of Corporate Sustainability Strategies. *Business Strategy and the Environment*, 25(5). article. <http://doi.org/10.1002/bse.1875>
- Oliveira MG, Freitas JS, Fleury AL, Rozenfeld H, Phaal R, Probert D, Cheng LC (2012) Roadmapping: uma abordagem estratégica para o gerenciamento da inovação em produtos, serviços e tecnologias. Rio de Janeiro. Elsevier, 2012.

- Phaal R Farrukh C Probert, D (2004) Technology roadmapping – A planning framework for evolution and revolution. *Technological Forecasting & Social Change*. Volume: 71. Edição: 1-2. Páginas: 5-26. Publicado: JAN-FEV 2004.
- Phaal, R Farrukh, CJ Probert DR (2007) Strategic roadmapping: A workshop-based approach for identifying and exploring strategic issues and opportunities. *EMJ-Engineering Management Journal*. Volume: 19. Edição: 1. Páginas: 3-12. Publicado: MAR 2007.
- Porter, ME, Kramer, MR (2002) The competitive advantage of corporate philanthropy. *Harvard business review*, 80(12), 56-68.

Assessing Organisational Energy for Effective Change: the Batteries of Change Model

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Keywords: Organization Development and Change; Organizational Energy for Change; Change Effectiveness; Batteries of Change Model;

1. Introduction

In the current turbulent environment, the performance and success of organizations is largely dependent on their ability to develop strong capabilities that can drive change. However, the brutal fact that about 70% of change initiatives fail, clearly demonstrates that additional models and assessment instruments are needed to support the development of organizational ambidexterity, which is conceptualized by Gibson and Birkenshaw (2004) as “an organizational unit’s ability to achieve internal alignment so that incremental change can be efficiently exploited while simultaneously pursuing adaptation to new revolutionary changes required by the external environment”.

To respond to this challenge, Boers, De Prins, Letens & Verweire proposed a framework of six batteries of change that are essential to charge an organization’s capacities for change. Three of these batteries are *rational/formal* change batteries: they help to manage the rational side of change through strategy, program and project management, management systems and processes. But equally important, successful change requires attention to people and cultural factors. Change agents need to master informal coalitions and the hidden dynamics of organizational change as well. These principles are reflected in three *emotional/informal* batteries of change.

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2. Objectives

The objective of this work is to further assess the validity of the framework of the six batteries of change. Whereas previous work has validated the model through an extensive review of the management literature on organization development and change and field testing in individual case studies, the goal of this work is to further validate the model based on survey data collected through at least four C-level managers of 53 organizations.

3. Methods

The internal consistency of a survey of the six batteries of change, the five underlying constructs of each battery, as well as a new composite measure of change effectiveness is assessed through the calculation of Cronbach alpha. Validity of the model is preliminary tested through correlation analysis of the batteries and their impact on change effectiveness.

4. Results & Conclusion

The alpha's of the batteries and the change effectiveness measure all approached or exceeded .900. Of the 30 underlying constructs, only four construct demonstrated reliability issues. The correlation analysis demonstrated significant correlations between the various batteries and change effectiveness. These results support the validity of the model, but also demonstrate that the current database of 53 companies can serve as an interesting benchmarking database.

References

- Gibson, C., & Birkinshaw, J. (2004). Contextual determinants of organizational ambidexterity. *Academy of Management Journal*, 47(2), 209-226.

Layout study based on performance indicator system

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Abstract To achieve high levels of industrial performance in a volatile and dynamic market, it is necessary for organizations to have a good physical arrangement planning on their shop floor. When layout design takes into account lean manufacturing tools, the gains are enhanced. However, it is necessary to build and implement a performance measurement system that can accurately audit the physical arrangement. Considering this scenario, the objective of this work is to propose a methodology for studies of layout improvement based on studies of performance improvement. To achieve this, a literature review on the subject of physical arrangement models and performance indicators was performed. As an illustration, a case study was developed in an auto company, with the purpose of indicating the importance of implementing a layout-oriented performance measurement system.

Keywords: layout study, performance measurement system, case study

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1. Introduction

The global industry trajectory is marked by high competitiveness. Since the beginning, with the Industrial Revolutions, to date, corporations have been struggling with the market in which they are inserted.

In order to survive in this context, it is important to find tools to differentiate, whether by price, quality or technology. When analyzing this scenario under the optics of manufacturing companies, it is possible to emphasize the importance of planning the physical arrangement of the shop floor. One that, which has a good performance, can be responsible for insurance of products being delivered in less time and with more quality, directly affecting the cost, thus making the company more competitive.

In both academic and industry, the discussion of the importance of layout planning its lean orientation has grown (Meller and Gau, 1996). Managers began to realize that in order to achieve productivity gains, the layout should also be studied, and often remodelled.

Silva (2009) cited examples found in the literature that explain the importance of layout planning. According to Muther (1976), the efforts put on planning, avoid large future losses, and, when is necessary to make changes, the system is flexible. Analysing from the optics of operations strategy, the implementation of layout improvement, generates impact on the performance objectives. It is important then, to use performance measurement systems to measure the impacts of gains in layout.

Layout study subjects and performance measurement systems are widely discussed in the literature and industry. However, the concomitant practice of such themes, which means, layout study, fundament in performance measurement, is not yet widely discussed. Thus, the objective of this research is to propose a methodology of layout studies, based on performance measurement systems.

2. Literature Review

The literature review is developed in two sections. The first one gives a brief revision on layout definition, types and direction on layout improvement. The second one revisits performance measurement systems.

2.1 *Layout studies*

Silva (2009) cited the definition of Gonçalves Filho (2005) on physical arrangement of a factory. It is defined as the disposition of elements and productive resources used for the production of a good or service, such as machines, equipment, facilities and personnel. The physical arrangement defines how the assets will flow through the operation.

According to Slack et al. (2012), the layout of a process must be determined by the variety and volume characteristics. When production volumes are low and the variety is high, flow is not a major issue. However, with high volumes and low variety, flow becomes a key issue.

The application of lean tools will be enhanced when the layout enables such application. Duggan (1998) gives some guidelines for implementing a lean layout. He states that the layout must contain a high throughput speed (the time from the beginning of the first operation to the end of the last process), that it must include several cell types to suit different products and processes. In addition, flexibility to meet varied demands and be able to adapt to new lines with new products.

Slack *et al.* (2009) also cite measures to optimize a physical arrangement. Among them, it is possible to mention: 1) security, 2) flow extension, 3) clarity of flow and 4) accessibility.

Pattanaik and Sharma (2008) proposed a methodology for cellular layout using lean manufacturing concepts. After applying such methodology, they verified that there was an increase in the percentage of activities that add value to the product and that there was a decrease in waiting time and waste. To do so, they combined some operations (principle of cell layout) and relocated machinery.

2.2 Performance measurement system

It is possible to analyse on what was described above by the cited authors, that they discuss ways to optimize the physical arrangement and results obtained through this optimization. However, to ensure performance improvement, it is necessary to implement a performance measurement system that can accurately measure results.

According to Slack et al. (2008), a performance measurement is a criterion used for judgment of the operation. Without a performance measurement system, it would be impossible to exert control over the existing operation. However, a system is required to effectively provide information on improvement.

According to Neely et al. (1995), performance measurement can be defined as the process of quantifying the efficiency and effectiveness of action.

By the optic of operations strategy, Slack and Lewis (2008) have defined five performance objectives, which are: 1) quality, 2) velocity, 3) reliability, 4) flexibility and 5) cost. Such objectives can be decomposed in performance indicators.

3. Case Study

In order to illustrate a layout study, based on performance indicators, a case study at a major vehicle manufacturer was carried out. The case study is structured as

follows: firstly, a certain area of the factory was chosen that undergoes constant reformulations in layout. Later, using performance metrics, before the physical arrangement changes, the layout was audited. It was then modified and had its performance analyzed again. Finally, the two layouts were compared in order to ensure that change implementation was effective.

The studied area are places positioned inside the factory where all the parts that will supply the assembly line, commonly called, supermarket of parts. Most of the parts assembled on the vehicles are located in such stations.

The parts transport is developed by RGV's (radio guided vehicles). Therefore, the activities carried out by the operators on the stations consist of supplying the carts with the necessary parts for the car model that will receive the parts.

3.1 Performance indicators

Like other manufacturing areas, the supply stations have their own indicators that measure the efficiency of the layout and operations. Unlike the production lines, which are rigid structures, that is, changes in layout would result in unworked days and high costs, the layout of one of these stations is it only formed by the arrangement of boxes and flow racks with parts and the physical structure necessary to the RGV rail. Indicators are important tools for the constant rearrangement of the layout, given the ease of implementing changes.

A performance measurement system was defined, with four metrics, detailed below. In addition, prior to deploying station changes, aiming to prove that the new layout would perform better than the current one, all four indicators were calculated, days before the changes began.

3.1.1 Operations time and Picks per minute

The studied company gives great value to the study of times. Depending on the production rate, each factory operation must be flexible to that variation.

The sum of the time of all activities results in measuring the workload of a station (engagement). The indicator "operations time" was calculated, and the results can be observed in table 1 below:

Table 1. Operations time

Operation time		
Work station	Vehicle	Time
1	X	82,34
	Y	113,51
2	X	114,52
	Y	114,52
3	X	63,66
	Y	188,55

There are three workstations on this supply station, and the indicator was calculated for two vehicle models. The calculated time is in the unit of centiminutes (1 centiminate = 0.6 minutes).

Another indicator used in the company is the amount of parts that the operator "buys" in his workstation by cart. The higher the number of pieces purchased, the better the station layout, indicating that the parts are well arranged in the physical space, since the operators do not have to have a great movement to pick up and deposit parts in the cart, in the stipulated time according to the production flow.

For confidentiality reason, the picks per minute could not have the calculation memory explanation. However, the station studied has a value of 9.47 parts acquired per minute.

3.1.3 Opportunities for improvement and improvement sheet

The third indicator used is called an "opportunity for improvement". The main goal of its construction is to indicate the opportunities for improvement and the theoretical time "saved" if improvements are actually implemented.

The improvements relate to eleven principles of those stations, such as visibility of parts in the boxes, need to stretch the arm to buy parts or need to move more than one step to deposit the part in the cart. If in the activities of the operator these principles are being fulfilled, then, there is no opportunity for improvement, since the layout is already meeting these principles. Otherwise, there is an improvement coefficient, established by the company, related to each principle.

Also for confidentiality reasons, the opportunities for improvement were synthesized, and the final calculation obtained showed that, if those eleven principles were met, the operations of the station could have a reduction of 1:50 min in the three workstations studied.

The last indicator that measures the performance of a station is the improvement sheet. It is built from the analysis of the indicators already defined above and simple analyses of the jobs. A list with all the problems and flaws found is created, aiming to identify activities that do not add value.

3.2 Indicators for new layout

Due to the limitations of the research project, the only indicator that was constructed for comparison purposes was the calculation of engagement. This calculation was performed on the design of the new layout in the software used. The operators movement was estimated in the new arrangement of the boxes and, by the frequency of parts purchased per vehicle, it was possible to carry out the complete calculation. However, fortunately, it was possible to prove that the time simulation is similar to reality, when the time of one of the stations was measured and the result was very similar to the theoretical one.

Table 2 below shows the new times calculated for each station and for each vehicle model individually.

Table 2. New operations time

Operation time		
Work station	Vehicle	Time
1	X	62,87
	Y	90,47
2	X	76,22
	Y	89,88
3	X	57,2
	Y	119,72

By the analysis of the two indicators, it is clear that the new one has brought important reductions in operating time. As a result, it resulted in increased productivity, and ergonomics for operators, since much of the time laundered for the tasks in the old layout was in motion. This movement has been diminished with implementation of improvements.

4. Methodology for layout studies

Aiming to assist companies and academics in layout studies, a study methodology based on performance indicators will be proposed.

4.1. Implementation of a layout-oriented performance measurement system

The first step to be followed is the design and implementation of a performance measurement system capable of auditing physical arrangements and bringing useful knowledge in order to assist the decision making process.

According to Globerson (1985), a performance measurement system should promote assertive and time-critical feedbacks and reflect on the company's strategy. In this line, Neely et al. (1997), in a literary review on the subject of performance measurement systems projects, grouped some guidelines for a good metric. Among them, it is possible emphasize that they should be simple to understand, should focus on continuous improvements and have an explicit purpose.

4.2 Layout audit

The second step to be followed for layout study is the application of metrics to audit the layout. This step has two main objectives.

The first major goal is to test the efficiency of the performance measurement system. It tests the ease of calculations, the way in which the data will be viewed and consumed, and mainly, it is verified if the information generated from the metrics, are able to say something relevant about the layout performance. Further, if the data extraction reflects and affects directly on the company's strategy. The second objective is that, given that the layout will undergo changes, check if

through a comparison of the old layout with the new one, the changes contributed to achieving higher performance in the studied station.

4.3 Layout improvement

This is the most critical stage of the layout study methodology, since the design of the new physical arrangement is crucial to achieve higher levels of performance.

De Carlo et al. (2013) conducted a case study in a textile mill. The study aimed to make redesign of the factory layout. For this, they analyzed three different methodologies for rearrangement: an empirical method, the SLP methodology, and lean manufacturing ideas. Table 3 below indicates the results collected and highlights that the layout developed from the lean philosophy obtained more performance gains.

Table 3. Comparison between methodologies

	Processing time	Movement	Orders	Revenue
Methodology				
Empirical	-2,95%	8%	-0,25	-500
SLP	-3,90%	-15%	1,8	3600
Lean	-4,15%	-24%	3	6000

In the same line, Eswaramoorthi et al. (2010) developed a model for designing a new layout. The authors propose a system based on takt time and production cost. Using this system, they achieved reductions of up to 27% in production costs.

Also, Silva (2009) carried out a study in several authors that shows other criteria to be taken into account in the development of a layout with high performance. Among them, it is possible to highlight, visual management, continuous flow (parts can flow smoothly and continuously) and minimized movement of people and materials.

4.4 New audit

Using the same group of indicators, the final step is to audit the layout again. By the case study analysis, it was possible to prove the importance of measuring the performance of the new layout, in order to verify its efficiency.

5. Conclusion

The objective of this work was to propose a methodology for layout study, based on performance indicator systems, having as principle, operations management. In order to reach the objective, a case study was developed in the physical arrangement of a parts supply station inside a large automotive industry.

The case study, and findings in the literature, has supported the proposal of a methodology for layout studies, which contemplates from its conception until its change, passing mainly through the development of a performance measurement

system. The implementation of the performance measurement system should have simple, easily interpreted metrics that can reflect on the company's strategy. The layout rearrangement therefore depends on a good performance measurement system, which can accurately measure operations, and should be based on some organizational suggestions found in the literature, such as visual management, continuous flow guarantee and low material handling and people.

For the method to be proven, further studies need to be carried out, in order to encompass more indicators and different types of production systems

References

- Meller, R.D.; Gau, Y.K. The facility layout problem: recent and emerging trends and perspective. *Journal of Manufacturing Systems*. V.15. p. 351 – 366. 1996.
- Silva, AL (2009). Desenvolvimento de um modelo de análise e projeto de layout industrial, em ambientes de alta variedade de peças, orientado para a Produção Enxuta. Tese (Doutorado) – Escola de Engenharia de São Carlos. 243.p São Carlos.
- Muther, R (1976). Planejamento do layout, sistema SLP. Supervisão ITIRO IIDA. Tradução Elizabeth de Moura Vieira, Jorge Aiub Hijjar e Miguel de Simoni. São Paulo
- Slack N, Jones, AB; Johnston, R (2012). *Operations Management*. Pearson
- Duggan KJ (1998) *Facilities design for lean manufacturing*. IIE Solution
- Slack, N, Chambers, S, Johnston, R, Betts, A (2008) *Operations and process management: Principles and Practice for Strategic Impact*. 2a ed. Pearson
- Pattanaik, L.N.; Sharma, B.P (2008) Implementing lean manufacturing with cellular layout: a case study. *International Journal of Advanced Manufacturing Technology*. V. 42, p. 772 – 779. 2008.
- Neely, A.D.; Mills, J.F.; Gregory, M.J.; Platts, K.W (1995) Performance measurement system design—a literature review and research agenda. *International Journal of Operations and Production Management*. V. 15. N.4, p. 80 – 116
- Slack N, Lewis M (2008) *Operations Strategy*. Harlow, England: Pearson Mission Globerson, S (1985) Issues in developing a performance criteria system for an organization. *International Journal of Production Research*, Vol. 23, n. 4, p. 639–646
- Neely, A, Richards H, Mills J, Platts K, Bourne M (1997) Designing performance measures: a structured approach. *International Journal of Operations and Production Management*. V.17. N.11, p 1131 – 1152.
- De Carlo F; Arleo MA.; Borgia O, Tucci M (2013) Layout design for a low capacity manufacturing line: a case study. *International Journal of Engineering Business Management*. V.5. n. 35
- Eswaramoorthi M.; Prasad PSS, Mohanram PV (2010) Developing an effective strategy to configure assembly systems using lean concepts. *International Journal of Lean Thinking*. V.1. n.

Miscellaneous

Pressures for Adoption of Green Supply Chain Management Practices: a Qualitative Comparative Analysis

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Abstract This paper helps to contribute to reducing the research gap concerning the adoption of Green Supply Chain Management (GSCM) practices in small and medium-sized enterprises (SME). An analysis of 14 SME in the chemical sector was performed using Qualitative Comparative Analysis (QCA) to examine the relationships between combinations of conditions sets toward increasing the adoption rate. Our conceptual model includes external and internal pressures, such as regulation, market, suppliers, society and mission. Empirical results indicate that pressures from suppliers or regulation or the combination of the mission and absence of market forces lead to the adoption of GSCM practices.

Keywords: Green Supply Chain Management, Small and Medium Enterprises; Chemical sector; QCA

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1. Introduction

Green Supply Chain Management (GSCM) emerged with the objective of integrating the supply chain (SC) to reduce operating costs across the product life cycle, while reducing negative environmental impacts (Srivastava, 2007; Zhu & Sarkis, 2007; Diabat & Govindan, 2011). Some researches (e.g. Huang & Huang, 2016) point out that the implementation of GSCM practices can also provide important competitive advantages.

According to the literature (e.g. Zhu et al., 2005; Santa-Eulalia et al.), pressures and motivations for the adoption of GSCM practices arise from external and internal groups or stakeholders, according to the literature. Zhu & Sarkis (2007) pointed out that not all organizations face the same types of pressure for the adoption of GSCM practices. Different companies in different industries are confronted with different pressures. For example, industries that have inherent processes with high environmental impact (e.g. chemical) must withstand greater national and international pressures and motivations to incorporate GSCM practices (Zhu & Sarkis, 2006). However, despite its importance, discussions about the pressures and motivations influencing the adoption of GSCM practices is rare in the literature (Huang & Huang, 2016).

In order to contribute to reducing this research gap, this paper provides an analysis of combinations of pressures which influence (or can lead to) the adoption of GSCM practices in small and medium sized enterprises (SMEs) of the chemical sector. To do so, we first adapted the conceptual framework employed by Santa-Eulalia et al. (2011). Next, we collected data from 14 SMEs, which were analyzed through Qualitative Comparative Analysis (QCA) with the objective of understanding which combination of factors better contributes to the adoption rate.

This paper is organized as follows: Section 2 introduces the theoretical background and the conceptual model explaining the research variables being studied. Section 3 presents the research method and Section 4 analyzes all collected data. Section 5 discusses the main results and finally Section 6 outlines some conclusions and indicates future research efforts.

2. Theoretical background

This subsection addresses the main research topics that have been studied to build the theoretical conceptual model.

First, adoption of GSCM practices helps the company to minimize the environmental impact of the product throughout its life cycle, from material acquisition, through manufacturing and utilization, until final disposal (Srivastava, 2007). In addition, it is important to highlight that these practices comprise internal and external activities to promote pollution prevention, waste reduction,

recycling, efficient material utilization, adequate raw materials and resources extraction, capture of harmful pollutants capture, followed by adequate residue destination, and so forth (Vachon & Klassen, 2006).

In this research, GSCM practices cover a large variety of initiatives related to inbound and outbound logistics, manufacturing, at strategic, tactical and operational levels. They all have in common the objective of reducing the environmental impact of SC operations.

Initiatives for the GSCM are translated into practices that are driven by pressures (Huang & Huang, 2016; Srivastava, 2007). The literature (Santa-Eulalia et al., 2011) shows a wide range of factors leading companies to adopt environmentally less impacting practices (Huang & Huang, 2016; Srivastava, 2007; Walker et al., 2008; Zhu et al., 2005). Some authors (e.g. Seuring & Müller, 2008; Walker et al., 2008) detected the fundamental pressures, which were then grouped into two main categories: external (or exogenous) and internal (or endogenous). Internal pressures relate to the organization goals and desires, while the external ones refer to any external force capable of stimulating the adoption of GSCM practices (Walker et al., 2008).

One of the most cited factors is related to Regulatory forces (Huang & Huang, 2016; Walker et al., 2008; Zhu et al., 2005). Governmental control policies and regulations including local, national or international regulations, have great influence (Seuring & Müller, 2008). For Handfield et al. (2002), this kind of pressure has increased a great deal, especially with reference to the final disposal of wastes and tailings.

However, the main pressure is probably related consumers and customers (Lee, 2008). This pressure is called Market in this study. Operating an SC is justified if both products and services are finally "accepted" by customers (Green et al., 1996; Srivastava, 2007; Zhu & Sarkis, 2007; Seuring & Müller, 2008).

In the Holt & Ghobadian (2009) study, it was also identified that one of the least influential pressures for the adoption of GSCM practices is Suppliers. Suppliers may help to provide valuable ideas used in the execution of environmental projects, but generally they do not act as a direct motivator (Carter et al., 2000). However in this research, this pressure was investigated to test this possibility in our specific empirical context.

Besides, over time, environmental deterioration has increased the awareness of society of environmental issues (Handfield et al., 2002; Walker et al., 2008). There are pressures from activists and nongovernmental organizations (NGOs) (Hall, 2000) which should not be ignored.

Internal pressures were the second most important factor for adoption of GSCM practices (Holt & Ghobadian, 2009; Zhu et al., 2005). This factor is related to the company's mission, which considers environmental priorities in their decisions. An increase in investor and shareholder pressure has also been observed in the development of environmental policies (Green et al., 1996).

Figure 1 proposes a conceptual framework to organize the main findings from the literature.



Figure 1 Theoretical conceptual model of research.

3. Method

We employed QCA to analyze and discuss which pressures or combination of factors influence the adoption of GSCM practices. QCA is a configurational comparative method (CCM) and was developed for small sampling situations comprising 10 to 100 cases (Rihoux & Ragin, 2009).

This method uses mathematical set theory to examine set relationships between combinations of conditions sets, which characterize the causal relationship present among cases and an outcome set. Combinations are described using Boolean operators and hence, they represent logic configurations. In this study, we applied the Crisp-Set QCA (the Boolean version) due to the available datasets from 14 SMEs from the chemical sector. Data was analyzed through the fsQCA© software, version 3.

These 14 SMEs are all located in Brazil, but in two different states. Inspired by Rihoux & Ragin (2009), we performed: Stage 1: Building a binary data table; Stage 2: Constructing the truth table (based on the Quine-MacCluskey method); Stage 3: Boolean minimization; Stage 4: Using the ‘logical reminders’ cases and Stage 5: Interpretation. They are explained in the next section. Data was collected using a structured questionnaire.

4. Results

First, it is important to explain that, since the pressures from the community had not been identified, this condition was then removed from our analysis. After creating a binary table (Step 1), we performed the minimization procedure (Step 2). This approach assesses the distribution of cases in combinations of causal conditions and subsequently, thus resulting in the truth table (Table 1). The process of analyzing the truth table requires a frequency and consistency threshold. Frequency specifies the minimum number of cases that will be considered in the analysis because not all combinations of conditions are observed empirically. Consistency is the degree to which one set is contained within another or it is the proportion of observations that yield the dominant outcome. Since the

sample is relatively small in this study, the frequency adopted is 1 and a cut-off value for consistency greater or equal than 0.85, since below 0.75 indicates substantial inconsistency (Rihoux & Ragin, 2009). In Table 1, we can observe six empirical combinations, with four consistent combinations (>0.85) which are used in the minimization process.

Table 1. Truth table with the causal conditions and outcomes to minimize.

<i>CaseId</i>	<i>REG</i>	<i>MAR</i>	<i>SUP</i>	<i>INT</i>	<i>Practices</i>	<i>Number</i>	<i>Consistency</i>
U4, U7, U8	0	0	0	1	1	3	1
U10	1	0	0	0	1	1	1
U2	0	0	1	0	1	1	1
U11, U12, U13, U14	1	1	1	1	1	4	1
U1, U3, U9	0	0	0	0	0	3	0.67
U5, U6	0	1	0	1	0	2	0.5

¹ Configurations with consistency > 0.85 are shown in bold

Legend: Regulation (REG), Market (MAR), Supplier (SUP), Society (SOC), Mission (INT)

After Stage 3 (Boolean minimization) and Stage 4 (using logical reminders), it is possible to produce the most parsimonious minimal formulas possible. Table 2 shows the minimal formula for our study.

Table 2. Consistency and Coverage Solution for adoption of GSCM practices

	Combinations of pressures				Outcome
	REG	+	SUP	+ mar*INT -->	Practices
Consistency	100%		100%		100%
Raw coverage	42% (5/12)		42% (5/12)		25% (3/12)
Cases coverage	U11, U12, U13, U14, U10		U11, U12, U13, U14, U2		U4, U7, U8
Unique coverage	8% (1/12)		8% (1/12)		25% (3/12)
Solution Consistency					100%
Solution coverage					75%

¹ Conventions and operations of Boolean algebra: an *uppercase letter* represents the [1] value, i.e., variable is present; a *lowercase letter* represents the [0] value, i.e., variable is absent. Boolean operator: OR (+), AND (*).

Table 2 shows that regulations pressure the adoption of GSCM practices either by the supplier or by the combination of internal pressures without market pressure. This solution covers 75% of the companies analyzed, as indicated by the solution coverage. *Consistency* refers to the proportion of enterprises covered by each combination of pressures. *Raw coverage* represents the proportion de enterprises adopted GSCM practices that are covered by a given term and *unique coverage* the proportion of enterprises adopting practices that are uniquely covered by a given term (no other term covers those enterprise). In the following section the results are described in detail (Stage 5 – Interpretation).

5. Discussions

Empirical evidences from our study call attention to the fact that three possible paths lead to practices adoption. The first possible configuration is regulation (*REG* → *Practices*). Regulation is solely a good reason for adopting environmental conscious practices. This is coherent with the literature (Diabat & Govindan, 2011; Huang & Huang, 2016). This is particularly important in industry sectors comprising hazardous products and materials (Seles et al., 2016). As our empirical evidences indicate, this reality is true in SME in the chemical sector.

The second (*SUP* → *Practices*) and third (*mar*INT* → *Practices*) paths introduce some novelty to the literature. As for the second one, despite the fact that some studies suggest that suppliers generally do not act as a direct motivator (Carter et al., 2000), our empirical evidences indicate that suppliers may help to provide valuable ideas used in the execution of environmental projects, leading to a more efficient environment management (Vachon & Klassen, 2006). Handfield et al. (2002) also highlighted the role of purchasing in an environmentally effective management. In addition, it is important to remember that our sample comes from SMEs which normally are part of a large SC with multinational suppliers. This can be an important force to adopt green practices.

Concerning the third path, some authors (e.g. Handfield et al., 2002; Lee, 2008; Seles et al., 2016) affirm that customers are most influential in the adoption of GSCM practices. Despite these studies, our empirical evidences call attention to the fact that Market is not a strong force for chemical SME. This could be due to the fact that our sample comes from a strongly regulated industry sector in which customers possibly have less importance. In fact, the absence of customer pressures when combined with strong internal desires to become green (*mar*INT*) lead to higher adoption. In this case, motivations from the top management (which are sometimes translated into explicit missions) play an important role, such as in the electrical sector in Taiwan (Huang & Huang, 2016).

Finally, it is interesting to observe that *society* has not emerged as a factor contributing to GSCM adoption, despite the existence of some evidences elsewhere (Hall, 2000; Handfield et al., 2002; Walker et al., 2008). We can hypothesize that this is similar to the absence of Market forces.

6. Conclusions

This paper presents a qualitative-quantitative study comprising SME in the chemical sector to evaluate some pressures and motivations to adopt GSCM practices. Our empirical evidences indicate that the adoption of these practices is mainly influenced by three possibilities, namely: a) the presence of strong regulations solely; b) or the exclusive presence of suppliers pushing environmental

practices; c) or the presence of internal motivations (e.g. the top management green conscience) only when the market does not provide pressure. This confirms several theoretical assumptions from the literature, but provides more precise evidence of possible configurations or paths leading to practices' adoption. For example, society and marketing are not sufficient pressures to force SME to adopt GSCM practices. Thus, this paper contributes to the literature by providing a novel way of understanding the adoption process of GSCM practices in SME.

The paper presents some limitations that can be addressed in future works. The adoption process may differ between industries, countries, regions, enterprises size (Zhu & Sarkis, 2006). In our case, only Brazilian SMEs were studied, probably inducing some bias in the research. Besides that, the position in an SC also plays an important role in intensifying environmental pressure (Lee et al., 2008). This variable is absent in our work. Moreover, the sample size of 14 SMEs allows us to perform a QCA study, but a larger sample could help improve some performance indicators, such as coverage and indicate other possible paths/configurations. Finally, other research methods (such as surveys combined with structural equation modeling) can be employed later.

References

- Carter, C. R., Kale, R. and Grimm, C. M. (2000). Environmental purchasing and firm performance: an empirical investigation. *Transportation Research Part E*, 36(3), pp.219-228. [http://dx.doi.org/10.1016/S1366-5545\(99\)00034-4](http://dx.doi.org/10.1016/S1366-5545(99)00034-4)
- Diabat, A. and Govindan, K. (2011). An analysis of the drivers affecting the implementation of green supply chain management. *Resources, Conservation and Recycling*, 55(6), pp.659-667. <http://dx.doi.org/10.1016/j.resconrec.2010.12.002>
- Green, K., Morton, B. and New, S. (1996). Purchasing and environmental management: interaction, policies and opportunities. *Business Strategy and the Environment*, 5(3), pp.188-197. DOI: 10.1002/(SICI)1099-0836(199609)5:3<188:AID-BSE60>3.0.CO;2-P
- Hall, J. (2000) Environmental supply chain dynamics. *Journal of Cleaner Production*, 8(6), pp.455-471. [http://dx.doi.org/10.1016/S0959-6526\(00\)00013-5](http://dx.doi.org/10.1016/S0959-6526(00)00013-5)
- Handfield, R., Walton, S. V., Sroufe, R. and Melnyk, S. A. (2002). Applying environmental criteria to supplier assessment: a study in the application of the analytical hierarchy process. *European Journal of Operations Research*, 141(1), pp.70-87. [http://dx.doi.org/10.1016/S0377-2217\(01\)00261-2](http://dx.doi.org/10.1016/S0377-2217(01)00261-2)
- Holt, D. and Ghobadian, A. (2009). An empirical study of green supply chain management practices amongst UK manufacturers. *Journal of Manufacturing Technology Management*, 20(7), pp.933-956. <http://dx.doi.org/10.1108/17410380910984212>
- Huang, Y-C. and Huang, C-H. (2016). Research on relationships among institutional pressure, stewardship behavior, green supply chain management, and organizational performance: the case of electrical and electronics industries in Taiwan. *Journal of Computing and Information Science in Engineering*, 16(4). DOI: 10.1115/1.4033435

- Lee, S. Y. (2008). Drivers for the participation of small and medium-sized suppliers in green supply chain initiatives. *Supply Chain Management: An International Journal*, 13(3), pp.185-198. <http://dx.doi.org/10.1108/13598540810871235>
- Rihoux, B. and Ragin, C. C. (2009). *Configurational comparative methods: Qualitative Comparative Analysis (QCA) and Related Techniques*. United States of America: SAGE Publications, Inc.
- Santa-Eulalia, L. A.; Rekik, L.; Bergeron, F.; Retamal, L. and Noël, M. (2011). Green supply chain management practices in SMEs in Québec. In: *SMEs: Moving Toward Sustainable Development Conference*, Network for Business Sustainability, Montréal - Canada.
- Seles, B. M. R. P., de Sousa Jabbour, A. B. L., Jabbour, C. J. C. and Dangelico, R. M. (2016). The green bullwhip effect, the diffusion of green supply chain practices, and institutional pressures: Evidence from the automotive sector. *International Journal of Production Economics*, 182, pp.342-355. DOI: 10.1016/j.ijpe.2016.08.033
- Seuring, S. and Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, 16(15), pp.1699-1710. <http://dx.doi.org/10.1016/j.jclepro.2008.04.020>
- Srivastava, S. K. (2007). Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews*, 9(1), pp.53-80. DOI: 10.1111/j.1468-2370.2007.00202.x
- Vachon, S. and Klassen, R. D. (2006). Extending green practices across the supply chain: The impact of upstream and downstream integration. *International Journal of Operations & Production Management*, 26(7), pp.795-821. <http://dx.doi.org/10.1108/01443570610672248>
- Walker, H., Di Sisto, L. and Mcbain, D. (2008). Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors. *Journal of Purchasing and Supply Management*, 14(1), pp.69-85. <http://dx.doi.org/10.1016/j.pursup.2008.01.007>
- Zhu, Q. and Sarkis, J. (2006). An inter-sectoral comparison of green supply chain management in China: drivers and practices. *Journal of Cleaner Production*, 14(5), pp.472-486. <http://dx.doi.org/10.1016/j.jclepro.2005.01.003>
- Zhu, Q. and Sarkis, J. (2007). The moderating effects of institutional pressures on emergent green supply chain practices and performance. *International Journal of Production Research*, 45(18-19), pp.4333-4355. <http://dx.doi.org/10.1016/j.procir.2014.07.091>
- Zhu, Q., Sarkis, J. and Geng, Y. (2005). Green supply chain management in China: Pressures, practices and performance. *International Journal of Operations and Production Management*, 25(5), pp.449-468. <http://dx.doi.org/10.1108/01443570510593148>

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We would like to thank all those who have sent in their work, because these works, after their revision and acceptance, constitute the essential nucleus and *raison d'être* of this conference. In addition, we give an especially warm welcome to our keynote speakers, coming from business and academic world, whose presence at the plenary sessions is an honour for us and which makes the conference more relevant. Likewise, we would like to express our recognition of the effort and work put in by all those people who have made it possible to organize IJC2017. We pay tribute to the Scientific Committee who with the thoroughness of their supervision have assured the quality of the accepted papers, to the institutions and sponsors for their trust and support, and to the members of the organizing committee for their keen motivation to ensure there were no loose ends, an almost impossible mission, and to all the people who have directly or indirectly influenced in the smooth progress towards the conference.