Lecture Notes on Multidisciplinary Industrial Engineering
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Zoran Anisic
Bojan Lalic
Danijela Gracanin *Editors*

Proceedings on 25th International Joint Conference on Industrial Engineering and Operations Management – IJCIEOM

The Next Generation of Production and Service Systems

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Lecture Notes on Multidisciplinary Industrial Engineering

Series Editor

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Preface

Every era carries its burdens and challenges. The twenty-first century is characterized by intensive digitization of industry with the aim of further shortening the product life cycle as well as increasing manufacturing efficiency and product quality. Industrial engineering and operational management (IE and OM) are disciplines that certainly enable companies to achieve these goals through the application of scientific methods and practical experience.

Launching and successfully organizing a series of *International Joint Conferences on Industrial Engineering and Operations Management (IJCIEOM),* for more than two and a half decades, is the result of an agreement among Associação Brasileira de Engenharia de Produção (ABEPRO), Asociación para el Desarrollo de la Ingeniería de Organización (ADINGOR), Institute of Industrial and Systems Engineers (IISE), European Academy for Industrial Management (AIM) and American Society for Engineering Management (ASEM). The aim is to enhance the connection between academia and industry and gather researchers and practitioners specializing in operation management, industrial engineering, engineering management and other related disciplines from around the world.

The 25th International Joint Conference on Industrial Engineering and Operations Management entitled "The next generation of production and service systems" was hosted by the University of Novi Sad—Faculty of Technical Sciences—Department of Industrial Engineering and Management, from July 15 to 17, 2019. It included 39 different topics from the field of industrial engineering, engineering management and operation management, with over 150 submissions sent in. The scientific committee accepted 95 contributions of authors from 15 countries all over the world of which the final selection of the proceedings included 55 top-quality papers. All papers were reviewed by at least two members of the scientific committee, composed of renowned scientists specialized on the specific topics, whose work is deeply appreciated.

The high-quality presentations and lively discussions on various industrial problems during the conference are taken as encouragement to proceed further with IJCIEOM conferences. We believe that this publication manages to evoke and convey the positive spirit of the conference. We trust you will find inspiration or even possible solutions to your engineering problem in the papers selected for this volume.

January 2020

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Contents

Increasing Resource Efficiency Through Digitalization – Chances and Challenges for Manufacturing Industries

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Abstract. Companies are increasingly focusing on the sustainability of their products and processes. Especially the manufacturing companies attempt to increase material and energy efficiency, as those costs already account for a major part of their total costs. The digitization of the production process, as a first step in the implementation of Industry 4.0, can be a great opportunity for realizing resource efficiency potentials thereby reduce costs in companies. However, the manufacturing companies are faced with the challenge, on one hand, to implement a successful design of digital transformation in the development and production of goods and services. On the other hand, it is about maintaining the competitiveness of companies, which requires a decoupling of economic growth from the consumption of resources - and thus a more efficient use of resources. Although company examples show a positive connection between digitalization and resource efficiency, it is often unaware of companies or not investigated and quantified. Firstly, companies have a problem identifying whether they are ready to implement digitization in their processes. Secondly, they are facing challenges on how to find adequate measures in order to increase resource savings achieved through digitization. This article explores the interactions of these challenges and highlights ways to improve the resource efficiency offered by Industry 4.0 approaches. Furthermore, it proposes a framework for increasing resource efficiency through digitalization in a company.

Keywords: Resource efficiency · Digitalisation · Industry 4.0 · Framework

1 Introduction

In recent decades, manufacturing companies have increasingly focused on considering and integrating aspects of sustainable development into their products and processes. There are many reasons for this, ranging from securing a competitive advantage over competitors, to creating a better image and marketing, to developing new innovative solutions (including technical, organizational or financial), or to make an important contribution to sustainability. Furthermore, the operating environment of companies has changed. For instance, the challenges at the company level are growing due to rising energy and raw material prices, the generally increasing public concern about

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social issues, cost savings (e.g. through waste reduction and effective resource management) and health and safety. The main challenge here is effectively to design the market success factors such as cost, quality, time and adaptability for a long-term successful production. Whereas previously manufacturing costs and quality were decisive factors, speed and flexibility are now gaining in importance [1]. A key lever for achieving these goals is increasing the efficiency of all production factors [2]. Industry 4.0 opens up new possibilities to manage and increase efficiency [3, 4]. In particular, resource efficiency can experience a sustainable increase through digital transformation and at the same time make a positive contribution to reducing negative environmental impacts and reduce costs.

The digital transformation means however significant change for the manufacturing companies [5]. It offers opportunities for qualitative growth and can be seen as a future perspective for a changed sustainability paradigm [1]. However, it presents also a challenge for them and opens several questions: How to implement the digitalization in the development and production of goods and services? What significance does digitalization have for increasing sustainability in companies? Which core elements of the digital transformation are relevant for increasing resource efficiency? Are they ready for the implementation of digitalization? What are the adequate measures to increase resource savings achieved through digitization? This article aims to provide some answers and to explain the challenges and potentials for increasing resource efficiency through digitalization. I addition, a framework for increasing resource efficiency through digitalization in a company is presented.

2 Digital Transformation: Opportunities for New Growth

In the context of industry 4.0 and digital transformation, the physical and digital worlds are becoming increasingly interlinked. Equipping machines, plants, work pieces or products with sensors and actuators and connecting them with information and communication technologies (ICT) and the Internet opens up countless new possibilities for designing production and value-added chains. This is accompanied by the digitalization of all business areas, as well as horizontal and vertical integration of corporate levels [6, 7].

Industry 4.0 enables a form of industrial value creation in which all production factors are real-time capable, intelligent and digitally networked to the extent that they affect the processes, products and business models of industrial enterprises [8, 9]. It comprises the networking of all human and machine actors along the entire value chain as well as the digitization and real-time evaluation of all relevant information with the aim of making value creation processes more transparent and efficient in order to optimize customer benefits with intelligent products and services [10].

The Internet of Things (IoT) [11] and Cyber-physical Systems (CPS) [3] are the central concepts of industry 4.0. They are accompanied by the automation and digitization of companies and the training of so-called intelligent production technology on the basis of modern ICT and the associated IT. Digitalization represents the consistent and comprehensive use of digital technologies to increase effectiveness and efficiency through automation, facilitated human-machine collaboration and the creation of new products and business models, taking into account the social aspects structure [12]. The Internet of Things (IoT) refers to the linking of clearly identifiable physical objects with a virtual representation within an Internet structure. In an industrial context, this enables horizontal and vertical networking along the value-added chain and the continuous organization, planning, control and monitoring of industrial combination processes from the normative-strategic to the operative level. CPS are systems in which information and software components are connected with mechanical or electronic components. This is accomplished with Smart devices and sensors, which can convert information into digital form, process it and transmit it, enable a holistic recording and control of all processes and procedures of a company [7].

The industry 4.0 therefore enables:

- continuous evaluation of process and machine states.
- the ability to take action or take countermeasures at the right time in order to keep.
- the process constantly at its optimum.
- aggregation and filtering of the data to be able to make the decision on a data basis.
- that does not contain any unwanted outliers or falsifications.
- Prediction and simulation of process impacts.
- creation of smart factories.

For all the applications and concepts of the industry 4.0 mentioned above the huge amount of data will be generated, stored, sent, managed and evaluated. Data management concepts such as Big Data and Data Mining have established themselves in order to be able to deal with these data volumes [13]. They also enable further increases in the efficiency of existing processes and the generation of new products and services [14].

3 Increasing Resource Efficiency Through Digital Transformation

Digital transformation offers numerous possibilities for increasing resource efficiency. The digitization of production is in many places in the development and implementation phase and should be seen as an ongoing process rather than a result [15, 16]. This enables companies to actively shape this process. It offers possibilities to partially decouple growth from resource consumption, which can only be achieved through the increasingly efficient use of natural resources in companies.

An essential feature of industry 4.0 is the digital consistency in the vertical integration of different levels within companies, as well as the horizontal integration between different actors in a value chain [1, 7]. The potential opens up at the level of individual processes within a company (e.g. field level, control level, process management level, operational management level corporate level), right up to system solutions for the supply chain and at the level of product life cycles. The goal is the dynamic management of these complex systems, in particular, the optimization of production processes, products, and services. In this context, the implementation of digital solutions should be oriented towards the management system and resources of the company. The decisive factors for the impact of digitization measures on resource efficiency are the system framework considered and the level in the value chain. The manufacturing companies organised by this way are defined as smart or intelligent factories. The Smart Factory provides a production environment that ideally organizes itself without human intervention. This includes production facilities and logistics systems. Core components are cyber-physical systems and intelligent networking [6].

3.1 Industry 4.0 Solutions for Resource Efficiency at Different Levels

In practice, a number of solutions have already been implemented for saving operational material resources through digitalization, such as energy and material, but also "intangible" resources, e.g. capital. The applications can be found not only on the process and company level, but also on the level of supply chain an product life cycle [17].

Individual digital solutions to increase resource efficiency are implemented, for example, to optimize the material or energy consumption of certain processes. In addition, energy consumption and material losses can be reduced at the process level by changing the machine utilization to an intensive optimum of machines. This also offers great potential in data and information transparency, which makes energy and material consumption transparent and reveals potential savings. The results of resource-efficient digitization at the process level are [18]:

- information on material and energy consumption can be provided in a standardized way,
- measurement data can be processed via uniform interfaces in information models and
- real-time key performance indicators can be provided.

An example of the individual solutions at the process level is for instance "digitization in industrial forging". The use of digital solutions in a forging process made compressed air consumption transparent and subsequently enabled compressed air to be generated in line with demand and energy savings of up to 10%; the use of electronic ballasts led on average to 5% less energy consumption. The further example shows implementation in the process industry [17]. In the process industry, with relatively high use of raw materials and supplies, the use of certain auxiliary materials can be reduced with the assistance of dynamic process controls in order to improve the supply of operating materials. In the steel industry, secondary metallurgical treatment can minimize the burn-up of chromium and other metals during decarburization of high-chromium steels, for example, by optimizing the oxygen supply [1, 17].

There are numerous ways to make production processes more effective and efficient. This can be achieved by the implementation of digital solutions on operation/company level. The applications range from business information systems in combination with measurement sensors, to smart production services, to solutions from information, communication and automation technology, such as simulation and forecasting models, self-learning assistance systems and diagnostic tools, or lab-on-chip systems for real-time analysis of very small quantities of substances [1, 17]. This changes the manufacturing processes in companies since adapted manufacturing processes are used. For example, production processes can be made more flexible and individual by using networked machines and components that communicate with each other via the Internet and form cyber-physical systems (smart factory) [17]. In addition to increasing resource efficiency, a reduction in inventories and processing times is mostly achieved. A further example of the increase in resource efficiency is the usage of new additive manufacturing processes such as 3D printing technologies, which make it possible to individualize the production of components. Generative production systems have the potential to enable time savings and improved resource and energy efficiency. Thanks to optimized component structures, they lead to weight savings, waste reduction and thus improved life cycle costs. Another application is in maintenance and quality management. Machines equipped or retrofitted with sensors and mechanical systems (retrofitting) enable Big Data Analytics to implement anticipating maintenance concepts (predictive maintenance) and forecast models for quality assurance. In quality management, the permanent collection and evaluation of data offer optimization potential through improved possibilities for the realization of Jidoka (automatic production stop in the event of errors or defects) [12]. The increase in resource efficiency can be especially achieved by introducing lean management methods within the manufacturing processes. Lean Management is an approach of continuous process optimization and encompasses the efficient design of the entire value chain. The main objective of lean management is to coordinate all processes and activities in such a way that any kind of waste along the value chain is avoided. After all, such philosophy ultimately leads to an economic design of uneconomical areas: Resources are better used, new potential can be discovered. The methods can be applied to all levels of a company, in production, marketing or sales [19, 20].

The digitization of production systems enables far-reaching changes in industrial value-added processes. Intelligent value chains are a compelling and complementary complement to digitization as they control the ecosystem of suppliers, production, logistics and sales [1]. This creates opportunities for the development and implementation of new innovative business models. Business models that integrate products and complementary services allow for cross-lifecycle concepts. The examples of the business models for the equipment manufacture are for instance [17]:

- pay-per-hour - The equipment manufacturer takes responsibility for the availability and reliability of his equipment during the operating phase by defining the environmental and general conditions. The plant manufacturer sells available, ready-to-use plants in the form of a pay-per-hour settlement using service level agreements.
- pay-per-piece - In this model, the plant manufacturer sells the manufactured product or service and thus also accepts responsibility for production. Examples are the production of compressed air (compressors) or conveyed piece goods (conveying and storage equipment). In this business model of pay-per-piece invoicing, the turnover is generated for each part produced by the plant.
- pay-per-value - In Application Lifecycle Management, the development and production of the product (service) also guarantees its further development (e.g. software). The business model implies pay-per-value accounting, whereby the customer's own product must exert a significant influence on the customer's end product.

3.2 Measures for the Digital Transformation

The digitization of production as the first step towards industry 4.0 can be an opportunity for companies to increase their own resource efficiency and thus reduce costs. Although examples show this positive correlation between digitization and resource efficiency, companies are often unaware of it or are not examined and quantified in more detail.

A study by VDI examined the implementation of digital transformation measures to increase resource efficiency. Using descriptions of best-practice cases from Germany, eleven concrete measures for digital transformation in practice and the necessary components were developed. These are measures from small and medium-sized as well as large companies from different industries. By combining these measures, companies can implement individual practical applications (see Table 1). The measures can be used in isolation or in combination to drive digital transformation in the enterprise while saving resources [17].

Table 1. Identification of eleven measures of digital transformation

ID	Measure	Description
1	Cross-linking of sensors and actuators	A basic prerequisite for digital value creation is the digital connection of sensors and actuators. This allows data from different sensors and actuators to be monitored and recorded over a longer period of time and also to be viewed in combination in an integrated process
2	Use of digital object memories	Physical objects (products, machines) are equipped with digital memory. Relevant data is stored in the memory and is directly accessible at the machine or product
3	Decentralized control	The intelligent workpiece becomes an important component in the decentralized production and value-added network. It has knowledge of its properties and provides information on how it can be manufactured. Thus it can control its own production process
4	Measures for worker support and assistance	Assistance systems can support workers in a wide range of manufacturing and assembly tasks with the help of mobile terminals
5	Dynamically cooperating systems and modularization	Modular encapsulated functionality makes it easy to add new or modified plant components to production plants, create, modify or dissolve interoperation between two or more parties with minimal effort
6	Introduction and use of positioning and localization systems	Tracking and locating systems make it easier to find machines and plant components in a production facility, as well as the finished products
7	Condition monitoring	Various operating states of plants and processes are continuously analyzed on the basis of recorded data and with the aid of suitable software solutions, and deviations are marked and reported

(*continued*)

Table 1. (*continued*)

ID	Measure	Description
8	Predictive maintenance	Predictive maintenance systems should detect machine faults (e.g. machine failures or malfunctions) before they even occur. Maintenance or early repairs should prevent errors
9	Consistent data integration	Consistent data integration and uniform access to data structures enable the integrated consideration of production and order planning. To implement agile production processes, vertical integration of Enterprise Resource Planning (ERP) systems is essential
10	Virtual product development	In virtual product development, a digital 3D model of a product is created on the computer. The virtual model can be modified, tested and optimized by simulations or produced using 3D printing
11	Cloud Computing	Individual workspaces (e.g. programs, storage space, computing capacity) are no longer provided on the hard disk, but via the Internet or the cloud

The case studies make it clear that identified process inefficiencies can often be reduced by digitization measures. These results should help companies to select appropriate measures. They form the basis for practical applications of digital transformation, the targeted use of which can lead to resource savings.

3.3 Framework for Increasing Resource Efficiency Through Digitalization

For many companies is the possible link between resource efficiency and digitization often not perceived. In many cases, digital solutions are used to optimize processes, but there is no systematic monitoring of the success or quantification of resource savings. Companies therefore often lack the basic information on their operational consumption of resources, which they could use to derive targeted measures. The implementation of industry 4.0 or elements of industry 4.0 must be considered from several points of view. The dimensions, which need to be considered, are the competitors of the same industry, the requirements of the customer and the company's own goals and needs [21]. Therefore, the process of digitization in companies must be holistic, transparent and more planned, and used as a strategic goal. A digitization strategy must be developed and implemented in the form of a roadmap (see Fig. 1). Figure two shows a framework and implementation steps designed in accordance with the PDCA circuit. The prerequisite for the implementation of digital solutions for increasing resource efficiency is a clear, strong and strategic involving of management within all projects.

The first step is the preparation phase, which includes two different detailed analyses. At the start, it is necessary to analyze in detail the existing business of the company and its relations with stakeholders. The current state analysis includes a detailed environmental analysis that should show which strengths and weaknesses exist in the company, in which direction should go development, identify the opportunities and risks offered by the market, and at the end define the development strategy.

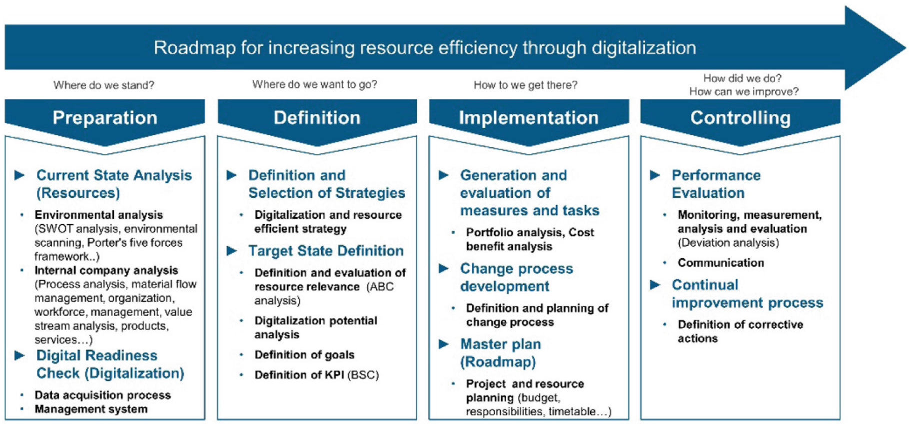

Fig. 1. Roadmap for increasing resource efficiency through digitalization

A second important part of the current situation analysis is the internal analysis of the company. The main goal of this analysis is to identify all processes and products. This is achieved with process analysis (identification of the system boundaries, identification of the material and energy flow and the identification of the process steps), and the visualization of the resources flow. At this point, it is also necessary to list all resources that are consumed or disposed by the company and identify the current measures to improve resource efficiency. After conducting a detailed analysis of the current state, it is necessary to analyze the readiness of the company for the implementation of digitization. This analysis is determined by using the Digital Readiness Check. Digital Readiness Check shows the digital potential of the company in the form of a maturity model [22]. The maturity level to which a company's digital transformation has progressed can be determined online by the digital maturity check. Haag et al. 2018 present another example of the maturity model, which classifies companies into six stages with the focus on data acquisition [23]. This model/framework is not only an evaluation tool but also in addition as a planning tool to support resource efficiency efforts in companies with a strategic approach.

After identification of the current state, occur the definition of where the company wants to go. A decrease in resource use can be achieved in principle with the strategies efficiency, sufficiency, and consistency. The second step, therefore, defines the digitalization and resource efficiency strategy. This is an analytical process of selection of the best suitable course of action to meet the organizational objectives and vision. Companies should develop a targeted strategy for resource efficiency measures as part of their digital transformation. The next step is a definition of the target state. The target state provides the details of a future state of a company that will be developed. In order to accomplish this, it is necessary to use the results of the current state (from step one) and where a company really wants to be within a reasonable timeframe (second step). Further, the definition of the relevance of resources for the company takes place, as well as the digitalization potential. The process begins by analyzing which value chains are most important for each company and where digitization can be critical to business outcomes and operational control. Not every company has to be completely “digitized”. Rather, it is a matter of defining the sections of the operational processes in which digitization is either absolutely necessary or can be expected to bring considerable benefits. Once we know where the company is heading; now we are in a position to define specific goals that will enable a company to achieve that vision. These goals are the specific outcomes, which we are trying to achieve. The goals should be defined for every resource and organization/management function. At this point, it is necessary to define Key Performance Indicators (KPI) in order to evaluate the success at reaching targets.

With the definition of the goals and KPI the implementation process can be started (third phase). The implementation only gets a real foothold in day-to-day business when the adopted strategies, goals and packages of measures are translated into concrete operational measures. It is important to keep an eye on the relation between effort and benefit. In practice, the evaluation of measures in terms of their impact on the achievement of objectives has proved helpful. This allows implementation priorities to be defined, which form the basis for upcoming decisions or budgeting. Asides of measurement operationalization, a change process should be defended and planned. This stage of preparation focuses on the involvement of other parties involved in the digitization process, such as the company’s own employees or external cooperation partners. There are not only communicative reasons for this, but such an approach can also contribute to distributing tasks and responsibilities within the company, integrating the expertise and experience of other participants, taking away the fear of change and ensuring the support of employees and customers for the transformation process. The result of this planning step is a concept for the change process. The last part of the implementation phase is development and definition final roadmap that contains a time plan as well as a description of fields of action, a budget and the projects that will be implemented.

Once all measurements are defined and planned in the form of a roadmap, a controlling phase takes place. This is done through continuous performance evaluation. The implementation of measures needs to be constantly monitored, controlled, analyzed and evaluated. The utilization of the framework is an iterative process. It is recommended to reevaluate the monitoring on a regular basis, and if required the correction measures should be defined and implemented.

4 Conclusions

The digitalization is associated with high expectations of reducing the consumption of natural resources in the manufacturing industry. It can help to raise the potential for increasing material and energy efficiency. The benefits are multiple; the competitive advantage over competitors is maintained, the resource efficiency gained enables new innovative solutions (including technical, organizational, financial and more) and business models to be developed and makes an important contribution to sustainability by reducing environmental impacts. The possible link between resource efficiency and digitization is often not perceived. From a business perspective, digital transformation offers great potential, but for most companies, it means a transformation process lasting several years and a challenge. A company's digital transformation aims to use digital technologies and business models to adapt to a changing market and further improve its performance. It is important to understand that the foundation for success is the corporate culture and the involvement of employees. Lean management is, therefore, the basis and prerequisite for Industry 4.0 and targeted digitization. The aim of this paper was to give a brief outline of the possibilities of digitalization for increasing resource efficiency at different levels and propose a framework for increasing resource efficiency through digitalization in a company. Nevertheless, for many companies the possibilities are not present; therefore further projects, subsidies, and initiatives are needed to show the potentials and to take measures.

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A Review Content Analysis Between Industry 4.0 and Sustainable Manufacturing

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Abstract. Manufacturing companies have been facing a dynamic environment due the Industry 4.0 and sustainable development phenomena and, consequently, a greatest attention from researchers has been attracted to investigate how the 4th Industrial Revolution interact or influence sustainable manufacturing. Therefore, the purpose of this paper is to investigate the academic progress regarding Industry 4.0 and Sustainable Manufacturing simultaneously, offering as the main result a review content analysis. More specifically, a bibliometric analysis provides a list of prominent journals and popular conferences and the summary of the main authors and their institutions. Moreover, a content analysis presents a semantic network, illustrating current research efforts and suggesting future research directions, identified by topics. In sum, the first topic suggests the need to explore and comprehend the interaction between the areas. The second topic brings the importance to analyse and understand requirements needed to successfully implement. The last topic shows the different ways to implement and assess the sustainable manufacturing in the context of Industry 4.0.

Keywords: Industry 4.0 · Sustainable manufacturing · Review content analysis

1 Introduction

Manufacturing companies have been facing an increasingly complex environment due to two different phenomena. First, the advent of digital technologies, e.g. mobile cloud, artificial intelligence, sensors and analytics, among others; associated with the abundance of data which have been redefining the manufacturing from the physical world to a digital one [1]. This phenomenon is been named ‘The Industry 4.0 Revolution’ and covers the perspectives of smart manufacturing, connected manufacturing, industrial internet of things (IoT), industrial internet etc. [2]. Second, as noted by Müller et al. [3], manufacturing enterprises are also dealing with the environmental demands translated by rigorous regulations set by governments, the scarcity of natural resources, the employees’ requirement for safer and healthier workplace, and increasing customers’ demand for more sustainable products and services.

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Due these phenomena, some authors have been devoting attention for understanding the fundamentals of the 4th Industrial Revolution and how they could converge with principles and practices of sustainable manufacturing in different perspectives. For example, Gabriel et al. [4] and Morrar et al. [5] discuss the social and environmental impacts of Industry 4.0 with a focus on small and medium-sized enterprises and social innovation perspective. Strandhagen et al. [6], Duarte et al. [7] and Cerri et al. [8] explore the challenges and opportunities that arise around the logistics and LCA process in the digital and sustainable context. In the macroeconomic level, Lin et al. [9] analyses and provide policy recommendations under Industry 4.0 for sustainable development.

Therefore, the main purpose of this work is to investigate the academic progress in the linkage of Industry 4.0 and Sustainable Manufacturing areas. To be more specific, this paper seeks to investigate the prominent journals and popular conferences, besides the summary of the main authors and their institutions. Moreover, this paper also proposes to understand current research efforts and main research directions.

2 Method

The technique used to compose a bibliographic portfolio (paper set) was the Knowledge Development Process-Constructivist (ProKnow-C) proposed by Ensslin et al. [10]. The first step of ProKnow-C consists in defining the search axes, their search terms, the database and the preliminary results, as showed in Table 1. It must be observed that were considered only articles from journals and conferences, written in English, and published from 2008 to the end of July 2018.

Table 1. Description of the search axes, its keywords, the database and the preliminary results.

Axes: Industry 4.0 and Sustainable Manufacturing	Web of Science	Scopus	Science Direct	EBSCO	Preliminary results
Keywords: (“industr* 4.0” OR “connect* manufactur*” OR “smart manufactur*” OR “industrial internet of things” OR “21st manufactur*” OR “4th industrial revolution”) AND (sustainab* OR “sustainab* operatio*” OR “triple bottom line” OR “sustainab* manufactur*” OR “sustainab* product*”)	51	27	47	24	149

In a second step, the test of adherence was carried out, where five papers were chosen in order to verify the validity of the search keywords. According to [10], the test verifies if there is a need to include new keywords. Thus, the search keywords were considered adequate after completed the reading of five validating articles [4, 11–14].

Following the ProKnow-C steps, the duplicates articles were excluded (using Endnote® Online tool), reducing the sample to 125 articles. Then, the titles were analysed, discarding 72 articles that were considered non-aligned with the research topic (Industry 4.0 & Sustainable Manufacturing), resulting in 53 articles.

After reading the titles, the degree of academic relevance was identified through the analysis of publication year and citations number. The results showed recent articles written in the last 5 years, with concentration in the 2017–2018 (70%). However, when verified the citation quantity (using Google Scholar tool), the majority accumulated in five citations and only two articles exceeded 100 citations [13, 15]. This could be explained by the concentration of publications in the last 2 years (2017–2018), which can indicate low level of exposure for scientific community. Due to this fact, any article was rejected, and all 53 articles were considered scientific relevant.

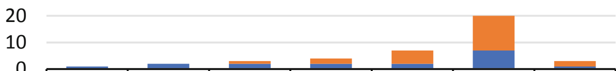
In the last step, abstracts and complete texts were read, and 18 articles were considered non-aligned with the topic, totalizing 35 articles in the sample. Finally, a snowballing approach was conducted, scanning the references and citations of the 35 articles. The objective was to identify additional articles for the sample. Then, following the same steps for the references - reading title, abstract, full text and scientific relevance verification - more 5 articles were added, composing, the final paper set with 40 papers, included in the references.

3 Results

Results cover the presentation and characterization of the paper set by a bibliometric analysis summary, and a content analysis of the paper set to identify research gaps, future directions, the theoretical domains involved, the domain of applications based on empirical studies, and other relevant aspects that define the economic and technological environment.

3.1 Bibliometric Analysis

According to the publication date of the papers, as it is showed in Fig. 1, there is a gradual increase in the number of papers related to Industry 4.0 and Sustainability Manufacturing from 2008 (one article) to the end of July 2018. More specifically, 57% of the articles (n = 23) are published in journals and 43% (17 papers) are part of conference proceedings.



	2008	2013	2014	2015	2016	2017	2018
Journal	0	0	1	2	5	13	2
Conference	1	2	2	2	2	7	1

Fig. 1. Article's evolution over the years.

Figure 2 list the most cited journals and indicates ‘Sustainability’, ‘Computer in Industry’, ‘International Journal of Precision Engineering and Manufacturing-Green Technology’ as the three most cited in the sample.

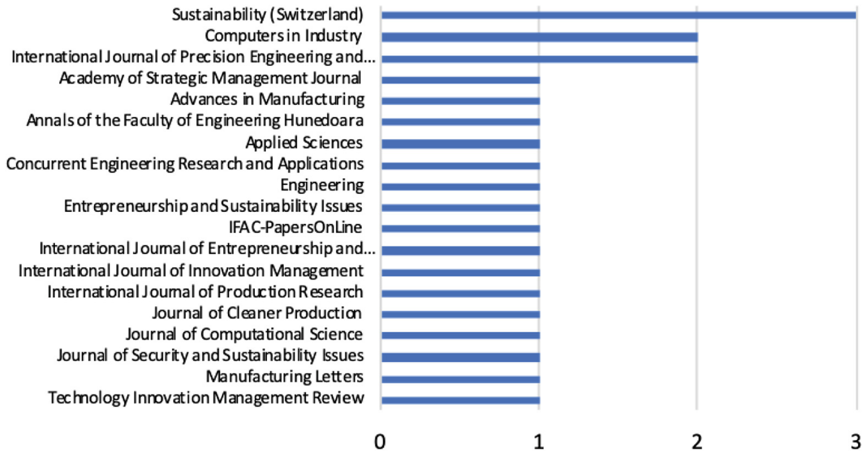


Fig. 2. Most cited journals in the sample.

Furthermore, the ‘Global Conference of Sustainable Manufacturing’, from CIRP, appeared as the most cited conference in the sample with five editions listed in Fig. 3 (11th, 12th, 13th, 14th and 15th).

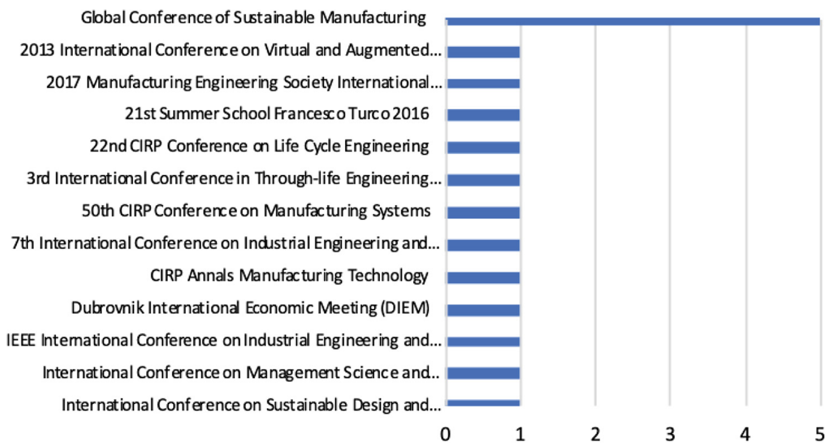


Fig. 3. Most cited conferences in the sample.

From the *contributor perspective*, 145 different authors were extracted from the sample, including all articles’ authors. However, most of them have just authored one paper and only 10 authors are involved in two or more papers: Günter Seliger from Technishe Universität Berlin (3); Bing Xue; Daniel Kiel; Donald Libes Grischa Beier, Gunnar Prause, Jan Ola Strandhagen, Julian Müller, Kai-Ingo Voigt and Silke Niehoff (2 publications each).

From the *affiliation perspective*, there are 73 different institutions listed including: 54 universities; 15 Research Centres/Institutions; and 4 Companies. Based on the number of authors and their affiliation the Friedrich Alexander Universität (FAU) from Germany is the most cited university (6 authors) and the Institute for Advanced Sustainability Studies (IASS), also from Germany, is the most cited research centre/institution (5 authors).

From the *geographical location perspective*, around 58% of the affiliations (42) are located in Europe, followed by America (16 in total), Asia and Africa 16% (11) and 3% (2), respectively. In particular, the top countries ranked from each continent are described. As the cradle of the term Industry 4.0, it is expected that most of the papers involve institutions from Germany (32%). Despite this, it was observed that China and South Korea have also interest in theme. By contrast, countries from the Americas, Africa, exception made to the United States (14% from total), are just currently starting to draw attention to the topic.

3.2 Content Analysis

Once the bibliographic survey carried out, the content analysis was performed to understand how the Industry 4.0 and Sustainable Manufacturing are been discussed. In order to achieve this objective, a semantic network was framed following the guidelines proposed by Saldaña [16] and using the software ATLAS.ti.® as digital support tool. Semantic networks can be understood as a graph consisting of vertices and edges which represent, respectively, concepts and their semantic relations.

Therefore, based on the semantic networks showed in Fig. 4, it was possible to relate the 40 articles according to the similarity between their studies providing, thus, topics that can support companies to understand how to implement sustainable manufacturing in the context of Industry 4.0.

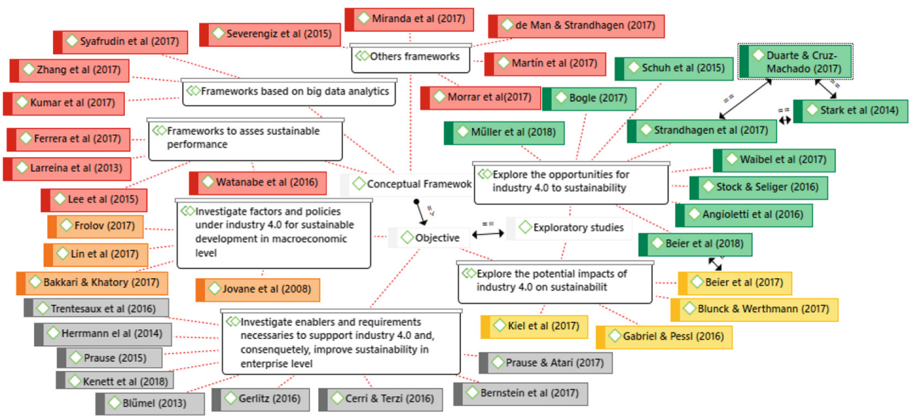


Fig. 4. Semantic network.

The first identified topic suggests that, in order to implement sustainable manufacturing in the context of Industry 4.0, it is necessary to explore and comprehend how different areas interact with each other. These impacts could be found in the results of the studies showed in Fig. 5.

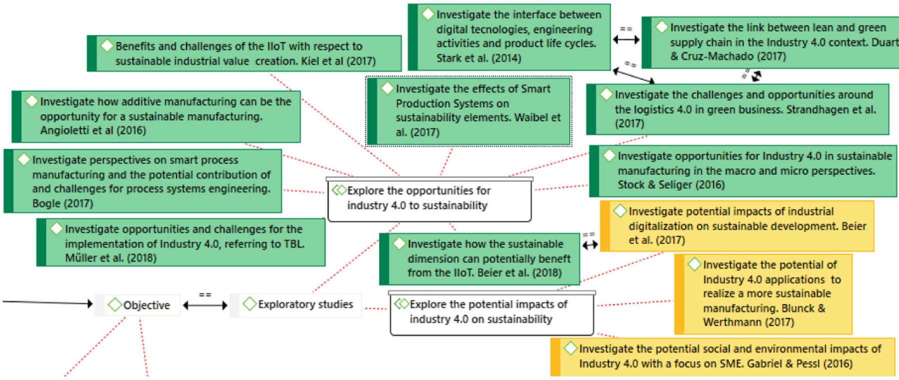


Fig. 5. Cluster of authors dedicated to exploring the opportunities and potential sustainability impacts of Industry 4.0.

In summary, results indicate that Industry 4.0 has a strong influence on sustainable manufacturing in relation to the economic, ecological/environmental and social dimensions. From an economical perspective, the findings of Blunck et al. [17] and Bogle et al. [18] indicate a positive impact where the interconnection of machines, products and humans and the omni-present information about everything (enabled by the IoT, CPSs and RFID-technology) making possible to react in a very fast, efficient and flexible way to every circumstance during operation. Consequently, manufacturing companies can respond faster and more flexibly to volatile market demands, increasing customer satisfaction [19].

Industry 4.0 promises several opportunities regarding the ecological aspects, e.g. reducing greenhouse gas emissions in logistics processes, supported by data-centered carbon footprint analyses [20]. In addition, it is observed a significant material savings due the use of 3D printing technologies [21], energy saving by new and more efficient digital technologies, besides the possibility of sharing renewable energy by Virtual Power Plants [22].

Regarding the social aspects, [4] argue that humans will still a key element in Industry 4.0, but, with the decrease of simple and manual tasks, the interface human-machine will increase the demand of expertise in new communication technologies, and data analysis will become increasingly important. Industries and educational institutions are been asked to think on to develop the required trainings of the future [4].

In a second topic, it was observed that, to have the interaction between Industry 4.0 and Sustainable Manufacturing, some requirements can be necessary. These requirements are investigated in the studies showed in Fig. 6.

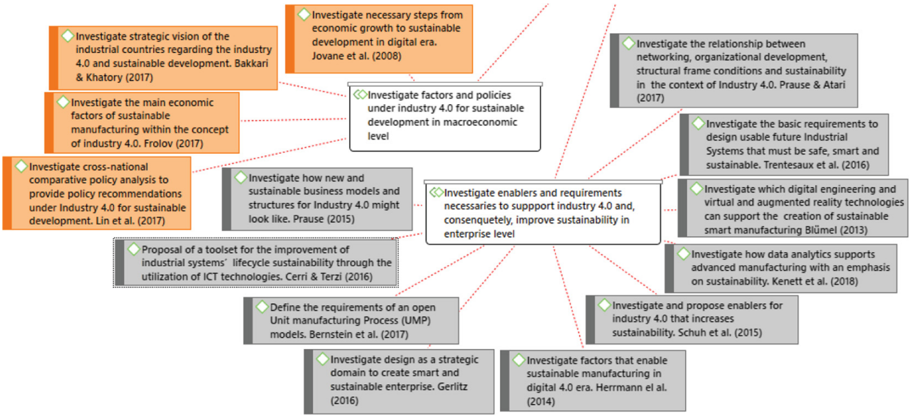


Fig. 6. Cluster of authors dedicated to exploring requirements to support Industry 4.0 and sustainability.

The requirements were divided into two levels. First, from an enterprise level, Prause [23], Prause et al. [24], Trentesaux et al. [25] and Gerlitz [26] indicated innovation and services, design-management, self-organization, self-optimization, goal-orientation and dynamics as success factors for sustainable, flexible and adaptable manufacturing organizations. Complementing, Blümel [27], Schuh et al. [28] and Kennet et al. [29] argue that the full automation, the IT-Globalization, the availability of complete and consist data and the cooperation between activities as the required pre-conditions to enable sustainable manufacturing in Industry 4.0. These results converge with the findings from Herrmann et al. [30] and Bersntein et al. [31] that also include human abilities as a key success factor of the future factories. Highly skilled and educated employees will be needed, who needs to be continuously trained to keep pace with the external requirements and technological improvements.

Second, from a macroeconomic level, Frolov et al. [32] highlights the need to develop a new type of intellectual value chain, production of individual and customized goods at reasonable costs and the use of learning factories as the most significant economic factors in development of industrial production in under Industry 4.0. Bakkari et al. [33] emphasized politicians as a decisive element to achieve the sustainable development. According to the authors, they have significant contribution to play in the adaptation of the training of engineers, managers and technicians in order to familiarize themselves with the Industry 4.0. In addition, Jovane et al. [2] bring, from Industry to university, that research institutes and centers should concentrate on the development of basic concepts for sustainable technologies.

After understanding the interconnection as well as the necessary requirements, the third topic suggests the need to understand how the implementation of sustainable manufacturing in the context of Industry 4.0 can occur and be measured. This way of "how can happen and be measured" are suggested by studies showed in Fig. 7.

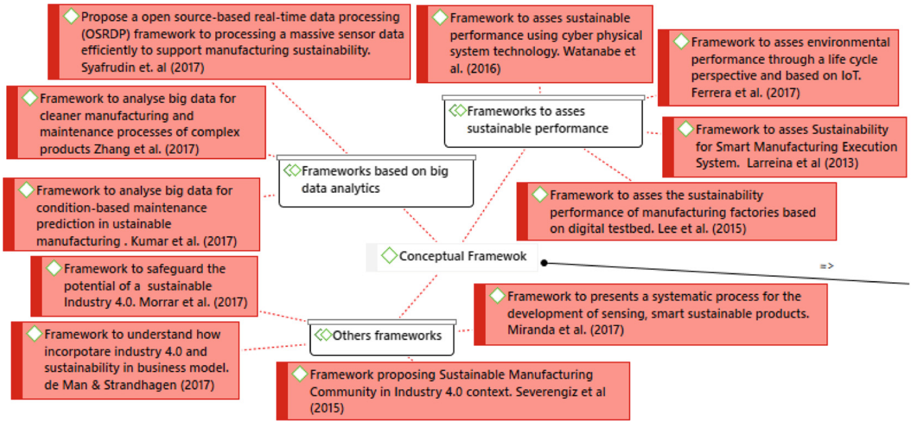


Fig. 7. Cluster of authors dedicated to development of conceptual frameworks.

Ferrera et al. [34], for example, propose the MAESTRI Total Efficiency Framework (MTEF), a management system in the form of platform based on the LinkSmart (middleware that provide interoperable interconnection of appliances, devices, terminals, subsystems, and services) and Device Connectors (electrical connector that provide the means for devices to communicate with the rest of the framework regardless of the communication protocol it uses).

Lee et al. [35] summarizes the Smart Manufacturing Testbed established by National Institute of Standards and Technology. The testbed provide a requirements infrastructure to evaluation on the sustainability performance of manufacturing industries using sustainability metrics and standards. This article converge with Watanabe et al. [36] that propose an evaluation procedure to evaluate performance in industrial production system considering some indicators to qualify and to quantify their sustainability in four aspects: environmental, social, economical and technological.

Sustainability could define the performance construct, and digital technologies are the core elements that form competences that configures the causal elements. Pinheiro et al. [37] model a causal network that could serve as reference for connecting sustainability to digital transformation.

Kumar et al. [38] develops a big data analytics framework to quantify the remaining life prediction uncertainty considering the prediction accuracy improvement, and an effective CBM optimization approach to optimize the maintenance schedule.

In addition, Syafrudin et al. [39] offer a several open sources technologies (including Apache Kafka, Apache Storm and NoSQL MongoDB) to process a massive sensor data efficiently when the number of sensors data and devices increases. Besides that, Larreina et al. [40] discuss Smart Manufacturing Execution Systems (MES), an interoperable platform that operates through Web Services and SOAP protocol (is a message protocol that allows distributed elements of an application to communicate), capable to provide higher connectivity between different systems. From a product perspective, Miranda et al. [41] provide a systematic process for the development of sensing (use of sensors to detect events and measure changes that occur in an environment), smart and sustainable products (S3 products).

Finally, Severengiz et al. [42] suggest the implementation of a Sustainable Manufacturing Community (SCM). The SCM is a web-based non-profit platform set out to collect knowledge, enabling for everyone access to product-based and process-based knowledge sorted by the life cycle of the physical product.

4 Conclusions

The main objective of this research was to review and analyse the academic progression about the linkage between Industry 4.0 and Sustainable Manufacturing, providing a structured content analysis of both areas.

The bibliometric results provided from 40 articles in the paper set, indicated Sustainability, Computer in Industry and International Journal of Precision Engineering and Manufacturing-Green Technology as the most prominent journals. Furthermore, the Global Conference of Sustainable Manufacturing appeared as the most popular conference in the sample.

In addition, from the contributors' perspective, 145 different authors appeared, and 10 authors were identified with two or more publications: Grischa Beier, Daniel Kiel, Donald Libes, Julian Müller, Silke Niehoff, Gunnar Prause, Jan Ola Strandhagen, Kai-Ingo Voigt and Bing Xue. From the filiation and geographical location perspective, 73 institutions were observed, leading by universities established in Europe, highlighting Germany as the most popular.

The content analysis provided a semantic network relating the 40 articles according to the similarity between their studies. These relations made it possible to identify topics that can support companies to understand how to implement sustainable manufacturing in the context of Industry 4.0. In sum, the first topic found suggest the need to explore and comprehend the interaction between the areas. The second topic brings the importance to analyse and understand requirements needed to successfully implement. The last topic shows the different ways to implement and assess the sustainable manufacturing in in the context of Industry 4.0.

When considering the results of this study limitations should be noted. First, papers were collected from only four databases. Second, there was a language restriction, including only researches published in English. Third, only papers from journal and conferences were considered, refusing another vehicle type. However, as a systematic literature review, appropriate restrictions should be specified for the review to be feasible. In conclusion, despite some limitations, this paper has reported the status of the Industry 4.0 and Sustainability simultaneously and has also suggested some potential directions.

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Blood Inventory Management System: Reducing Wastage and Shortage

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Abstract. Blood banks face inventory management problems associated to demand uncertainty and high inventory levels. An efficient blood inventory management is related to the use of simple, transparent and easy-to-understand procedures by blood banks' employees. However, the literature about good practices in blood bank inventory management is scarce, reinforcing new developments need on this subject to ensure a good availability of blood products and reducing wastage. This research presents a blood inventory management system implemented in software, DOAR, able to meet demand while minimizing blood bags wastage. DOAR is simple, user-friendly and able to optimize blood inventory and donations. The purpose of the software is to provide a link between the demand by blood components and collected blood bags.

Keywords: DOAR · Blood banks · Shortage · Wastage · Inventory control

1 Introduction

Blood Banks are responsible for supply products made from blood to hospitals in order to attain patients' needs [1]. As such, [2] define as blood banks' responsibility the guarantee that the donated blood is used efficiently and effectively, minimizing wastage and shortage. Blood scarcity is a worldwide problem. Katsaliaki [3] argue in favor of coordinated efforts in order to reduce wastage associated to blood inventory management practices, out-of-date transfusion practices and production and distribution procedures.

Considering blood supply chains, transfusion occurs through products produced from blood (red blood cells, platelets, fresh plasma among others) presenting different expiry dates depending on the type of product and the form of storage [4]. Thus, [5] classify these products as perishable, making necessary an effective inventory management system in order to reduce disposal while maximizing availability. As such, [1] argue in favor of the use of an efficient process to manage blood's products inventory in order to guarantee blood products' availability and reduce wastage associated to their perishable characteristic.

Perishable products pose challenges in inventory management, such as tradeoff between product availability and waste due to expiry date, temperature out of control,

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problems in refrigeration equipment, among others [6]. As such, blood products shortage and wastage is related to coordination lack between blood bags' supply and blood products' demand. As such, monitoring blood products inventory improves the understanding about blood supply chain, providing balance between supply and demand [7].

The adequate supply of blood bags depends on an effective strategy for collection campaigns. In this sense, management tools can be adapted for health systems reality [8]. Integrated approaches for blood inventory's and donors' management through software is still necessary in order to establish the need for collection and ideal inventory levels [8]. Stanger et al. [6] identified some key elements improving blood inventory management performance: (i) employees training; (ii) ideal stock levels and order sizing; (iii) promote supply chain actors' collaboration; (iv) transparency of the inventory level and; (v) simple inventory procedures.

Blood donors are the raw material source for this supply chain and it is a key element to ensure the system working well [7]. Thus, a policy devoted to donors' management improves the quantity of blood available. Williamson and Devine [4] understand that the use of information and communication technologies (ICTs) can be useful for this purpose.

Another key element is the optimized inventory levels definition in order to balance supply and demand, avoiding scarcity and mitigating the waste of collected material associated with poorly targeted collection campaigns [8].

Stanger et al. [9] have identified key elements that contribute to improve blood inventory management in UK hospitals:

- Human resources and training – training employees to raise awareness of the importance of good inventory management as a key element for a good system performance;
- Define optimized stock levels and order sizes – useful for setting collection targets that can be adjusted continuously;
- Collaboration between departments – promote collaboration between chain links in order to reduce unnecessary requests, improving availability for use and allocation of available blood products;
- Transparency of inventory (transparency and visibility in inventory levels) – inform about inventory levels, since it is a key element to raise the decision-making of chain links on the blood products' quantities to be requested;
- Easy inventory procedures – reduce the complexity and workload for employees, ensuring the optimal supply of products and providing sufficient flexibility so that the blood bank can respond to unexpected changes in demand.

We identified some approaches developed that meet at some level these elements among others [9]. However, all these approaches are limited because they (i) not cover all blood products, (ii) are not implemented in software; (iii) are too complex to be understood by Blood Banks employees and; (iii) does not integrate a functionality that manage blood donors. As such, [6] conclude that it is necessary to develop blood inventory control systems for blood banks able to define blood bags targets to be collected, establish optimal stock levels, being simple and flexible, providing information in a simple and transparent way.

As such, this paper presents an approach implemented in software that, considering the premises proposed by [6] and improving donors' management, is able to meet demand while minimizing the wastage associated to the expiry date.

2 Methods

The development of DOAR followed a user-centred approach, considering the feedback of blood banks employees in order to attend their expectations and provide a simple and flexible solution, respecting their real-life needs. Figure 1 illustrates the methodology used for this development. First stage defines system requirements through an iterative process with stakeholders. Second phase establish and validate the prototype, presenting the main functionalities that will be evaluated by the users. The third stage develops and tests the functionalities. Finally, in the last stage, DOAR was deployed at the blood bank, identifying potential errors and/or improvements.

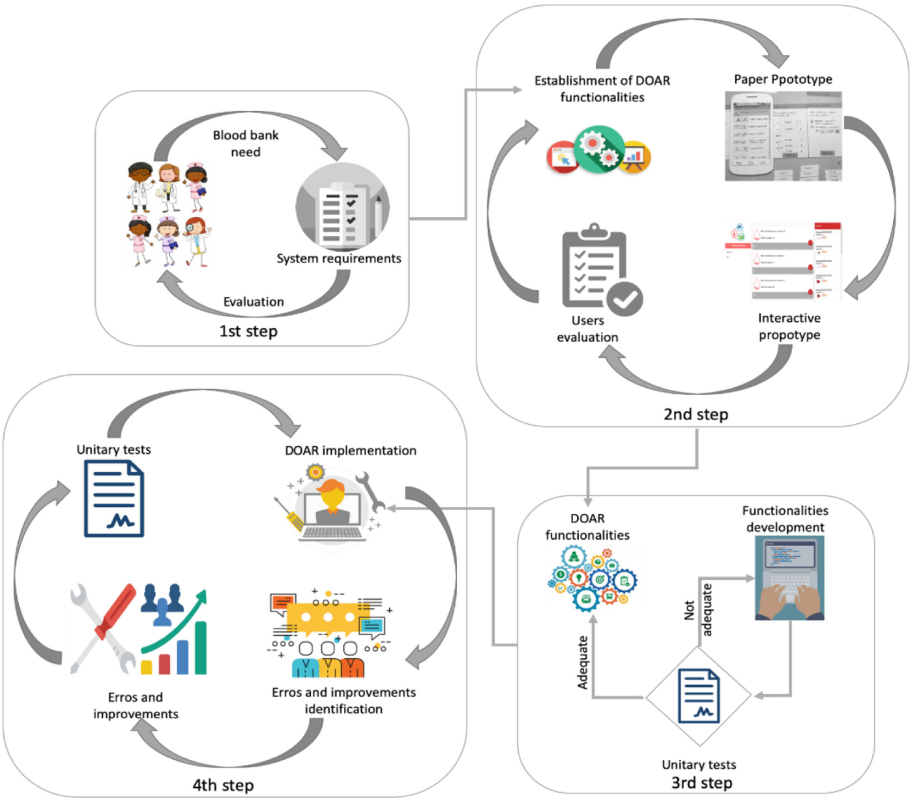

Fig. 1. DOAR development methodology.

On the first step, the iterations with Blood Bank allowed to specify/refine the system requirements, through interactions with users and environment where the system is implemented. Visits and tests with users are essential for discovering new requirements that had not been identified before, which were listed according to the degree of priority. Prototyping was used for this purpose.

The requirements obtained in previous step are expressed in use models and iterative prototypes are proposed to be validated. The requirements validation process is used as a subsidy for the elaboration of interfaces according to the needs of the user and, when validated, it is possible to establish new functionalities, creating new prototypes that must be validated until proceeding to the next stage.

For each use model, an interface is developed in paper, integrated to the interactive prototype and then evaluated by users. The evaluation is performed through the analysis of the user interaction with the prototype. For this purpose, the user is invited to respond questionnaires about the prototype. Considering their point of views, the prototypes are remodelled or integrated a new usage model.

The third step is performed iteratively. In each iteration, some functionalities are chosen to be implemented according to interfaces defined in high fidelity prototype. The features chosen for implementation in the first iteration are those identified as most important by users.

The features are developed according to the priority they were classified by the development team, from highest to lowest. In this way, it is necessary to preserve details such as the number of clicks to access some information and/or the layout of interface elements in relation to the prototype. From this information, it should be checked whether users presenting interacting difficulty with the system interface and whether adjustments must be made to improve man-machine interaction.

Each functionality is tested through a set of unit tests, specified before the development. When detecting errors, the functionality must be corrected by the developer. This step can be performed associated to step 4, in which a new set of usage models are under maintenance.

Finally, on the fourth stage, the system goes through the testing stage. As such, the system is tested in real environment, in order to identify corrections to be done through errors reports by users. The maintenance process is to use deployment feed-back to review or fix functionality.

3 Results

DOAR aims to promote a balance between supply of blood bags and demand for blood components, allowing high availability of blood products with a low wastage rates, resulting in better management of blood bags and their blood components, promoting an optimized use of the products, in order to avoid discards and providing adequate volumes for clinical needs. The conception of the system is illustrated in Fig. 2.

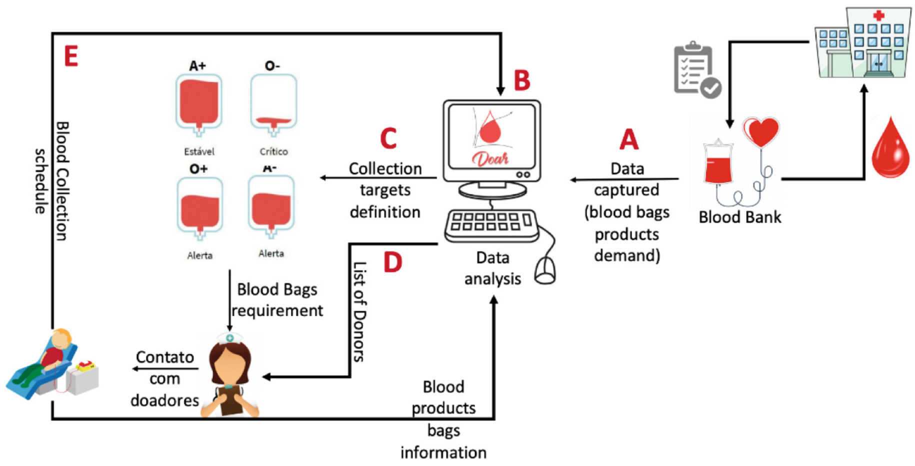

Fig. 2. DOAR conception.

DOAR works as follow:

A. Data collection: DOAR collects blood products bags demand and aggregate them into weekly demands by blood bag type.
B. Analysis of the demand data for projection of optimized levels of stocks (use of statistical models - bootstrap): DOAR determines the ideal stock levels for each blood component for the analysed week through adapted inventory management models, considering each blood product statistical distribution.
C. Blood bags collection targets definition: Considering the inventory management model based on periodic reviews, the weekly collection goal for each blood component is defined by the difference between the desired stock level (established in the previous step) and the current stock.
D. Availability of donor list: Considering the need for collection by blood type, the system lists donors who are eligible for donation.
E. Blood collection schedule: The system provides scheduling feature, allowing blood banks employees to track and track donor schedules by day/time. From this feature, they can track donations that are being made during the week.

In order to exemplify the system developed, Fig. 3 presents DOAR main screen, available when logging in the system. It presents the general collection information of each blood component. In the upper left corner, the collection period is highlighted. It is observed that the collection period refers to the week beginning on 02/17/2019 and ending on 02/23/2019. It is also available the information about each blood component, being presented in their specific fields informing the number of bags needed to be collected during the week. As the collections are carried out, this value is being updated. Another indicator in this field is the drop of blood that presents the performance of the collections in relation to what should be collected and how much has already been collected during that week.

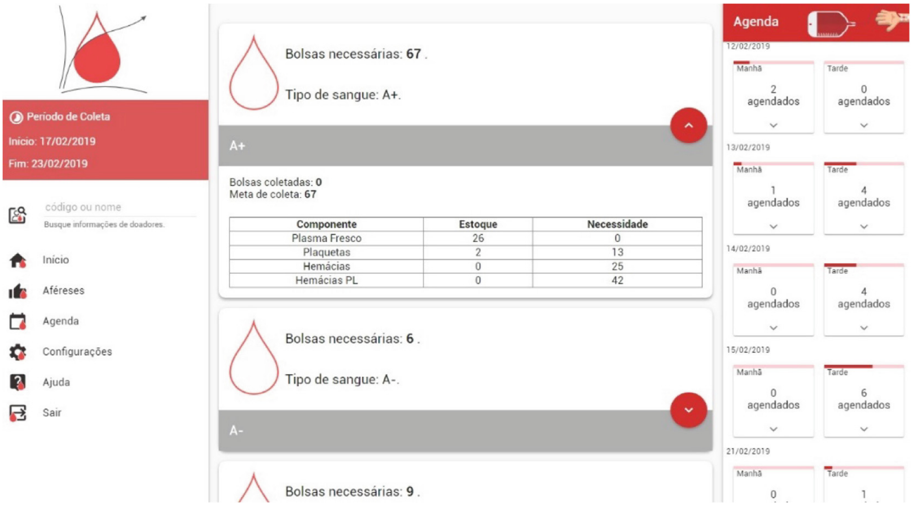

Fig. 3. DOAR main screen.

Other information presented on the main screen refers to scheduled donations by day. In its simplified view, information on how many donors are scheduled per day and per shift are displayed. When you click the scheduled box, the screen expands and displays the names of the scheduled donors.

4 Conclusions

DOAR is a user-friendly system that aims to optimize blood inventory levels and improves donors' management process. The purpose of the software is to provide a link between the demand for blood components and the collected blood bags. It was developed based on the following assumptions:

- Definition of ideal stock levels and order size - use of periodic review model when defining blood bags collection goals, considering the average consumed and service level, which are parameters adjusted continuously and automatically;
- Transparency of the inventory level (transparency and visibility in stock levels) - the system explicitly and clearly indicates the goal of the bags to be collected by blood type, amount already collected and the stock levels of each of the blood components;
- Simple inventory procedures - complexity and reduced workload, making easy the understanding by blood bank staff, avoiding extra activities to employees.

DOAR has a direct interface with Hemovida (system of Brazilian Health Ministry), which simplifies the process, since there is no need for new data. Thus, this software is indicated for the process of management of blood components and donors for blood banks using the Hemovida system. However, it can implanted in a Blood Bank that does not use Hemovida. In this case, an interface must be created for the system used or, if necessary, a module can be deployed so that the data is entered directly into DOAR, through a database dedicated exclusively to the system.

As future steps, other modules will be developed to be integrated into the DOAR, in order to:

- Integrate automated contact functionality with donors;
- Include the scheduling functionality of blood bags (by day/hour) by hospitals;
- Insert a module to integrate Blood Banks of Rio Grande do Norte state, allowing the exchange of products among the participants of the network;
- Develop a new database in order to DOAR replace Hemovida.

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Perspectives for IoT-Based Integration of Distributed and Automated Manufacturing Lines for Mass Customization

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Abstract. IoT (Internet-of-things) platforms can connect sensors and devices along supply chains of production and logistics systems, as well as end users of products, allowing for co-designed and customized solutions. This paper aims to present perspectives for the IoT-based integration of manufacturing lines. More specifically, it will address the implementation of these platforms for the cyber-physical integration of distributed and highly automated manufacturing lines of customized items. A Systematic Literature Review was conducted in order to identify the main characteristics of the research area and to cluster research and practical perspectives. As results, bibliometric analysis has evidenced the continuous growth of the research area and the most important scientific journals publishing content related to IoT-based platforms for distributed manufacturing lines. In the content analysis, the perspectives are clustered in: (i) conceptual propositions and requirements, (ii) new methods and models for supporting decision-making, (iii) development of technology-based approaches, and (iv) empirical studies. As conclusion, the paper wraps up with the description of interesting avenues from both a scientific and a praxis-oriented point-of-view.

Keywords: Advanced manufacturing · Industry 4.0 · Cyber-physical systems (CPS) · Internet of Things (IoT) · Production and logistics intelligent systems

1 Introduction

The performance of distributed production systems of mass-customized products depends on the decision making alignment and synchronization of information and material flows along product design, supply planning and execution, manufacturing and logistics [1, 2]. The increasing digitalization of production and operations supported by the use of information and communication technology, which connects physical and information flows in cyber-physical systems enables the acquisition of real-time system state data that can be used to support better decisions along manufacturing networks [3, 4].

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In this direction, the increasing use of sensor-equipped collaborating machines and devices, often referred to as “Industry 4.0” [3, 5], enables the collection of data about the current system state in real-time. Considering production, transport, inventory and supply data is a step in the direction of an industrial digital twin representing the real physical system virtually [6, 7]. Combined with the increasing power of today’s computers, this representation will support an integrated planning and control with the ability to react rapidly to execution changes.

The main technology related to these new paradigms is called the Internet of Things (IoT), which can be defined as an infrastructure capable of interconnecting physical and virtual systems, by means of information and communication technologies of various devices connected to the Internet [8, 9]. The integration of distributed production systems based on IoT technologies allow several opportunities to recon-figure supply chain structures and integrate their operating processes [10]. This enables the development of Distributed Manufacturing (DM) systems, combining cyber-physical technologies to create manufacturing networks geographically distributed [11]. It is expected that in DM Systems the use of resources will be more efficient, providing better control of the production process, reducing product lifecycle costs and enabling optimal resource loading in response to customer-generated variable-demand tasks [11, 12].

However, there is an increasing need to develop feasibility studies for the implementation of IoT platforms in distributed manufacturing systems [13, 14]. These platforms appear as infrastructure necessary for integrated and synchronized decision-making in distributed, automated and flexible production systems [15].

Some reviews have already dealt with the distributed manufacturing systems in different directions. Mourtzis and Doukas [16] specify the main trends, issues, and sensitive topics in decentralized manufacturing systems through a systematic review of the literature. Srai et al. [17] set out the key challenges and opportunities emerging from distributed manufacturing, describing the concept, available definitions and consider its evolution in recent production technology. However, a systematic literature review dealing with IoT-based integration of distributed manufacturing networks were not found in the literature. In this context, this paper aims to present a Systematic Literature Review covering the main perspectives for IoT integration of distributed and automated manufacturing lines for mass-customization products.

The following research questions guided the development of this research: (i) what is the temporal evolution and main journals that link research involving the theme? (ii) What are the important themes for research involving IoT in distributed and manufacturing? (iii) What are the research perspectives and what is the current state of development of the area? The review was conducted on the scientific bases Web of Science and Scopus through a bibliometric analysis in order to identify the main characteristics of the research area and a content analysis to identify and cluster research and practical perspectives.

2 Methods

The systematic literature review methodology applied in this research is based on the model proposed by Moher et al. [18], following the steps: search and paper collection, papers screening and results analysis. Search was performed in Web of Science and Scopus databases, considered as the largest repositories of scientific documents [19]. A search strategy was constructed based on the definition of main terms of the area, Table 1 presents the final versions of the search strings used in each database, as well as the amount of results in terms of the number of publications. Only papers published in journals and in English were considered for the elaboration of the bibliographic portfolio.

Table 1. Search strings.

Database	Search string	Results
Web of science	TS = ((“IoT” OR “Internet of Things”) AND (“distributed manufacturing” OR “mass customization”))	33
Scopus	TITLE-ABS-KEY-AUTH ((“IoT” OR “Internet of Things”) AND (“distributed manufacturing” OR “mass customization”))	32
	Total	65

The final search was performed in May 2019, 65 articles were found, 33 from the Web of Science database and 32 from Scopus. The terms used for the first construct were “*IoT*” and “*Internet of Things*” and for the second “*distributed manufacturing*” and “*mass customization*”, search was applied in the titles, keywords and abstracts of the papers. The research protocol was built according to the process model presented in Fig. 1, the main purpose of this study was to select only papers that clearly covered application and/or development of IoT-based integration of distributed manufacturing

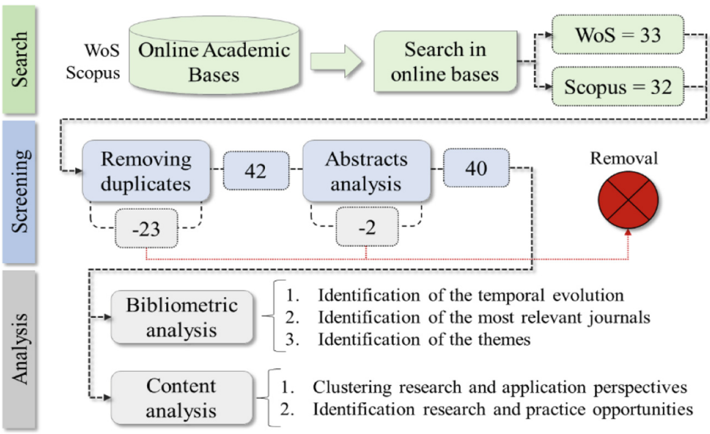

Fig. 1. Methodological research flow process.

lines. Thus, the classification taxonomy including all steps was composed as follows: (i) search: including the process of searching the databases and compiling the data; (ii) screening: removal of duplicate papers and analysis of abstracts to identify theme alignment; (iii) analysis: including a bibliometric analysis in order to identify the main characteristics of the research area and a content analysis to identify and cluster research and practical perspectives.

The final selection included 40 papers published in journals with thematic alignment, the bibliometric and content analysis was performed considering this group. The bibliometric analysis covered the following aspects: identification of publications temporal evolution, most relevant journals and main topics in the area. The content analysis focused in classification of research and application perspectives and identification of research and practice opportunities. The perspectives are clustered in: (i) conceptual propositions and requirements, (ii) new methods and models for supporting decision-making, (iii) development of technology-based approaches, and (iv) empirical studies.

The software R 3.5.2 [20] with IDE RStudio 1.1.463 were used as a computational resource for data manipulation and analysis. All analyses were supported by the "Bibliometrix" 2.1.2 package [21].

3 Results

3.1 Bibliometric Analysis

Figure 2 shows the temporal evolution of publications in the selected portfolio. The first year that appears publications in journals indexed in the databases considered was 2015 with three publications, in the following years the number of publications has grown consistently. Between 2017 and 2018 publications increased 125%. This analysis allows to highlight the growing interest in IoT-based applications in distributed manufacturing considering mass customization aspects.

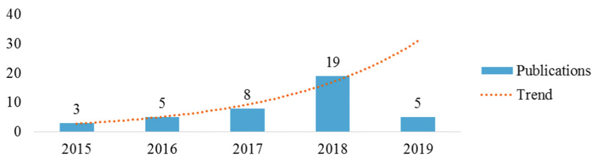

Fig. 2. Publications temporal evolution.

Figure 3(left) shows the ten journals with the highest concentration of publications in the analyzed group. The International Journal of Production Research was the one with the highest number of publications. Figure 3(right) shows the ten most cited journals, in this case there is great emphasis on the International Journal of Advanced Manufacturing Technology as well as several other journals that link studies of operations management, logistics and technology.

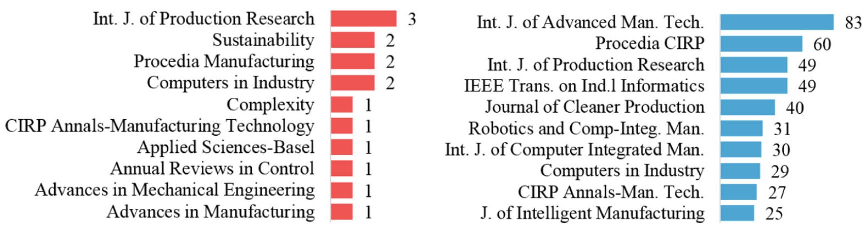

Fig. 3. Journals of analyzed group (left) and most cited journals in the analyzed group (right).

In the Fig. 4 a thematic map was constructed based on Cobo et al. [22], considering the most evidenced terms in the keywords of the publications, relating the density and centrality of the terms from four perspectives: motor, specialized, emerging and basic themes.

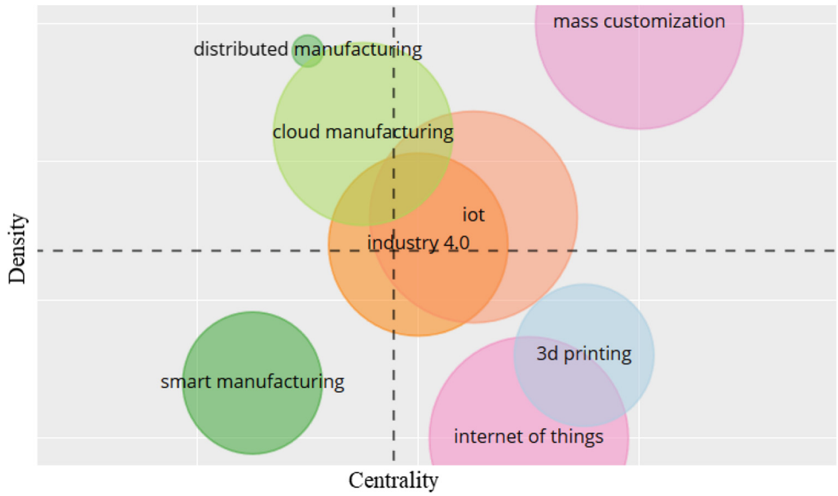

Fig. 4. Thematic mapping of the area.

The themes located in the right upper quadrant represent motor themes, being well developed and important areas for the structuring of a research field, in the case Mass *Customization*, *IoT* and *Industry 4.0* appear in this classification. The themes in the upper left quadrant represent specialized themes, with the terms *Distributed Manufacturing* and *Cloud Manufacturing* appearing in this classification. In the lower left quadrant are the emerging themes, appearing *Smart Manufacturing*, highlighting the literature consolidation on industry 4.0. Finally, in the lower right quadrant are the basic themes, which are considered important for the development of the field, being more generic and transversal, the themes *3D printing* and *Internet of Things* are in this category.

Figure 5 shows a keywords co-occurrence network by multidimensional scaling [23] using edge betweenness centrality clustering algorithm [24]. This analysis allows the identification of a main cluster of terms (in red) that deals with the intercession between the themes investigated in this research. As central terms appear cyber-physical systems and mass customization, another smaller cluster is formed in the lower left corner, dealing with more isolated studies of IoT systems and technology. Other related terms such as optimization, shop-floor and challenges appear more isolated in the network.

In the next section will be discussed the content of the papers selected aiming the classification of research and application perspectives and identification of research and practice opportunities.

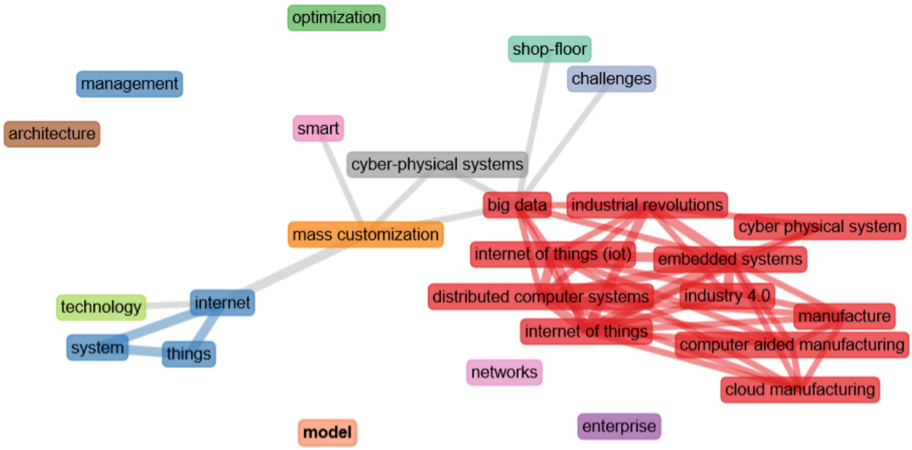

Fig. 5. Keywords co-occurrence network.

3.2 Classification of Research and Practical Perspectives

The content analysis carried out allowed the classification into four perspectives: (i) conceptual propositions and requirements, (ii) new methods and models for decision-making, (iii) development of applied technology-based approaches and (iv) empirical studies, including the operational, economic and social viability analysis of implementing such platforms. Table 2 shows the classification of publications by perspective.

Most publications are concentrated on the first two aspects, which indicates that the research area is in an early stage of development with a focus on conceptual and requirements studies and the proposal of new models for decision-making. Figure 6 shows the development of the research area over time by the four perspectives proposed.

Table 2. Classification of studies by perspective.

Perspective	Authors
(i) Conceptual propositions and requirements	Bendul and Blunck [25], Thramboulidis et al. [26], Jin and Ji [27], Pilloni [28], Ribeiro and Hochwallner [29], Vukanović [30], Wang et al. [31], Xiong et al. [32], Yin et al. [33], Filho et al. [34], Trstenjak and Cosic [35], Wang et al. [36], Zhong et al. [37], Srai et al. [17], Ng et al. [38], Tien [39], Zhou and Piramuthu [40]
(ii) New methods and models for decision-making	Babiceanu and Seker [41], Park et al. [42], Song et al. [43], Chen et al. [44], Chung et al. [2], Huang et al. [45], Kang et al. [46], Latorre et al. [47], Li et al. [48], Safar et al. [49], Simon et al. [50], Sinclair et al. [51], Tsai and Lu [52], Liu and Zhang [53], Li et al. [54]
(iii) Development of applied technology-based approaches	Cerdas et al. [55], Shen et al. [56], Park et al. [57]
(iv) Empirical studies	Cozmiuc and Petrisor [58], Fettermann et al. [59], Kokuryo et al. [60], Takenaka et al. [61], Valmohammadi [62]

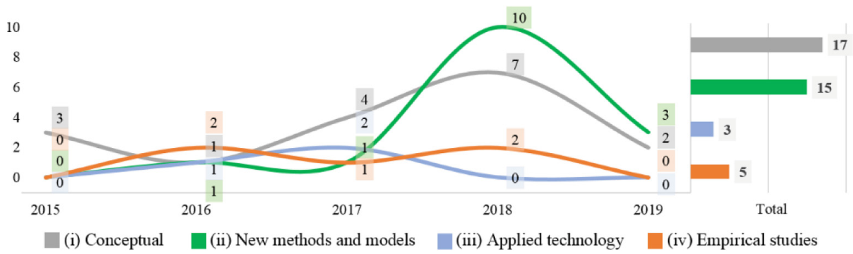

Fig. 6. Perspectives for IoT-based integration of distributed manufacturing over time.

For perspective (iii) few studies are related, although the area of IoT technologies is better developed in a general aspect, the cut of the literature involving distributed manufacturing includes few studies. For empirical applications, few studies were found by the search performed. Fettermann et al. [59], Takenaka et al. [61] and Valmohammadi [62] conducted surveys to evaluate the adoption of IoT technologies in the context of industry 4.0. They found convergent results indicating significant contributions of IoT adoption for various aspects involving production and logistics. Only two papers have reported real case studies of IoT applications for distributed manufacturing and mass customization. Cozmiuc and Petrisor [58] have reported the case of Siemens adoption of a cyber-physical system by using IoT technologies for integration and mass customization of production, Kokuryo et al. [60] have reported a Japanese case study to demonstrate the usefulness and flexibility of adopting the IoT and printing technology using cloud computing and cyber-physical systems for custom manufacturing.

4 Conclusions

This article conducted a systematic review covering IoT-based technology for distributed manufacturing and mass customization. The results indicate a great interest in the research area, which also shows that the area is at an early stage of development, with few studies addressing practical and empirical aspects of the theme.

The recent development of the area indicates great direction of research for the next years integrating the topics covered in this research. The impact of production systems adopting additive technologies and the effect of IoT platforms on manufacturing networks have been mainly studied separately. Actually, the first experiences observed suggest that there is a strong interaction between these two technological areas that mutually enable the introduction of new organizational forms and new business models. For instance, products obtained by additive manufacturing, which require long printing times, can in particular exploit the possibility to dynamically organize a network of factories distributed throughout the territory in complex supply chains, managed in real time to cope with peak demand and to offer a unique interface to the customer.

For future researches, practical studies integrating these two technologies can strongly contribute to the development of the area, besides it was noticed an absence of studies that approach conceptually in a more general way the main aspects for the IoT-based technology application in distributed manufacturing systems.

The analysis of the distributed and automated manufacturing lines, supporting the planning and implementation of the IoT platform, indicates interesting avenues from both a scientific and a praxis-oriented point-of-view regarding IoT-based integration of distributed and automated manufacturing lines along supply chains: (i) the structuring of manufacturing in distributed, networked and highly automated production units based on advanced manufacturing technologies, supported by integrated and intelligent transportation and logistics systems, as well as through the adoption of lean manufacturing practices and techniques; (ii) customization of devices considering various dimensions of customization (composition, structure, geometry, assembly) with improvement of cost benefit ratio and reduction of time to delivery; and (iii) monitoring the effectiveness of items by combining data from design, manufacturing, and transportation with those collected during the effective use. We strongly believe that the following interesting avenues can be the way to the theoretical and practical development of the research area towards an integrative supply chain management of distributed systems.

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Stochastic Liquidity Model and Its Applications to Portfolio Selection

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Abstract. Liquidity is a classical economic concept derived from an investor's preference to hold assets that are easier to sell; generally, the greater the uncertainty, the greater the liquidity. Despite the large number of liquidity measures that have been proposed in the scientific literature, the financial market, and the recent international financial crisis, liquidity has played a minor role in the Modern Finance Theory, which focuses substantially on the return-risk trade-off. This study presents a financial engineering approach that deals with the liquidity phenomenon for a portfolio optimization problem. The proposed stochastic model was applied to investment portfolio formation using real data in two different financial markets (Brazil and USA), and its efficiency was tested comparing its results with those of another classical portfolio optimization model. The proposed model presented good out-sample performances in both markets, even when using fewer shares than those used in traditional models.

Keywords: Portfolio optimization · Stochastic liquidity · Mixed linear programing · Risk management

1 Introduction

The concept of liquidity has been interpreted differently over time. The liquidity level of the assets has been assessed according to how fast they can be transformed into cash. Liquid assets can readily be converted into cash if there is a trading market. Investors implicitly incorporate the notion of liquidity into their decisions, in other words, investors prefer to hold liquid assets rather than illiquid assets. The present study understands liquidity of an asset as the trading volume combined with the trading days.

"The Modern Finance Theory" is based on the duality return vs. risk. In particular, the portfolio optimization model, known as mean-variance (MV) defines an optimal combination of assets with minimum feasible risk in order to exceed the pre-established return goal. The risk measure adopted was variance [1, 2].

Many problems related to the choice of using variance as a risk measure have been identified, mainly because it penalizes equally both positive deviations (desirable to investors) and negative deviations (undesirable). This and other weaknesses have led to the development of new risk measures which, in turn, have led to the development of

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new portfolio optimization models [3–6]. Among them are the following models: (i) Mean-absolute Deviation (MAD) [7] and (ii) downside risk models, such as Lower Partial Moment (LPM) [8, 9] and Conditional Value at Risk (CVaR) [10–12].

The purpose of the present study is to investigate the viability of a portfolio optimization model that incorporates a stochastic liquidity evaluation process. In order to reinforce and make it easy to identify different liquidity intensities and effects on portfolio value, two distinct free and competitive markets were selected for testing and comparison. Firstly, the American stock market, which is regarded as being a high liquidity market (NYSE). Secondly, the emerging Brazilian stock market (B3), regarded as being a low liquidity market and one of the members of BRICS.

2 Theoretical Framework

This section presents a brief review of CVaR and portfolio liquidity. A standard linear model for CVaR is also defined.

2.1 The Conditional Value at Risk (CVaR) Model

There are four properties in order for a measure π of risk X to be considered coherent [3]: (i) Monotonicity, in other words, if $X \leq Y$, $\pi(X) \leq \pi(Y)$; (ii) Translation, $\pi(X + a) = \pi(X) + a$; (iii) Homogeneity, $\pi(\lambda X) = \lambda\pi(X)$ and (iv) Subadditivity, $\pi(X + Y) \leq \pi(X) + \pi(Y)$. The Conditional Value at Risk (CVaR) measure fulfils all conditions, while Value at Risk (VaR) violates the fourth property, and it is not a coherent risk measure [3]. Moreover, VaR assumes normal distribution of asset returns, and there are significant differences when asset returns are non-normal with large left tails or if the assets present few data as the illiquid stocks [13–15]. CVaR at confidence level β is defined as the expected conditional value of losses of a portfolio since the losses are greater or equal to VaR.

Considering $z = f(x,w)$ as the portfolio loss related to investment x and the unitary return w of each asset, and $\alpha_\beta(x)$ as the VaR of the portfolio at the level of confidence β, the CVaR at the same level of confidence is defined as the expected conditional value of portfolio losses since the losses are greater than or equal to VaR, as follows:

$$CVaR = E\left[z/z \geq \alpha_\beta(x)\right] \tag{1}$$

A general model was developed to estimate CVaR without knowing VaR [12]. This proposal reaches the optimum solution using a linear programming model, which allows for computational treatment and the solution of large-scale problems.

$$\min Z = \alpha + \frac{1}{(1-\beta)S}\sum_{s=1}^{S}\mu_s \tag{2}$$

Subject to:

$$\mu_s \geq 0 \text{ s} = 1, \ldots, \text{S} \tag{3}$$

$$\mu_s \geq -\sum_{i=1}^{N} x_i r_{is} - \alpha \text{ s} = 1, \ldots, \text{S} \tag{4}$$

$$\sum_{i=1}^{N} x_i \mu_i = \rho \tag{5}$$

$$\sum_{i=1}^{N} x_i = 1 \tag{6}$$

$$x_i \geq 0 \tag{7}$$

Where:

α – variable that represents the VaR of the portfolio at the level of confidence β,
β – confidence level used,
S – number of scenarios used to represent the uncertainty of the analysed assets,
μ_s – auxiliary variable used to estimate the CVaR,
x_i – participation of asset i in the portfolio,
μ_i – expected return of asset i,
ρ – expected portfolio return,
r_{is} – return of asset i in scenario s,
N – number of analysed assets.

Despite the development of new concepts of risk measures, traditional portfolio optimization models assume that investors can trade any type and number of assets at any time. However, in reality, investors face liquidity constraints in virtually all financial markets, in other words, they are incapable of quickly changing portfolio positions when necessary [16].

2.2 Liquidity and Portfolio Value

Being unable to initiate or unwind a portfolio position instantly is a fact of life for traders in most financial markets. This is consistent with the characteristics of current financial markets, in which it may take an extended period of time to accumulate or unwind a specific portfolio position [16]. Despite the electronic trading resources, several studies have showed that large orders are often divided into smaller ones and are not implemented in a single moment of trading [17–19].

Liquidity is usually defined in terms of the bid-ask spread and/or transaction costs associated with trading a security, such as the brokerage fee, one of the simplest factors that can be observed in transaction costs [20]. Nonetheless, there is still controversy regarding the definition of liquid market or liquid/illiquid assets and their appropriate liquidity measures [21]. This article differs from others because it considers the classical and broad definition of liquidity of the analysed asset. This approach aligns with conventional wisdom, and consistent evidence from other studies [22]. Moreover, the recent international financial crises have shown that firms with high trading volumes tend to be more liquid. This study interprets liquidity as a condition that limits negotiators' ability to buy and sell assets, thus being an additional restriction to portfolio optimization models. Although apparently undesirable, illiquid shares play an important role in portfolio management, and they are often used to balance risk vs. return.

3 Methodology

This article presents a mathematical optimization model based on stochastic calculus, which was tested in a proposed experiment that improved the liquidity conditions of the potential assets from two distinct markets by forming two random samples. The sizes of the samples are similar to those in many other financial studies [23].

Initially, all shares listed and traded between January 2010 and November 2014 on the B3 (449 shares) and the NYSE (3,250) were classified in each market according to their respective trading volumes and trading days. During the review period, the prices, volumes, and trading days were collected by the Bloomberg system. Altogether, seventy five shares were selected: forty five American stocks (dal; phm; ph; dd; pcp; rai; flr; px; rcl; slb; hp; emn; apd; clx; gis; ua; kim; abb; bbl; ois; pay; ofc; sune; igt; uhs; amg; lho; rax; hme; ce; fn; hql; glob; fro; swft; wes; burl; my; lad; omam; acco; ares; tnk; sgf; mxf) and thirty Brazilian stocks (abev3; bbas3; bbdc4; bnbr3; bobr4; brkm5; brml3; cesp6; cruz3; cyre3; dasa3; elet3; embr3; goau3; goau4; hgtx3; jbdu3; jbss3; krot3; ligt3; lixc4; pcar4; pdgr3; pfrm3; rhds3; timp3; tupy3; usim5; vagr3; visa3). The shares of companies that had gone private during this time period were excluded. The selected shares were subsequently grouped into high (70% of trading volume combined with trading days), medium (20%), and low liquidity (10%). Stratified samples composed of six high, medium, and low liquidity groups from both markets were randomly formed.

4 The Proposed Model

All portfolios are formed to be sold one day. Moreover, in a real-world market, the stocks are traded at discrete random times [24]. The present study shows a simple but realistic mathematical model that assumes a planning horizon T, subdivided into t equal intervals for trading the portfolio, which comprises N shares, each one assuming a trading probability p. The stability of the trading condition of the assets observed during the analysed periods considers that probability p remains constant over time T and during the t discrete attempts to negotiate during the planning horizon.

This study used historical trading prices during the time period analysed. Since the prices were effectively used during the negotiations, the comparison between the proposed model and the classic optimization models was more realistic. Based on the prices, stochastic calculus was used to simulate an investor (or portfolio manager) who intends to put together and break up portfolios in different time periods.

The activity of buying one share for later sell is assessed at time $t = 0$. Sale attempts start at $t = 1$, with an estimated price S_1 until the final date $t = 3$, when the sale has to be completed. Each sale attempt has an estimated price S, a trading probability (p), and a non-trading probability ($1 - p$). If the expected sale value during the planning period T is profitable, the share is bought (or the portfolio is formed), otherwise, there is no investment recommendation. According to this logic, a probability $p = 1$ means that the formed portfolio is immediately sold. The generic mathematical expressions of the expected value of an asset and the portfolio value composed of N assets where each asset's weight is x are as follows:

$$\bar{S} = pS_1 + p(1-p)S_2 + p(1-p)^2 S_3 + \ldots + p(1-p)^{n-1} S_n \tag{8}$$

$$PV = x_1 \bar{S}_1 + x_2 \bar{S}_2 + \ldots x_N \bar{S}_N \tag{9}$$

Equation 8 shows the expected value of the share price as a function of its trading probability and its estimated price at each trading moment. The model defines the most profitable allocation strategy based on the conditional trading probability.

The objective function intends to minimize the risk of the portfolio while respecting the fact that the distribution of values between the portfolio assets must be equal to the amount invested. The target return restriction is adjusted by the liquidity probabilities p of each share and by their market prices S in each trading attempt t. The value of the portfolio is expressed by the sum of the net present weighted values of the shares during planning period. An advantage of this type of structure is that the mixed return liquidity restriction (Eq. 17) may be added to any traditional portfolio optimization model.

Moreover, the following assumptions were considered:

- The portfolio has to be negotiated at the end of $t = 2$ attempts; therefore, its final portfolio value and the final number of shares are equal to 0 (the portfolio is dismounted);
- The assets, in terms of liquidity, are independent and do not share common results [25];
- Direct transaction costs (e.g.: brokerage fee) are constant over the planning horizon T;
- Portfolio value is composed only of share prices;
- Interest rate r is constant over the planning horizon T.

The mathematical stochastic liquidity optimization model (SLOM) is shown below:

$$\min Z_{xb,xs} = \sum_{i=1}^{N} xb_{it=0} S_i RM \tag{10}$$

Subject to:

$$\sum_{t=1}^{T}\sum_{t=1}^{T}\left[\frac{p_i xs_{it} S_{it}}{(1+r)^t}-\frac{C_t}{(1+r)^t}\right]\geq \bar{R}_p \tag{11}$$

$$PV_{t=0}=M_0 \tag{12}$$

$$PV_{t=T}\geq 0 \tag{13}$$

$$\sum_{t=1}^{T} xs_{it}=xb_{it=0} \quad \mathrm{i}=1,2,\ldots,\mathrm{N} \tag{14}$$

$$xb_{it}, xs_{it}\in Z^{+} \tag{15}$$

$$0\leq p_i\leq 1 \tag{16}$$

$$PV=\sum_{i=1}^{N} p_i(1-p_i)^{T-1}x_{Si} \tag{17}$$

Where:

xb_{it} – number of available trading stocks of asset i at the beginning of period t,
xs_{it} – number of traded stocks of asset i on date t,
RM – adopted risk measure (in this study is CVaR),
$\bar{R}_p$ – expected portfolio return,
N – number of analysed assets,
M_0 – total amount invested on date 0,
PV_t – portfolio value on date t,
C_t – transaction costs on date t,
p_i – trading probability of share i,
S_{it} – price of stock i on date t,
r – interest rate used.

The objective function (Eq. 10) minimizes the risk of the portfolio formed at the initial date according to the adopted risk measure. Equation 11 presents the profitability target from the sale of the portfolio at the estimated price of the shares until the deadline T, based on their conditional trading probabilities. The constraints 12 and 13 represent the portfolio value at date t = 0 (equal to the initial investment M_0) and at date T (equal to 0 due to the sale of the portfolio). Equation 14 shows the final balance between the number of shares bought and sold during the analysed period T.

5 Results

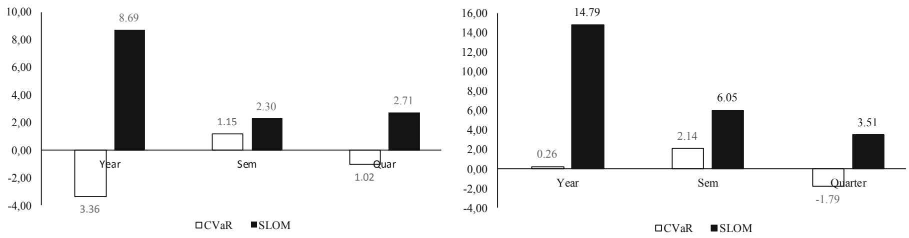
An experiment based on the allocation of 1,000 American and Brazilian monetary units was carried out in order to compare the portfolios formed using different optimization models. We compared the formed portfolios from the viewpoint of multiperiod strategies with different time periods of portfolio formation (1 year, 6 months, and 3 months), including putting them together and breaking them up. Performance was evaluated during the in-sample and out-of-sample periods. The participation index of illiquid shares (PIL) was created to identify and measure the influence of illiquid stocks. Sharpe ratio (SR) was used to compare the performance of the formed portfolios [26]. Small-scale simulations (quarters) were carried out using a Microsoft Excel® spreadsheet and the Solver optimization algorithm. Large-scale simulations (semester and year) were carried out using a LibreOffice® spreadsheet and its optimization algorithm.

The American and Brazilian samples were analysed during 35 different time periods totalling 280 portfolios formed by the optimization models tested under in-sample (IS) and out-sample (OS) conditions. In order to identify the practical advantages of the SLOM model, an initial demonstration was carried out using the probabilities 0.95 and 0.20, as being high/medium and low liquidity, respectively. The formed CVaR and SLOM portfolios were compared using the SR and PIL indexes.

Generally, in all periods, the volatility and return of the Brazilian sample were, respectively, greater and smaller than those of the American sample, indicating greater instability and, consequently, greater difficulties in terms of forming portfolios. The greater difficulty in forming Brazilian portfolios can also be explained by the discount rates that are, on average, twice as large as those in the US market.

The CVaR model takes into account only the return-risk trade-off and considers all of the assets as equally liquid. Thus, as expected, the PIL of the formed portfolios was high. On the other hand, the SLOM model distinguishes shares according to their liquidity condition. Therefore, SLOM formed portfolios for both samples had the lowest PILs, under in-sample and out-sample conditions and during different time periods.

The CVaR model uses all the potential shares because they are all considered liquid ($p = 1$) and assumes a constant average expected return for each share over the period analysed. These characteristics increase the chances of forming portfolios in different time periods. On the other hand, the SLOM model has a different logic. By combining the trading probability with the estimated price, the model allows for the possibility of not forming a portfolio. Accordingly, investors who have illiquid stocks in their portfolios should keep them until there are better trading conditions and prices for these assets. In other words, investors should demand a higher premium for the illiquid shares included in their portfolios. The same conclusion has been reported by other studies that used different methodologies [27]. Figures 1 and 2 summarize the Sharpe ratios and PIL results of formed portfolios. With regard to the SR and PIL, in the most important period (out-sample), the SLOM portfolios showed the best performance.



(a) (b)

Fig. 1. Average Sharpe ratio of Brazilian (a) and American (b) portfolios for different periods of time.

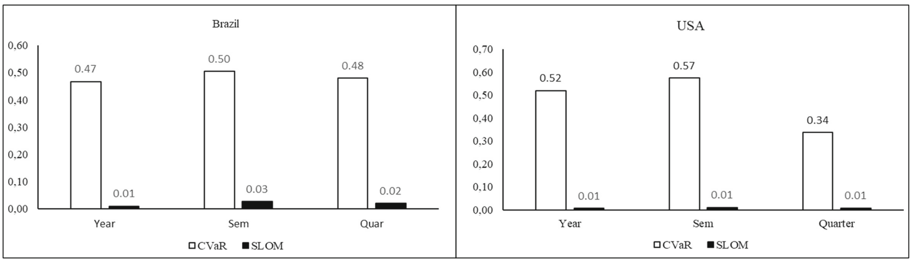


Fig. 2. Average PIL ratio of Brazilian (a) and American (b) portfolios for different periods of time.

Table 1 presents the statistical significance of differences observed at a 1% and 5% level. According to Table 1, there is significant evidence of better results of the SLOM method at 5% significance level for the Sharpe ratio and at 1% significance level for the PIL index. With regard to the SR, in the most important period (out-sample), the SLOM portfolios showed the best performance.

Table 1. Statistical significance results.

Index	Share	In sample	Out-sample
SR	BR	SLOM > CVaR**	SLOM > CVaR*
SR	US	SLOM < CVaR*	SLOM > CVaR*
PIL	BR	SLOM < CVaR**	SLOM < CVaR**
PIL	US	SLOM < CVaR**	SLOM < CVaR**

** (*) denotes statistical significance at the 1% (5%) significance level

6 Conclusions

In this paper we studied the performance of portfolios formed under liquidity conditions of candidate assets from two distinct markets. This work contributed to literature by developing a mathematical optimization model based on liquidity stochastic calculus with promising results for financial management.

The 2007–2009 (USA) and the 2008–2010 (Brazil) financial crises demonstrated the need for development of new portfolio management approaches that incorporate the concept of liquidity in investment decisions. In the present study, in particular, the clustering of the potential assets based on the liquidity concept resulted in portfolios with good performance.

The SLOM portfolios had good out-sample performances in both markets, even when using fewer shares than those used in the CVaR model. The possibility of controlling the liquidity of the shares, associated with their respective price projections, allows for a more realistic assessment of the values of the formed portfolios.

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Career Expectations of Generation Z

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Abstract. In this study we address the importance of understanding career expectations of members of Generation Z. This generation represents the demographic cohort after the Millennials with a starting birth years in the mid-1990s to mid-2000s. Most of Generation Z have used the Internet since a young age and are comfortable with technology and social media. The research was conducted on 357 under graduate students currently enrolled in University of Novi Sad. The results indicate that life-balance, expertise, learning and freedom are found as the most important career aspects for Generation Z students. Gender differences in career expectations were examined. We make several suggestions for how human resources professionals can adjust and evolve current HR practices in order to respond to requests of their future employees. Since there were no Generation Z studies conducted in Serbia, these results give an important insight into current position of Serbian students in relation to findings from similar studies conducted in other countries.

Keywords: Generation Z · Career expectations · Human resource management

1 Introduction

While Generation X and Millennials (Generation Y) are at their jobs, currently the biggest generation is either at the university or engaging in their first jobs [1] while bringing attention to researchers and HR professionals who are striving to understand the work preferences of this new group. Understanding generational differences and identifying motivation drivers, shared attitudes and values is the key for successful recruitment and retention of talents.

Even though very similar, there are some key differences between Millennials and Generation Z regarding their priorities and organizational behavior. Every generation has its unique traits, but Millennials were the first generation that was unlike any preceding.

2 Theoretical Perspectives

2.1 Generation Z

Generation Z is defined as “the most materially endowed, technologically saturated, globally connected, and formally educated generation our world has ever seen” [2]. The

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members of Generation Z were born in 1990s and raised in 2000s during the most challenging period in the recent history [3]. McCrindle [2] defines Generation Z as those born in 15-year span: from 1995 to 2009. Members of this youngest generation are considered digital natives for integrating technology into their lives since their youngest age. They prefer visual content and, while mostly doing social interaction online, they highly value face-to-face communication.

Some studies predict that the gap between highly-skilled and unskilled workers will continue to grow with Generation Z [2]. These studies note that a growing elite of highly trained workers will emerge. The workers will have highly developed both technical and (inter)personal skills. It will be very challenging to effectively retain such employees. A different research has found that advancement, money rewards and meaningful work are of the greatest importance to the members of Generation Z cohort. It is not so important for them to have a good manager or to work for a fast growing company, but they point out the importance of their ideas to be listened to and their opinion to be valued. The members of Generation Z feel their generation is creative, open-minded and intelligent [4].

The results of a study conducted in Romania [5] indicate that members of Generation Z prefer to work in groups and want to develop a good interpersonal relationship with their coworkers. They express need for professional development but they expect to be monitored and guided through this process by a mentor. They express a strong need for security which reflects in their desire to have a secure job and high salary.

Some researchers justify that there are significant differences between the members of Generation Z and Generation Y, despite their similarities. These researchers agreed that HR professionals need to adapt their activities to the requirements of new generations [6].

2.2 Career Expectations

Pemberton [7] distinguishes the total of 8 different career themes: competition, freedom, management, life-balance, organizational membership, expertise, learning and entrepreneurship.

Competition is defined as the idea of a career as a contest. Competitive persons need recognition of their achievements, otherwise they feel frustrated and dissatisfied. People with highly expressed freedom need autonomy in work and setting priorities. Having high score on management implies the importance of position, title, status and rewards, as well as the use of a whole range of skills to achieve results through and with others. Life-balance suggests the importance of the right balance between work and off-work life, so flexible work practices are expected by that kind of people. Organizational membership implies identification with organizational goals and values. People with high scores on expertise need the opportunity to develop their expertise by specialization. Learning is defined as being challenged and learning to overcome obstacles through acquisition of new knowledge and skills. Finally, entrepreneurship is defined as set of features such as self-conviction, self-determination and self-control that stimulate risk taking, rather than making a person frightened and resistant.

A global workplace expectation study was conducted in 2014, which included the total of 1005 respondents from 10 different countries. Generation Y and Generation Z workplace preferences were examined; according to this study, generation Z has more entrepreneurial spirit, prefer face-to-face communication and is motivated by opportunities for advancement. Only 25% of Generation Z respondents consider money as a motivator to work harder, opposed to 42% of Generation Y [4]. Recent research conducted on university students in Slovakia explored career preferences of Generation Z. The results suggest that the nature of job and work-life balance are the most important factors [8]. The same authors [9] also tried to identify and explore the possible barriers to work motivation for Generation Z. Job aspects such as not enjoying the content of work, bad team climate, workload, and having no sense of purpose, are identified as key barriers to work motivation.

Schweitzer et al. [10] argue that inequities in the labor market originate in gender expectations. In their study on gender differences in pre-career expectations they found that, when compared to men, women expect lower salary and longer time to be promoted.

3 Method

The purpose of this study is to investigate career expectations and to look into possible gender differences in career expectations of Generation Z. The research questions for this study are:

- RQ 1: What are career expectations of students, members of Generation Z?
- RQ 2: Is there a statistically significant difference between career expectations for male and female students, members of Generation Z?

3.1 Data Collection

Sample for this study included students from the University of Novi Sad currently enrolled in undergraduate studies. Target respondents were defined as students born in 1995 or later with no limitations regarding the field of study (see Table 1).

Table 1. General description of sample by year of birth.

Year of birth	Frequency	Percent	Cumulative percent
1995	43	12%	12%
1996	73	20.3%	32.3%
1997	75	20.9%	53.2%
1998	69	19.2%	72.4%
1999	88	24.5%	96.9%
2000	11	3.1%	100%
Total	359	100%	

Table 2 shows the distribution of respondents by gender. The sample was not evenly distributed by gender, since more than half of the sample were female students.

Table 2. General description of sample by gender.

Gender	Frequency	Percent
Male	127	35.4%
Female	232	64.6%
Total	359	100%

The quantitative data was obtained through an anonymous online survey. Data collection was carried out in Q1 2019. Respondents accessed the online survey through SurveyMonkey®. Descriptive statistics, frequencies and T-test were analyzed with IBM® SPSS® Statistics software, version 24.

3.2 Measurement

This paper investigates career expectations of generation Z. The total of 8 different career themes are examined: competition, freedom, management, life-balance, organization membership, expertise, learning and entrepreneurship.

Career Expectations Questionnaire, adapted from an expectations questionnaire presented in a book "Strike a New Career Deal" (Pemberton, 1988), was used to explore career expectations of students. Each of 24 questions relates to one of the 8 employee-employer related themes: 1. *competition* (3 questions), 2. *freedom* (3 questions), 3. *management* (3 questions), 4. *life-balance* (3 questions), 5. *organization membership* (3 questions), 6. *expertise* (3 questions), 7. *learning* (3 questions) and 8. *entrepreneurship* (3 questions). Students rated how important are statements describing their future career expectations, ranging from 1 meaning "No importance" to 4 meaning "Very important". Questionnaire for socio-demographic characteristics has 2 items.

The Cronbach's Alpha for Career Expectations Questionnaire was 0.837. The internal consistency of multi-item scale is established, since this value is above recommended threshold of 0.700.

4 Results

In the first section we examined the score distribution of Career Expectation Questionnaire. The structure of career expectations and its eight dimensions is analyzed in the next section. We used the key provided with questionnaire in order to compute the career expectation dimension's variables. Factor analysis was not performed for the purposes of this study. In the last section we discuss gender differences in career expectations of Generation Z.

4.1 Score Distribution of Career Expectation Questionnaire

The respondents reported the highest level of agreement (mean > 3.60) on questions that represent: *competition* (question 1), *life-balance* (questions 4, 6, 16), *organization membership* (question 9), *expertise* (question 22, 13) and *management* (question 14).

The lowest level of agreement students referred to the other two items that address *competition* (question 19 and 11) and point to specific situations where their performance and abilities are compared to others in work environment (see Table 3).

Table 3. Score distribution of Career Expectation Questionnaire.

Question		Mean	Std. Dev.
1	Promotion	3.89	0.384
6	A balance between work and other areas of my life	3.84	0.448
9	Being part of an Organization	3.78	0.526
4	Enough leisure time to travel, relax and be myself	3.70	0.591
22	Knowing every year that I have further developed my expertise	3.62	0.530
14	Being able to get the most out of people in order to achieve the set goal	3.62	0.649
16	Being able to put work in its place as an important, but not the only part of my life	3.60	0.635
13	To be recognized for my expertise	3.57	0.656
18	To be involved in assignments which will take the organisation forward	3.47	0.651
5	Being able to contribute new ideas which will help build the future	3.39	0.746
10	Being given challenges which stretch me intellectually	3.38	0.710
2	Control over how and when I work	3.35	0.676
20	Knowing that I am respected for the specialist skills that I bring	3.32	0.809
21	Being able to work when and where I want so long as I can deliver results	3.32	0.784
8	Opening up new business directions through initiating new ideas	3.31	0.737
24	The excitement of creating something new whose success depends on me	3.29	0.795
12	Being able to identify closely with an organization	3.26	0.754
23	Being able to make decisions without being controlled by organizational bureaucracy	3.26	0.760
3	Being able to get a job done well through managing the efforts of others	2.95	0.867
15	Taking the risk of getting a new business venture off the ground	2.87	0.821
17	To have the status that comes with being part of a successful company	2.73	0.873
7	Leading a team on key organizational projects	2.60	0.881
19	To be able to see that I am doing better than those I am in competition with	2.48	1.027
11	Being able to show that I have more to offer than my colleagues	2.32	0.997

4.2 Career Expectations of Generation Z Students

Students expect to have good life-balance when they begin to work, but they also expect that their career will allow them to develop their expertise by specialization.

They are also challenged by learning to solve problems by developing new skills and creating new knowledge. Members of Generation Z do not see career as a contest. They do not attach importance to position, title, status or rewards, and express low interest to entrepreneurial features such as: risk taking, initiative problem solving, independence and commitment (see Table 4).

Table 4. Career expectations of Generation Z.

	Minimum	Maximum	Mean	Std. deviation
Life-balance	1	4	3.71	0.41
Expertise	1.67	4	3.50	0.47
Learning	1	4	3.41	0.53
Freedom	1.33	4	3.31	0.57
Organization membership	1	4	3.26	0.51
Entrepreneurship	1	4	3.16	0.59
Management	1	4	3.06	0.58
Competition	1	4	2.90	0.66

4.3 Gender Differences in Career Expectations of Generation Z

T-test for independent samples (equal variances assumed) compared the results of career expectations for male and female students, members of Generation Z. There were statistically significant ($p < 0.05$) differences between male and female students on *competition*, *organization membership*, *expertise* and *learning* (see Table 5). The female students showed statistically significant higher levels of these career aspects.

Table 5. T- test for gender differences in career expectations of Generation Z.

	Gender	Mean	Std. deviation	Std. error mean	t	df	Sig.
Competition	Male	2.74	0.670	0.059	–0.237	357	0.001
	Female	2.98	0.635	0.041			
Freedom	Male	3.28	0.557	0.049	–0.631	357	0.529
	Female	3.32	0.580	0.038			
Management	Male	2.98	0.622	0.552	–1.806	357	0.072
	Female	3.10	0.548	0.036			
Life-balance	Male	3.66	0.459	0.040	–1.723	357	0.086
	Female	3.74	0.374	0.025			
Organization membership	Male	3.06	0.579	0.051	–5.860	357	0.000
	Female	3.37	0.427	0.028			
Expertise	Male	3.38	0.518	0.046	–3.849	357	0.000
	Female	3.57	0.429	0.028			
Learning	Male	3.28	0.635	0.563	–3.524	357	0.000
	Female	3.48	0.457	0.030			
Entrepreneurship	Male	3.18	0.654	0.058	0.599	357	0.550
	Female	3.14	0.548	0.036			

The magnitude of the differences (Cohen, 2013) was small for competition (eta squared = 0.01) and learning (eta squared = 0.04), while this difference was medium for expertise (eta squared = 0.09) and organizational membership (eta squared = 0.08).

5 Discussion

The results of this study offer some insight into career expectations of students, who are members of Generation Z. The results indicate that *life-balance*, *expertise*, *learning* and *freedom* are found as the most important career aspects for Generation Z students. Female students show higher levels of *competition*, *life-balance*, *organizational membership*, *expertise* and *management*. These findings are largely consistent with present research on characteristic of Generation Z in work context.

This is an early, but valuable, insight on how important are certain job-related factors to generation Z and how to use them to adjust job design, benefits and other aspects of work. Findings presented in this paper may be useful to the research community, as well as human resource managers and recruiters in terms of obtaining more information on career expectations of students who will soon be entering organizations and become full-time workforce.

6 Conclusion

Identified importance of life-balance to Generation Z in this research, as well as in previous researches [9], will make organizations and human resources professionals to put a different perspective on productivity. For Generation Z the work will not be valued with the amount of work hours they get, but with the actual output they make. Flexible workhours and flexible workplace as we know will have to evolve even more to satisfy the growing desire for more time to spend away from work. Companies who fail to realize that “9 to 5” workday is becoming a part of the past will have difficulties in attracting and retaining Generation Z employees. The human resources professionals will have to provide the continuing education for their young employees who expect to develop their expertise through differentiation, but also to learn to overcome obstacles through acquiring of new skills and knowledge. Their technological supremacy will urge organizations to develop unconventional learning methodology in order to keep up with Generation Z needs. The new technologies such as augmented reality, virtual reality and different interactive tools could be used for new knowledge and new skills acquisition. And finally, the managers will have to rethink the chain of command and their managerial style when managing Generation Z employees who are seeking for greater freedom in decision making and task prioritization.

The present study examined the career expectations of students from the University of Novi Sad. Larger and more (geographically and culturally) diverse sample size is needed to examine the generational stability of career expectations. This study explored only eight variables, but there could be more factors that can influence career choice. To extend and support the results of this study future research has to be conducted.

The new generations of employees who have no fear of change are starting to look for their first jobs. The organizations must make sure that they offer them a dream job, not a safe job. A job that is built on great relationships between employees, supreme work conditions, while fostering freedom and flexibility.

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Group Technology: Hybrid Genetic Algorithm with Greedy Formation and a Local Search Cluster Technique in the Solution of Manufacturing Cell Formation Problems

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Abstract. Group Technology (GT) is a manufacturing philosophy that explores similarities in product and process design. Starting from a binary machine-part matrix, the objective is to form clusters, made up of families of parts and machine cells aiming to minimize the number of voids and exceptional elements in the cells. Since this is a combinatorial problem, the proposed hybrid genetic algorithm (GA) finds good solutions with a partial greedy population that uses similarities with machines and with parts. A local search k-means based method can recreate cells with small movements among machine assignments. The proposed framework performance presents good results, most of them overcoming literature classic problems solutions, when considering the group effectiveness indicator. The results are presented and discussed.

Keywords: Genetic algorithm · Local search · Group Technology · K-means · Cell Formation Problems

1 Introduction

The Group Technology (GT) is a manufacturing philosophy based on the principle of identifying and grouping machines and parts by similarity, leading the production systems to obtains advantages throughout all stages of design and manufacturing [1].

Applying the GT in a productive process will result in a binary machine-part incidence matrix. The cellular manufacturing layout consists in to arrange these elements into cells, seeking to minimize extracellular movements and maximize the intracellular ones. The Manufacturing Cell Formation Problems - MCPF's are considered NP-arduous because of their combinatorial nature and the literature related presents a considerable number of methods applied in their solution, where some of the best known and used for quality comparison are: rank order clustering – ROC [2], modified rank order clustering – MODROC [3], GA [4], SA [5], which uses the grouping efficacy index to measure the grouping effectiveness.

In clustering problems, the modified algorithms with local search techniques are inserted in basic heuristics, overcoming them in terms of grouping effectiveness. The proposed framework employs these hybridizations in a GA, in the search for solutions for the MCFPs, being specifically the method k-means the one chosen to improve the

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individuals of the population. As objective function, the coefficient of effectiveness, known in the literature as being a good index of clusters of cellular performance, is applied as well as being used in the GT problems used to compare results.

2 Machine-Part Cell Formation Problem

Group Technology gives similar treatment to similar elements, that is, it divides the manufacture into small groups (cells) of machines that will process pieces with greater similarity between themselves (families).

Thus, the parts of that family will always be processed by the same machines and tool changes will have reduced configuration time, also reflecting in the same way in the processing time of the system.

The application of the GT in a production system consists of asserting several steps and, in an inner process of the Production Flow Analysis (AFP), a binary matrix is generated relating existing pieces and the corresponding machines that process them. This matrix is called incidence, and at this stage it is necessary to relate those of greater similarity so that the parts families and machine cells are constructed, knew as Manufacturing Cell Formation Problem (MCFP).

With the main objective of assigning machines to cells and parts for families, this arrangement needs a function to guide the performance of these groupings. Some are well known, such as the use of machines [6], clustering efficiency [7], clustering efficacy [8], etc. According to [6], two are the most used: efficiency and effectiveness of grouping.

The grouping efficacy (μ) mentioned below is adopted for two reasons: first because it overcomes the weaker discriminating power of grouping efficiency measure by assigning equal weight for the number of voids and the number of exceptional elements; the second is because the results obtained in the works used as performance comparison apply this group quality indicator. This measure is defined as follows:

$$\mu = \frac{e - e_0}{e + e_v} \tag{1}$$

where e is the total number of operations (1's) in the given matrix, e_v is the number of voids (0's in the diagonal groups), and e_0 is the number of exceptional elements (1's out the diagonal groups).

Also, [9] and [10] justify this index adoption since it: incorporates both the with-in cell machine use and the inter-cell movement; generates block diagonal matrices which are interesting in practice; is independent from the number of cells, among others.

In the Fig. 1, there is a one-piece binary incidence matrix. Reordered, to form machine cells and parts families, it has voids (in green) and exceptional elements (in red). An empty means that although machine and part have been assigned the respective cell and family, the machine will not process the part. An exceptional element implies intercellular movement, since the part will have some processing in another cell, increasing the processing time, among other complications.

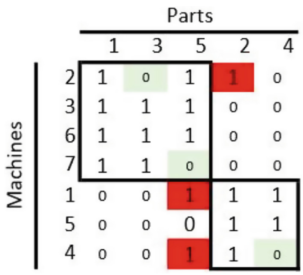

Fig. 1. Example of a reordered two cell incidence matrix.

Considering the example in the Fig. 1, the Eq. 2 shows the calculus of grouping efficacy (μ) coefficient, since the e, e_0 and e_v can be easily found:

$$\mu = \frac{18 - 3}{18 + 3} = 0{,}7143 = 71{,}43\% \tag{2}$$

3 The Proposed Heuristic for Cell Formation Problems

The framework presented in this paper solves MCFP problems by applying a hybrid genetic algorithm that uses a local search method to refine the solutions.

With an initial population partially formed by a greedy constructor method, the convergency can be reached faster than only using random construction methods. In addition, procedures are used to accelerate these convergences, like the neighborhood research, where an GA solution is used as a starting point for another algorithm: a local search method as the k-means algorithm, applied to a chromosome, trying to improve its cluster efficiency.

3.1 The Genetic Algorithm with Local Search

Combining the survival of individuals with each other and inspired by natural and genetic selection mechanisms. This general theory of systems with robust adaptation finds an excellent practical application in the optimization of mathematical functions.

GAs differ from other heuristics by having distinct characteristics: act on a set of points (population) and not on isolated points; operate in a space of coded solutions and not directly in the search space; they need, as information, only the value of an objective function (function of adaptability or suitability); use probabilistic transitions rather than deterministic rules [11].

Briefly, a GA begins with an initial population and the adaptation of the chromosomes is calculated. Genetic operators are applied to selected individuals (a better adaptation implies a greater chance of selection), based on their suitability, and a new generation of individuals is created. This procedure will be repeated until some final criterion is reached.

In the population, each individual is represented by a chromosome, denoting viable solutions to the problem. Thus, to this framework, each gene is a cell or family and each locus, a machine or part (depending on the portion of the analysed chain), thus having length equal to the number of machines plus the number of pieces presented in the $M \times N$ matrix, as it can be seen in Fig. 2.

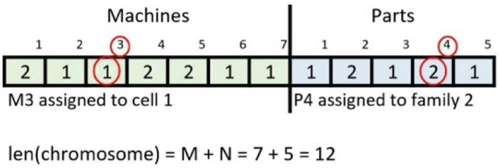

Fig. 2. Example of a chromosome denoting the two-cell formation shown in Fig. 1.

As mentioned, some genetic operators will be used: cloning, crossover and mutation. Cloning consists in the inclusion of the individual in the next generation. In other hand, crossover combines information of chromosomes from selected individuals, generating new ones. Otherwise, with low probabilistic rate, the mutation randomly disrupts the machine-cell designation, trying to avoid local maxima. The selection technique is the Roulette Method [6], with selection proportional to the fitness.

After selection, as can be seen in Fig. 3, and occurring only in the chromosomes' "machine" portion, the genetic combination draws a cut position where the data origins from one parent and after, from the other one. A constructor algorithm, driven by these cells' segments, will construct the families' ones.

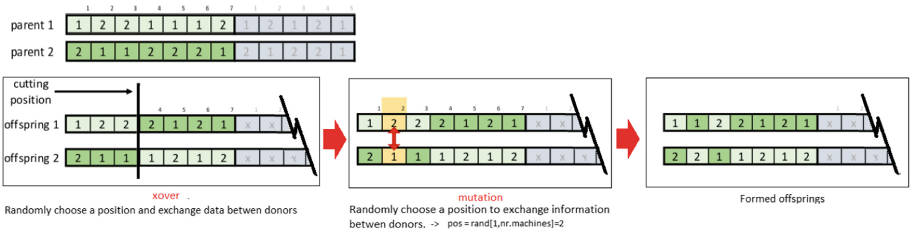

Fig. 3. The genetic operators: crossover and mutation.

The refinement of the individuals is used before a new iteration starts. As mentioned, the procedure is the k-means, which is a non-hierarchical method that aims to produce partitions in a set of objects with prior knowledge of the quantity of these.

The procedure starts with k-centroids defined at random, and, in successive iterations, each element is grouped according to some criterion, such as least squares. Because it is an iterative method, centroids are constantly recalculated until they no longer change.

Just as the calculation of the distance between the points is necessary, since cohesive groups are desired around a common point (centroid), it is also necessary to calculate the similarity between the machines. This coefficient calculation consists in the coincidences between them, so a XNOR logic (Eq. 3) between the binary vectors is calculated, where a nonzero bit in S_{ij} indicates that both machines are equal in terms of part processing, so the sum of the elements of S_{ij} implies that the higher the result, the greater the similarity between the evaluated elements (vectors R_i and R_j in Eq. 3).

$$S_{ij} = \left(R_i \text{ XNOR } R_j\right) \tag{3}$$

With a totally generated chromosome, the k-means algorithm starts from known centroids: the cells already characterized. The objective is to carry out movements, in order to improve these groupings. Because it is costly, this local search has a stop criterion of only 1 iteration.

The centroids calculation promotes exchanges based on the distances between the elements. After reconstruction of the "machines" chromosomes fraction, the constructor procedure creates the "pieces" segment. Recalculating the adaptation, if better than the original, will replace it in the current population.

3.2 The Greedy Constructive Heuristic

Like the genetic operators, also the greedy algorithm of manufacturing cell formation will only act on the chromosomes' machine segment and so, it begins by calculating the distance matrix between the machines, where each row of the incidence matrix is a n-dimensional point. The Eq. 4 shows the distance equation, where x_i and y_i are the vectors; i = {1,…n} is the position index of the vectors.

$$d = \sum_{i=1}^{n} \|x_i - y_i\| \tag{4}$$

For the initial cells' formation, 5 pairs of machines are grouped with great distances from each other, where a random choice will compose the first cell.

The other cells will only have a single machine: that one which accumulates the biggest distance between all the already allocated, for all the cells. Once defined all these seeds of cells, the algorithm designates each not yet allocated machine to that cell with the shortest accumulated distance to its members. In cases of tie, a random choice is made. In cases of tie, a random choice is made.

3.3 The Part-Segment Constructor Algorithm

Based on the calculation grouping efficiency's coefficient [3], the training strategy of [9] that tries to maximize the grouping coefficient considering the association of a part to a family. This iterative procedure, as presented by the authors in Eq. 5, computes the effect of allocating each piece to a family. As such, the one that maximizes the function is chosen and ends when there are no more allocations to be made.

$$F^* = \arg\max\left\{\frac{N_1 - N_{1,F}^{out}}{N_1 + N_{0,F}^{in}}\right\} \tag{5}$$

where N_1 is the total number of operations (1's) in the given matrix, $N_{1,F}^{in}$ is the number of voids (0's in the diagonal groups for the association of a part i to a family f), and $N_{1,F}^{out}$ is the number of exceptional elements (1's out the diagonal groups for the same association of a part i to a family F).

4 Method and Computational Results

The method applied by the framework consists in to form an initial population which has half part of the individuals made by a greedy method that uses similarities of parts and machines to compose the chromosomes. The complement of the population is formed by individuals of random constitution, aiming to counterbalance the homogeny generated by the other method of formation.

The test-bed of the work consists in the application of the framework on 25 problems provided by [6] and related in Table 1.

Table 1. Problems obtained from the literature for analysis.

Problems	Autor (source)	Size
p01	King and Nakornchai [7]	5 × 7
p02	Waghodekar and Sahu [8]	5 × 7
p03	Seifoddini [9]	5 × 18
p04	Kusiak and Cho [10]	6 × 8
p05	Kusiak and Chow [11]	7 × 11
p06, p07	Chandrasekharan and Rajagopalan [12]	8 × 20
p08	Mccormick et al. [13]	16 × 24
p09	Srinlvasan et al. [14]	16 × 30
p10	King [2]	16 × 43
p11	Carrie [1]	18 × 24
p12	Mosier and Taube [15]	20 × 20
p13	Kumar et al. [16]	20 × 23
p14	Carrie [1]	20 × 35
p15, p16, p17, p18, p19	Chandrasekharan and Rajagopalan [12]	24 × 40
p20	Paydar [17]	27 × 27
p21	Carrie [1]	28 × 46
p22	Kumar and Vannelli [18]	30 × 41
p23	Stanfel [9]	30 × 50
p24	Paydar [17]	53 × 37
p25	Chandrasekharan and Rajagopalan [12]	100 × 40

The authors also analyze the results form GA [4], Zodiac [19], Grafics [20], MST [21], GATSP [22]. Their own proposal, here denominate G&R is also compared with this framework results, all related in Table 2. The formation of a population is 5% of the best individuals (clones), 50% of selected individuals for crossing, and the rest, with 80% random and 20% greedy formation. The population size is 150 individuals, regardless of the size of the problem, as well as the mutation rate, equals to 2%. For each problem, 20 rounds of the GA are performed, statistics are generated and comparative data between the framework results and the literature are also related.

Table 2. Comparison between cluster efficiency indexes obtained from the literature, by different methods and the presented framework.

	C[a]	Literature best efficiency grouping index						Best	Diff	Generations[c]			Time (s)		
		Zodiac	Grafics	MST	GAtsp	GA	G&R	Ftns[b]	(%)	Min	Avg	Max	Min	Avg	Max
p1	2	73,68	73,68				73,68	81,25	10,27	0	0,0	0	0,01	0,01	0,02
p2	2	56,52	60,87			62,50	62,5	69,57	11,31	0	0,0	0	0,01	0,01	0,02
p3	2	77,36			77,36	77,36	79,59	79,59	0,00	0	0,0	0	0,02	0,03	0,04
p4	2	76,92			76,92	76,92	76,92	76,92	0,00	0	0,0	0	0,01	0,02	0,02
p5	3	39,13	53,12		46,88	50,00	53,13	56,25	5,87	0	1,0	2	0,02	0,06	0,09
p6	3	85,24	85,24	85,24	85,24	85,25	85,25	85,25	0,00	0	0,0	0	0,03	0,03	0,05
p7	2	58,33	58,13	58,72	58,33	55,91	58,72	58,72	0,00	0	0,5	1	0,03	0,05	0,07
p8	6	32,09	45,52	48,70			52,58	51,96	−1,18	1	14,5	41	0,19	1,36	3,64
p9	4	67,83	67,83	67,83			67,83	67,83	0,00	1	1,0	1	0,14	0,14	0,15
p10	5	53,76	54,39	54,44	53,89		54,86	54,86	0,00	2	3,3	5	0,32	0,47	0,76
p11	6	41,84	48,91	44,20			54,46	54,95	0,90	2	29,5	98	0,25	2,73	8,75
p12	5	21,63	38,26		37,12	34,16	42,94	43,36	0,98	6	6,0	6	0,59	0,59	0,59
p13	5	38,66	49,36	43,01	46,62	39,02	49,65	49,25	−0,81	2	3,2	6	0,24	0,35	0,61
p14	4	75,14	75,14	75,14	75,28	66,30	76,22	76,14	−0,10	1	1,0	1	0,16	0,17	0,20
p15	7	85,11	85,11	85,11	85,11		85,11	85,11	0,00	1	1,0	1	0,25	0,26	0,29
p16	7	73,51	73,51	73,51	73,03	73,03	73,51	73,51	0,00	1	1,4	2	0,25	0,32	0,42
p17	9	20,42	20,42	51,81	49,37	37,62	51,97	52,83	1,65	2	5,5	15	0,48	1,15	2,86
p18	9	18,23	44,51	44,72	44,67	34,76	47,06	47,5	0,93	16	72,8	129	3,02	12,98	22,86
p19	9	17,61	41,67	44,17	42,50	34,06	44,87	45,45	1,29	25	72,8	129	4,64	13,10	23,05
p20	4	52,14	41,37	51,00			54,27	54,31	0,07	3	13,1	32	0,41	1,50	3,55
p21	9	33,01	32,86	40,00			44,62	46,91	5,13	70	109,	148	14,93	22,95	30,97
p22	11	33,46	55,43	55,29	53,8	40,96	58,48	61,27	4,77	3	6,8	15	0,88	1,82	3,79
p23	11	21,11	47,96	46,3	45,93	37,55	50,51	58,82	16,45	6	50,1	139	1,84	13,78	38,77
p24	2	52,21	52,21				56,42	59,16	4,86	10	77,6	145	1,89	13,39	24,65
p25	10	83,66	83,92	83,92	84,03	83,90	84,03	84,03	0,00	1	1,9	2	0,78	1,19	1,32

[a]Number of cells;
[b]The best results obtained during the application of the framework on the problems in the several consecutive rounds;
[c]Number of generations to obtain de better efficiency index ([a]).

The implementation of the framework is done in Python language on a i7-7700HQ notebook, with 2.8 GHz and 16 GBytes of RAM. Although not being the scope of the work, the implementation of algorithms in Python is feasible for building the necessary programming codes, being free of easy access to documentation, as well as good libraries of functions already created, such as Numpy, for example.

Also, operating on some of the problems studied, [23] obtained similar values to those found here. Although with a different strategy, they also considered the Euclidean distances between machines and, subsequently, cells.

5 Conclusion

In this study, a hybrid genetic algorithm is proposed with the objective of maximizing clustering efficiency in cell manufacturing problems, of NP-hard combinatorial nature. To obtain good solutions in reasonable computational time, local search techniques associated with genetic algorithms are applied. The present framework also proposes strategies of combined greedy and random formation for the initial populations, as well as constructive procedures of individuals managed by biased rules of pre-optimization, obtaining very satisfactory results in the questions of grouping of efficiency and computational time, pointing very favorable perspectives of using this structure in solving this type of problem.

The maximization of clustering efficiency performed by this framework is compared with 6 other proposals. Briefly, it is assumed that all the average values obtained exceeded the other applied methods mean values. Moreover, for 88% of the problems, the efficiency indicators were equal to or better than the best known in the literature (52% already in the first performed generation). Still, for more than half of the problems, the results surpassed those then known values of the literature, as show in Table 2.

In the formation of the initial population, it is observed that the greedy constructive algorithm consumes more processing time than the random one, besides taking the set of individuals to have a greater homogeneity. Furthermore, greater uniformity leads to worse results from construction, which reinforces the decision to define a randomness rate of 80% and 20% of greedy formation. In addition, in this composition, the best results already appear in the first iterations (initial generation and first iteration), without further improvements in the following iterations, of each test.

The k-means local search algorithm did not imply significant differences in the results when applied with rates higher than 75%, on the individuals generated in the current population. Thus, since its interference in computational cost is directly linked to the increase of this rate, it was limited to this value.

The Python language is a bit slower than compiled languages, but it is free, easy to develop, with ample support material, and the time taken to get the results is satisfactory. Moreover, the local research combined with a good construction procedure, even being computationally expensive, allow an accelerated convergence in the search for good solutions of these types of problems.

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Hospital Operations Management: An Exploratory Study from Brazil and Portugal

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Abstract. This study aims to analyze the main dimensions related to Hospital Operations Management (HOM) through workshops held in four hospitals in Brazil and Portugal with the participation of 60 hospital management professionals. The dimensions of the HOM were adapted from the literature and the most important area according to the professionals was described as "Planning, Scheduling and Control of Hospital Operations", with 91% importance. Other areas were also relevant as Patient Flow Management, Quality and Supply Chain Management. After discussion of the main topics, the researchers involved present a management scheme about Hospital Operations Management in order to guide other researchers and hospital managers on the subject.

Keywords: Hospital Operations Management · Healthcare · Patient flow · Lean Healthcare

1 Introduction

Hospitals have been focusing on decreasing costs and there is considerable energy being put into improving hospital operations. In this context it is needed to look at strategies of operations, management of the capacity, technology and location of the installation [1]. Health managers have adopted management techniques from other industries with the objective of increasing the efficiency of their processes and reducing costs, adapting to a restrictive budgetary dynamic in the health area. The application of such techniques to the area of Operations Management (OM), which traditionally deals with production capacity management, supply chain, planning and quality [2] is evidenced. In this context, the use of Operations Management and Lean Thinking techniques with the objective of eliminating waste, increasing productivity and maximizing delivery of value to the customer [3, 4] also emerges.

OM focuses on the systematic orientation of the processes involved in the production of products and services. Such an area requires a holistic view of the processes, with great impact on the costs necessary to operate an organization. OM concepts apply to the entire production chain and these concepts are also applicable to non-operational fields such as marketing, finance and information technology [5] and healthcare.

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In the context of Hospital Operations Management (HOM), Dobrzykowski et al. [6] conducted a survey to analyze Operations Management and Supply Chain Management in hospitals, their main topics or areas, what methodological approaches in this field of knowledge, and discuss the future of research in the area. These results show that the frequency of studies increased significantly from 1995 and 2000 and remained at maximum levels since that time. Sixteen topics were synthesized in four major areas. These are: Introduction and key questions of service management; Strategies and objectives of service operations; Design of service operations; Planning, scheduling and control of service operations. This is a good starting point to understand the OM in Hospital environment, but more and deeper studies are needed to identify best practices for improvement of performance in Hospital OM. The objective of this study is to identify and represent the perspective of professionals about the main areas of Operations Management in the hospital environment, through exploratory workshops with hospital managers. This will create the ground basis for identification and/or development of new models, practices and methods to improve the HOM.

2 Hospital Operations Management

Operations Management (OM) is a key function for organizations, since it coordinates from the planning, supplying, scheduling, control and transformation activities of a production system [7]. Currently, globalization has influenced the field of OM going through a continuous change and including areas of study extending the boundaries of the operation function. The challenge of defining OM limits remains a problem, but efforts to integrate such functions over the last decade can cite the major research areas of OM in the present: Inventory control; Aggregating planning; Forecasting; Scheduling; Capacity planning; Purchasing; Facility location; Facility layout; Process design/technology; Maintenance; Quality; Work measurement; Strategy; Distribution; Quality of working life; Project Management; and Services [8].

The OM discipline has, over the years, developed a set of laws related to the operations productivity phenomenon. Productivity is defined as output per unit of input resource, e.g. units produced per hour of work or per hour of machine [9]. Five laws are cited by Schmenner and Swink [9], which are:

- Law of Variability: the greater the random variability, whether it is required or inherent in the process itself or in the processed items, the less productive the process.
- Law of Bottleneck: The productivity of an operation is improved by eliminating or better managing its bottlenecks. If a bottleneck cannot be eliminated in any way, say, by adding capacity, productivity can be increased by maintaining a consistent output through it.
- Law of Scientific Methods: Labor productivity i.e. production per worker-hour of work can be improved in most cases by the application of methods and movement of Scientific Management.
- Law of Quality: Productivity can often be improved, as quality, that is, compliance with customer-valued specifications is improved and waste is reduced. Several

techniques of quality movement may be responsible for these improvements. This may be a more controversial law. It is stated as a probabilistic law that does not need to be maintained in all situations, for example, not in close to zero situations, but has been demonstrated in the majority.

– Law of Factory Focus: Factories that focus on a limited set of tasks will be more productive than similar factories with a broader set of tasks. This is the influential observation of Wick Skinner, drawn from his study of factories in a variety of factories.

Service operations management is the term used to cover the activities, decisions and responsibilities of managers in service organizations. Service operations managers are responsible for providing services to the organization's customers, where a service is the combination of results and experiences of a customer [10].

From OM hospitals need to maximize their income with the available resources, taking into account different requirements of flexibility, delivery, reliability and acceptable clinical results for the design, planning, implementation and control of management mechanisms between patient flows, diagnostic, therapies and support activities [6].

Dobrzykowski et al. [6] conducted a research to analyze Operations Management and Supply Chain Management in hospitals, their main areas are described in sixteen topics synthesized in four major areas as presented in Table 1.

Table 1. Classification of HOM topics - adapted from [6].

Nº	Topic/section	Category description
	Topic 1	Introduction and key issues in service management
1	1.1	Introduction and key issues in service management
	Topic 2	Strategies and objectives of service operations
2	2.1	Service management
3	2.2	General aspects of operations strategy and objectives
4	2.3	Strategic quality issues in services
5	2.4	Service productivity
6	2.5	Information technology and new technologies in services
7	2.6	Supply chain strategies and objectives
	Topic 3	Service operations project
8	3.1	Selection and design of the service delivery system
9	3.2	Design of long-term capacity/capacity and demand decisions
10	3.3	Design of service operations in supply chains
	Topic 4	Planning, scheduling and control of service operations
11	4.1	Planning, scheduling and control of service operations
12	4.2	Planning, scheduling, and capacity control
13	4.3	Short-term planning and control
14	4.4	Inventory management and control
15	4.5	Design, measurement and compensation of service work
16	4.6	Planning, scheduling, and control in supply chains

3 Methods

The method chosen for the study was based on the realization of workshops with managers of 4 hospitals based in Portugal and Brazil to explore the understanding and applications related to the theme of Operations Management focused on the hospital environment. This exploratory study contemplated a total of 60 professionals from the most varied formations, as: Accounting Sciences, Administration, Computer Science, Economy, Hospital Management, Hospitality, Human Resources, Law, Medicine, Nursing, Pharmacy and Biochemistry, Psychology, Radiology, Social Service and Systems Analysis.

The workshops, in short, were structured between a theoretical and a practical moment. At the theoretical moment the researchers approached the topics of Hospital Operations Management based on the chosen literature and set out for a practical moment of discussion and adaptation of the themes between the groups. At the end of the workshop a structured questionnaire was answered by the participants containing basic professional data, research questions and questions to identify the main topics and subtopics related to Hospital Operations Management that hospitals have been using or want to apply in their flows.

Three workshops were conducted to gather information through focus groups and questionnaires, so the researchers of this study developed a generic model to represent the main dimensions of HOM and a final workshop was held to present the scheme and validate it. As initial results of the questionnaire we have a total of participants in 60% with more than 10 years of experience in hospital management; 32% with 5 to 10 years and 8% with 1 to 5 years of experience. 100% of respondents answered that the theme of the workshop was relevant to the academic and business field.

4 Workshop Results

As a result of the workshops, adapting some terms according to the health professionals, and regarding the large area of HOM we have (Table 2): IV. Planning, scheduling and control of hospital operations with 91% of greater relevance; III. Design of hospital operations with 72%; II. Strategy of hospital operations with 70%; and I. Introduction and key issues of operations management with 45%.

In relation to the sub-areas of HOM, the results of the workshops demonstrate: IV A. Planning, scheduling and control of the flow of patients with 91% relevance classification; III A. Capacity management and demand management with 89%; II B. Hospital quality strategic issues with 81%; IV B. Stock management and control with 79%; II C. Hospital productivity with 74%; II E. Strategies and objectives of the supply chain with 74%; II D. Information technology and new technologies in hospitals with 72%; II A. General aspects of the hospital operations strategy with 66%; III B. Design of hospital operations in supply chains with 57%, and, I A. Introduction and key management issues with 38%.

Table 2. Result of the questionnaires – areas and sub-areas adapted from [6].

HOM areas	% “very relevant”
IV. Planning, scheduling and control of hospital operations	91%
III. Design of hospital operations	72%
II. Strategy of hospital operations	70%
I. Introduction and key issues of operations management	45%
HOM sub-areas	**% “very relevant”**
IV A. Planning, scheduling and control of the flow of patients	91%
III A. Capacity management and demand management	89%
II B. Hospital quality strategic issues	81%
IV B. Stock management and control	79%
II C. Hospital productivity	74%
II E. Strategies and objectives of the supply chain	74%
II D. Information technology and new technologies in hospitals	72%
II A. General aspects of the hospital operations strategy	66%
III B. Design of hospital operations in supply chains	57%
I A. Introduction and key management issue	38%

Other sub-areas were frequently cited during the workshops with the goal of further studies, such as: Finance and Cost Management, People Management and Communication, Engineering and Maintenance called as Support Operations.

5 HOM Scheme

After analysing results, the researchers understood that area IV really should be an important field as presented by practitioners and that area III is closely related to this area. Thus, in the model of this study, the hospital operations project is integrated with the planning and control of hospital operations, called “Hospital PPC”. The Hospital PPC is divided between two major streams: patients, and materials and medicines. And are supported by “Operations Support” such as: Finance and Cost; Engineering and Maintenance; People Management and Communication; and, Information Technology. All planning, flow and support operations are guided by a “Hospital Operations Strategy” and measured by Quality and Productivity KPIs (Fig. 1).

According to the exploratory study contained in this article, the areas of HOM are better detailed and described for a better understanding of the development of the work analyzing researchers in these fields according to the current literature:

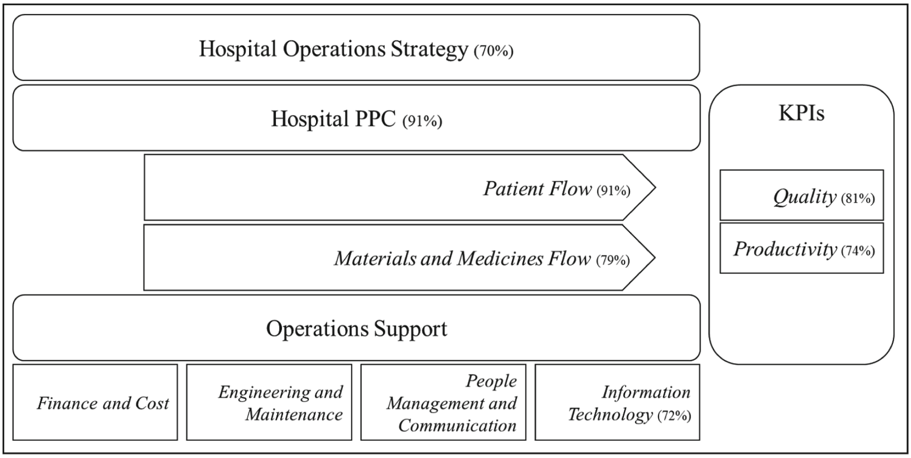

Fig. 1. Hospital Operations Management scheme.

5.1 Operations Strategy

The literature referring to the strategy in operations management is not completely clear [11]. However, although Operations Management and Operations Strategy cannot be totally separated, they have different characteristics and approach problems in a different way. Operations Management is an activity of resources and processes that produce and deliver goods and services. An organization has a production function, as it has a set of products and/or services. The Operations Strategy is concerned with the overall objectives of the organization related to the operations implementation, that is, it is concerned with the whole business. Therefore, Slack and Lewis [11] conclude that "operations" are not always "operational".

5.2 Production Planning and Control

Every organization, whether of any nature, has the central function of producing some output for an end customer. For this organization to be effective in this delivery, the organization's managers must understand and apply certain fundamental principles of production planning and control the process that permeates their operations. The service organization approach to planning and control may come up against at least four major reasons that generally provide the greatest influence on how PPC is designed in service organizations: Timing, Customer Contact, Quality, Inventory [12]. The planning and control of the production of a hospital can be synthesized in two general flows: patients and materials/medicines.

Flow of patients – Hospitals typically divide the patient's flow by acuity or function, taking an effort to shorten waiting times, promote safety, and organize the person's picture [13]. Operational performance indicators are closely related to patient flow [14]. It is always important to visualize and monitor the flow of patients and to obtain models for the organization of these flows is paramount. Currently, some main approaches are used to model flow between them: queuing theory and process model simulation [15].

Flow of materials and medicines – McKone-Sweet et al. [16] in their study raised some problems related to Supply Chain Management (SCM) in hospitals such as: Conflicting goals across supply chain; Lack of data and performance measures; Availability of IT systems; Need for education of materials managers and supply chain professionals and executives; Group purchasing organizations practices that support hospitals. The importance of the flow of materials and drugs in the hospital context, due to the investments estimated in inventory between 10% and 18% of total hospital revenues, prompts discussions in SCM and inventory management [17]. Hospitals need to engage improvements across the SCM (external and internal) to manage inventory [18].

5.3 Operations Support

According to Porter [19] in the value chain view there are primary activities related to the operation and production of a good or service and supporting activities that support the primary activities. There are several support activities in an organization, such as: Firm infrastructure; Human resources management; Technology development; Procurement.

5.4 KPIs

Indicator systems are the basis for performance management in hospitals and present several main dimensions used to measure hospital performance, such as: Clinical efficiency; Production efficiency; Personnel; Social accountability and reactivity; Safety, and Focus on patient [20].

6 Conclusion

OM tries to respond to the challenges presented since its initial studies and to succeed, research needs to build theories and test them by influencing business leaders. OM needs to periodically rebuild its core and use it as a platform to interface with other areas of managerial knowledge and OM being the custodian within the business context of managing value-adding processes from Taylor to Toyota continuing to evolve [21]. This study concludes that the areas of HOM are broad and require greater depth of study and that, among the professionals associated with Hospital Management, the area that has attracted the most attention is Planning, Scheduling and Control of Hospital Operations, for Patient Flow Management and Materials and Medicines Management.

OM has used Lean Thinking tools and concepts to add more value and sustainability to the measures of excellence that companies use in process evaluation and improvement [22]. Thus, HOM's connection with improvement philosophies such as Lean Healthcare is necessary to avoid the risk of thinking in "silos", rather than in flows (lean).

As a suggestion of future studies, the authors indicate the replication of this exploration and other hospitals from diverse regions and the creation of models and frameworks that interpret HOM in a global way indicating general techniques and tools for the management and improvement of hospital operations.

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The Relationship of Continuous Improvement Practice with Service Operations Competitiveness in Healthcare

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Abstract. Although it is reasonable to admit that higher maturity in the continuous improvement practice may generate greater contributions to service operations competitiveness, there is little or hardly any discussion aiming to understand this relationship. Therefore, this paper proposes, in an explanatory form, a reflection on this research field by investigating the relationship between the continuous improvement maturity level and the stages of the service operations competitiveness, relating the abilities of each continuous improvement maturity level to the aspects inherent to each service operations competitiveness stage. The findings of this study are innovative in the research field as this research offers the proposal of a theoretical model that seeks to identify the relationship between the service operations competitiveness and its continuous improvement maturity level.

Keywords: Continuous improvement · Service operations competitiveness · Health care service operations · Hospital service operations

1 Introduction

This research aims to study of the relationship between the continuous improvement maturity levels and the stages of service operations competitiveness, using as a reference for this research the four-stage service operations competitiveness model [1] and the continuous improvement maturity level framework [2]. One may consider that the aspects inherent to each level of the continuous improvement maturity model associate with different evolutionary stages of the four-stage service operations competitiveness model. Nevertheless, the dimensions that characterize the evolution stages of service operations competitiveness model show no relation to the process improvement practices, which seems to be a gap in the current studies.

Finally, the reason for choosing the four-stage service operations competitiveness model and the continuous improvement maturity framework, is because both classical models remain being explored as a proved reference in recent operations and service operations management studies [3–6].

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2 Theoretical Reference

The usage of management practices to improve efficiency and quality in the healthcare area is still recent [7]. Current healthcare organizations are increasingly more dynamic and complex systems, and they are becoming even more focused on improving the quality of patient care and complying with local and global regulations [8], thus making it necessary to review their process under the perspective of continuous improvement [9].

In this context, the use of self-evaluation models is vital to achieve a continuous improvement culture [10] and when considering the long-term benefits, the use of self-evaluation models looks as the right way to achieve a continuous improvement culture and to provide quality service in the healthcare sector [11].

2.1 Continuous Improvement Maturity Level

The continuous improvement efforts emerge as an answer to a context of great market dynamism where the performance of a business relates to company's ability to manage its continuous improvement process and operations [2]. Although it is a simple concept, implement continuous improvement capabilities is hard and even more challenge to maintain it, since constant learning and adaptation are necessary [12]. Far from being a single binary characteristic such as having it or not having it, the behavior and practices show it is possible to identify an evolutionary pattern in continuous improvement development [2].

The research on practices and capabilities of continuous improvement in organizations resulted in a model with different levels of maturity of continuous improvement, where the progress between different levels represents a learning process for the organization [2, 13]. In this model, each stage represents the maturity level of organizations and ranges from level zero where no continuous improvement activity is available to level five where organizations show full capability in continuous improvement. Model like this enables a learning organization process in a way that for each stage in the model it expects to observe behavior and attitudes that translate in behavioral patterns associated with each level of maturity, also known as routines, which are part of the organizational culture and are the organizational skills of the company [2].

Finally, although some authors suggest working with a three-levels continuous improvement maturity model to assess business from public sector, this model still uses the five-level of continuous improvement maturity framework, reinforcing the view that continuous improvement is an evolutionary process [4].

2.2 Service Operations Competitiveness

The functional role of an operation works neutrally or as a business strategy support or even as something that propels the business strategy [14]. This model was the precursor to the four-stage service operations competitiveness model [2] where the development of this strategic capacity results from a systematic progression, from a basic role to a more complex and important one, through a continuous series of operations capabilities

[5]. The four-stage service operations competitiveness model reached classic status in literature and is the basis for several studies in the operational strategy field, and it is still present in the most diverse studies about manufacturing and service operations management [14–17].

Overall, the four-stage service operations competitiveness model comprises the relationship between the four evolutionary stages proposed by the researchers - service provision (stage 1), professionalization (stage 2), competitive differential (stage 3) and delivery of world class service (stage 4) - with six dimensions related to service operations capabilities - quality of service, back office, customer, use of new technologies, workforce and management [1]. In this model, the practices that serve as a reference to assess the situation of the company and to understand the opportunity to move to a more advanced stage are available at the intersection between of each competitiveness stage with each operations capability.

If in the past research period, the penetration of service operations studies in the most important Operations Management Journals was low [3], in the recent research period, work characterize the context of operations strategy to competitive priorities [18, 19]. More recently, managing the fit between competitive and operations strategy reveal to be of interest of both strategic and operations management researchers as it discuss a way of testing the perceived level of strategic fit between the current competitiveness and operations strategy of a business using classical work [1, 5, 14].

2.3 Proposed Theoretical Framework

The theoretical model used in this study refers to the context of the theoretical research conducted by reviewing the main literature related to the field of service operations competitiveness and continuous improvement. This model shows main variables found in the four-stage service operations competitiveness model [1] and the variables found in the continuous improvement maturity model [2]. The way of reading this theoretical model is from the top to the bottom. First, companies are somewhere between the evolution stages of service operations and these competitiveness stages are results of different organizational capacity. These capabilities are in the center of the theoretical model of Fig. 1 and they connect the four-stages of service operations competitiveness model [1] with the continuous improvement maturity model [2].

The continuous improvement maturity framework comprises five levels of maturity where companies with continuous improvement practice classify its maturity level according to different behaviors and practices [2]. The proposed theoretical model shows three main groups of capabilities (a) purpose, (b) process and (c) people that interconnect among themselves and work to improve the continuous improvement maturity in an existing organization [20]. Organizations can use models like these which give a list of the behavior and practices [1] and [2] to analyze its service operations competitiveness and its continuous improvement maturity level respectively. Figure 1 summarizes the main constructs that work as the reference to the theoretical model proposed in this study. Based on this theoretical model, one can look for elements to verify the relationships between stages of service operations competitiveness and continuous improvement maturity level. The constructs both as regards the theoretical model of competitiveness in service operations and the model of

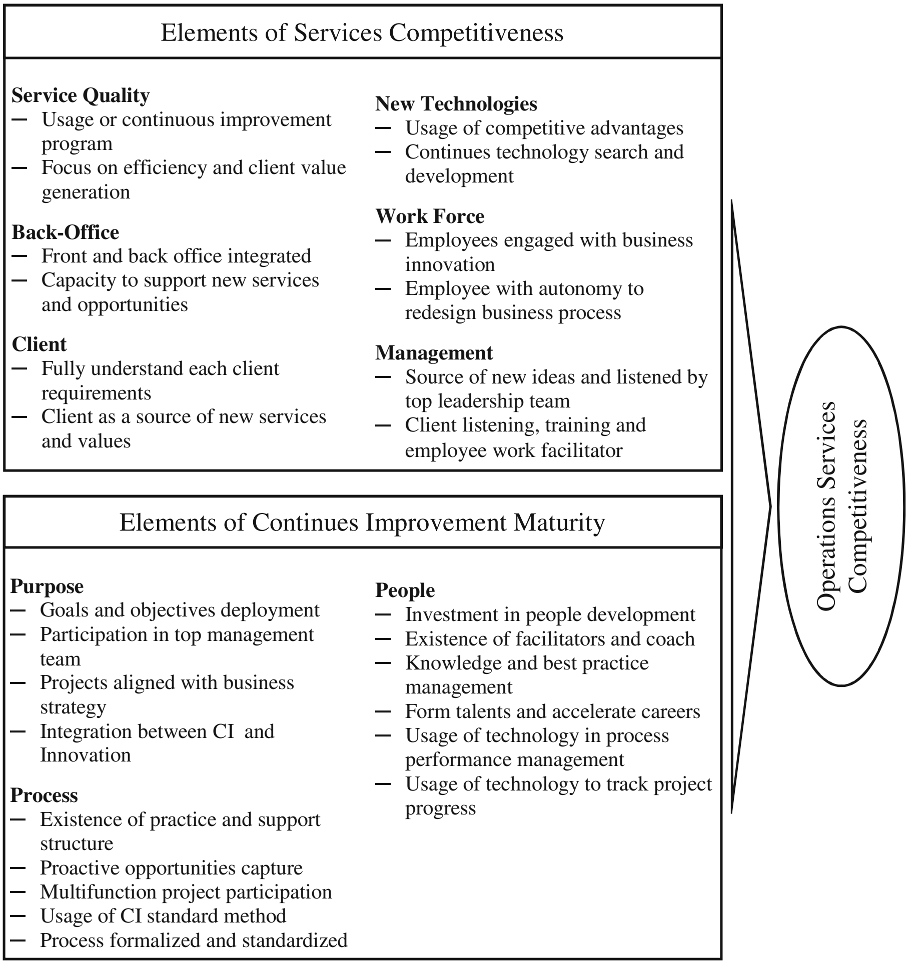

Fig. 1. Theoretical model – constructs.

maturity in continuous improvement [1, 2, 20] work as a guideline during the field research to look for evidence of behaviors and practices in the three cases used in this study.

3 Methodology

The execution of this study considered three research phases. First, a theoretical research carries out through a literature review focused on the following aspects (i) a reference model of the four evolutionary stages of the service operations, (ii) practice of continuous improvement in service operations, (iii) skills and maturity levels of continuous improvement.

In the second phase, based on the results of the systematic review of the first phase, a model with clear constructs guides a field study by the case study method to identify the relationship between levels of continuous improvement maturity and the service operations competitiveness. As a research instrument for the interview and data collection, a field research protocol based on the results of the bibliographic review contains the main variables to analyze the maturity in continuous improvement and to identify the stages of competitiveness in service operations. A pilot with five senior professional with experience in operations management and continuous improvement management in companies of diverse segments ensures the main variables considered in the proposed theoretical framework are adherent and capture the main characteristics related to organizations in different levels of maturity in continuous improvement and different stages of competitiveness in service operations in an organization.

Finally, during the third phase of this research, the collection of the data relies on different sources of information such as executive interview, company websites and internal documents. Thus, reliable evidence of behavior and practices [21] work to explain existing level of continuous improvement practice and current stage of service operations competitiveness in the three hospitals used on this study case.

In addition, the selection of companies for this study was considering they have continuous improvement practice structured either through specific approaches or programs or through quality systems as well they were finalist for the national quality award or at least they had certifications through credible quality systems. Thus, the selection of interviews participants considers the capacity to answer questions about both the practice of continuous improvement and the dimensions of the model's competitiveness as well to provide the data requested during the company study.

Regarding the research method used in this research, this study has characteristics of exploratory field research and uses a qualitative approach. This work uses a multiple case study to explore the application of the theoretical model proposed in a group of hospital care companies to identify the level of maturity in the practice of continuous improvement and its competitive stage in a target group [22]. The criteria of having a certificate of quality seemed to be adequate to identify company candidates, considering that the structuring of the continuous improvement practice is a compulsory requirement to get quality certification in hospital sector. Therefore, 246 hospitals were available in the database of hospitals accredited by ONA (National Accreditation Organization), where among them, hospitals with accreditation by ONA belonging to the category "Accredited with Excellency", which includes 95 hospitals.

4 Results

When comparing the specialized literature and the theoretical model proposed in this study with the results observed in the three hospitals analyzed in this research, it allows the following discussion. As first observation, not all companies are on the same continuous improvement maturity level, and they are not on the same service operations competitiveness stage. Only Company B in level 5–full capacity of continuous improvement and stage 4–world-class service delivery. Company A is on level 3–goal-oriented continuous improvement and stage 3–competitive differential achieved and, last, Company C is on level 1–pre-continuous improvement and stage 2–professionalization. Although only one company is on the highest continuous improvement level and on the most advanced operations competitiveness stage, all other companies show practices in different maturity levels and development in these two knowledge areas.

As a second point of discussion, considering the theoretical model presented in Fig. 1, the continuous improvement maturity level of each company can have an influence on its competitiveness stage. The elements listed below not only contribute directly to the maturity level of a continuous improvement program, but also can have an influence on the competitiveness level on which the service operation can works [2, 20]:

- Direction and aim of the continuous improvement program;
- The balance between continuous improvement and innovation;
- The changing culture in a company;
- The structure how workers engage involved in continuous improvement programs;
- The standardization and formalization of processes;
- The use of a standard improved method;
- The technology support;
- Training and development of people.

Company B was as the company with higher maturity on continuous improvement practices and higher stage of competitiveness, thus Company B is a reference to the purpose of its improvement program, its continuous improvement process that exists in the company and the level of involvement of people around the program. Company A was the second company with higher maturity on continuous improvement practice and higher stage of competitiveness stage, with main elements that seems to lack, so this company may have a higher maturity level in its continuous improvement program. The elements that enable the company to evolve from stage 3–competitive differential to stage 4–world-class service delivery are integration between continuous improvement and innovation, proactive capturing of improvement opportunities, talent development and career progress. Finally, Company C, it was the company with the lowest maturity on continuous improvement practice and lowest competitiveness stage. When we observe the main elements of the existing practices in Company C, it is at the beginning of an evolutionary journey of its continuous improvement program, using basic elements such as routine management, formalization and standardization of the processes, monitoring of the goals and indicators, and capturing of continuous improvement ideas and suggestions. In addition, Company C has a continuous improvement structure under development and does not use a standard improvement method, thus not having made great efforts in developing and training continuous improvement coaches and facilitators.

5 Conclusions

This study offers, as a contribution, the proposal of a theoretical model that seeks to identify the relationship between the service operations competitiveness of a company and its continuous improvement maturity level. Nevertheless, the company is on the highest service operations competitiveness stage and highest continuous improvement maturity level does not suggest that a company is on a lower continuous improvement maturity level must be on the lowest competitiveness stage. This observation happens with Company C, which, although it is starting its journey in developing continuous improvement practice, this company is on competitiveness stage 2 (professionalization). This observation suggests that the continuous improvement dimension can be (i) a new service operations capability in the four-stage competitiveness model or eventually (ii) a catalyst that contributes as a development means between other capabilities of this same model, which contributes to the evolution throughout different service operations competitiveness stage [1].

The results showed here are innovative in the research field as it studies the relationship between the continuous improvement maturity levels and the evolutionary stages of the hospital service operations competition, suggesting a positive relationship between the continuous improvement capacities and its reflection on the service operations competitiveness stages. In addition, they also bring a clear implication, first in the research area, as it adds further discussion and contribution to a body of knowledge in the service operations management research area by suggesting opportunity to review and integrate the classical models of four-stage service operations competitiveness and continuous improvement maturity framework [1, 2]. Second in practice terms, as this research bridge the gap between practice observation in companies that implements continuous improvement programs and is looking to become more competitive once the theoretical framework discussed here can help companies evaluate their current capabilities to evolve to a much higher stage of service operations competitiveness. And finally, as third implication is the impact in the society, although this study limits to three companies in hospital sector it could expand to further industries including government where theoretical framework proposed here could advance advanced while helping justify to organizations where make sense to invest efforts if they are looking to improve their service competitiveness.

Finally, this study has as a limitation the fact it considered only three companies as part of the case study and it limits hospital service sector as the area of observation, thus pointing to an opportunity to conduct a more extensive study to understand the variables associated with the theoretical model proposed here. The conduction of future studies would give the opportunity to analyze in detail how each variable of the theoretical model relates to each other both for service operations competitiveness and for continuous improvement maturity frameworks.

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Data Analysis for Prediction of Forest Fires

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Abstract. The earth offers various resources for humanity but these resources are limited. Somethings have to be done in order to save this resources and also nature within sustainability perspective. Nature is essential for life by offering water resources, clean air and various food resources, etc. Forests have a great impact on these essential resources besides aesthetics. However, many forests were lost due to unexpected and uncontrolled forest fires especially at recent years. The main idea of this study is, an effective forest fire prediction system can help us to save forests. In this study, several basic methodologies are studied to predict the forest fires with a dataset containing meteorological data, from the literature. Some preventive actions can be taken with a successful prediction information. Also this prediction facilitates the planning of resources to cope with forest fires. For prediction study, neural networks, linear regression, decision tree and random forest methodologies are used within Python and MATLAB environment. The dataset from the literature which contains meteorological data (temperature, rain, humidity, wind) and also size of burned area data, is used in this study. Results are compared and it is realized that neural networks performs better than the other in means of accuracy value, for forest fire prediction with meteorological data.

Keywords: Data analysis · Forest fires · Prediction

1 Introduction

Forests, which are part of nature and can be described as the antidote of global warming, greatly affect ecosystems and therefore all assets. One of the major threats to forests is the forest fires. The control of the fires' results and negative effects is very important. Therefore, the early estimation and determination of the forest fires and appropriate planning activities must be done for the protection of the forests. The spread and effects of forests fires depends on appropriate meteorological conditions such as air temperature, relative humidity, and wind. These meteorological data and some indexes such as DMC (calculates with temperature, rain, relative humidity data and some equations [1]) which is used in some studies to ensures the accuracy of the prediction.

If planning and prevention work can be done correctly with an accurate estimation, use of available but limited resources could be more efficient and effective. And eventually, this reduces the forest fires and their negative impacts.

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2 Prediction of Forest Fires

Several methods were used in the literature for prediction of forest fires. According to [2], some sensors are used for the detection of forest fires and it is known that meteorological values have an effect on forest fires and some fire indices. In the study, Data Mining (DM) method was investigated for estimation of burned areas. The actual data for a region in Portugal was tested with a choice of five different DM techniques and four different features. This study is important in terms of ensuring the most effective, correct use of the available resources and making improvements [2].

Sakr et al. [3] used artificial intelligence for prediction and presented a new forest fire risk prediction algorithm based on support vector machines. The algorithm depends on the previous weather conditions to estimate the fire hazard level of a day. Implementing the algorithm using data from Lebanon has demonstrated the ability to accurately predict the danger of a fire [3].

Rajasekaran et al. [4] collected and analysed data by using Hadoop tool to predict forest fire before it occurs. There is a machine learning tool called Mahout, which is used to aggregate and filter data sets and can estimate the current output. People can be alerted via GSM when a fire occurs. Signal and infrared image processing is used to track signals and images throughout the forest every 30 min, and this data are stored in datasets. Thus, forest fire can be predicted by using these data [4].

Lin et al. [5] was found that observing local weather and human behaviours was the most important factors related to forest fire, since the high incidence and destruction of forest fire determined the importance of forest fire prediction or early detection. Therefore, a fuzzy inference and big data analysis algorithm were proposed to evaluate fire risk and quantitative potential fire risk was calculated. The rechargeable wireless sensor network collects the 24-h continuous weather information. The risk of high potential forest fires can be measured with this algorithm to prevent forest fire situation [5].

In this study, we decided to use linear regression, decision tree, random forest and neural network models for prediction of forest fires and finally compare the results of all these methodologies. Random forest is a machine learning algorithm that is flexible and easy to use, it is used for classification and also regression. Random forest is basically a controlled learning algorithm. According to the working principle, it actually creates a group of decision "forest" structure by bagging method. It creates multiple decision trees and then combines these decision trees for accurate estimation. The algorithm also adds additional randomness to the model when growing trees [6].

Decision Tree is basically a tree-based learning algorithm and frequently used. It can be integrated into the solution of all problems. For a large data set, it is a method used to divide it into smaller groups by applying certain rules of decision. In other words, it applies some procedures when making decisions, and thus uses the data that has a large number of records in smaller groups. This structure, which is easy to understand, has the advantages of being able to operate on different data types and being easy to interpret [7].

Regression is basically one of the methods used statistically. The relationships between variables in a dataset can be analysed with this method. Therefore, it is generally preferred by many disciplines. Linear regression, which is the first step for the analysis which can be called as complex, is the most basic technique used to model the relationship between different variables. This method is divided into two sections as simple regression and multiple regression. The main difference between them is the number of independent variables. In simple regression this number is one, but in multiple regression it can be more than one [8]. For multiple regression the general equation is (1). So, in this study it was decided to use multiple linear regression in Python.

$$Y = \beta_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_k X_k + u \tag{1}$$

For neural networks, the structure and working methods of the brain and nerve cells should be taken into consideration. Because it seems to be similar in principle. There are many different kinds of artificial neural networks. It can be divided into different classes as single-layer, multi-layer or feedforward, feedback. There are different advantages of this method. Unlike other methods, artificial neural networks, maintain operation even if there are incomplete data (like missing data or information) [9].

In this paper; linear regression, decision tree, random forest and neural network models were used to estimate the forest fire risk level based on four main meteorological data: temperature, humidity, wind and rain. The first three methodologies were coded in Python environment, and neural network model was developed in MATLAB. The dataset of Montesinho Natural Park [2] from literature was used in this study. This dataset contains temperature (in °C), relative humidity (in %), wind (in km/h), rain (in mm/m^2), burned area (in ha) data with some index and other data such as month, day.

Three different scenarios were defined for prediction of the burned area. After each scenario, RMSE (Root Mean Squared Error) (2), MAE (Mean Absolute Error) (3) and MAPE (Mean Absolute Percentage Error) (4) are calculated in order to evaluate the performance of the prediction model and scenario and choose the best way. Before the prediction, we normalize all dataset with D Min Max normalization with the equation of (5). Because D Min Max normalization method gives realistic results [10]. (For Eqs. (2)–(5), n: number of data, y: real data, y′: prediction, e = y′−y).

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n} e_t^2} \tag{2}$$

$$MAE = \frac{1}{n}\sum_{t=1}^{n} |e_t| \tag{3}$$

$$MAPE = \frac{\%100}{n}\sum_{t=1}^{n} \left|\frac{e_t}{y_t}\right| \tag{4}$$

$$x' = 0.8\frac{x_i - x_{\min}}{x_{\max} - x_{\min}} + 0.1 \tag{5}$$

In addition, another criterion as the percentage of accuracy was used and calculated as follows: if the absolute value of difference between denormalized test and train data is less than 1, then it accepted as true.

For each method a number of experiments were done to decide the parameter values. After experimental study, parameter values were decided as follows: for random forest, n estimator is 500 (the number of trees in the forest is 500), the random state value is 100. Also for all methods, 80% of whole dataset were used for training, 20% for testing.

2.1 Scenario – 1

At Scenario – 1, four meteorological data - temperature, rain, relative humidity and wind - were used for predict the area's value. Before the prediction to reduce skewness and improve symmetry, the logarithm function (6) was applied to the area attribute, then the dataset was normalized with D Min Max normalization.

$$y = \ln(x + 1) \tag{6}$$

The neural network model was developed in MATLAB environment. Different structures for prediction were studied, it was decided to construct the neural network with feedforward backpropagation, multilayer perceptron and has three hidden layers (each layer has ten neurons) with four input (temperature, relative humidity, wind and rain) and one output (area – prediction value) for good prediction. The constructed network was trained and then retrained for good prediction. Results for Scenario – 1, error values and the percentage of accuracy are given in Table 1.

Table 1. The results for Scenario – 1.

	Random forest	Decision tree	Linear regression	Neural networks
RMSE	1.2973	1.9022	1.4512	1.3056
MAE	1.0229	1.45631	1.1082	1.0389
MAPE (%)	67.1546	90.8090	66.8717	60.1874
Accuracy (%)	57	50	51	52

When all the solution methods applied for Scenario – 1 are examined, it is seen that neural networks gives the low MAPE value among the all methods. As a result, it can be said that, neural networks is the best method for estimating with meteorological data according to Scenario – 1.

2.2 Scenario – 2

At the second scenario, it was thought that, the dataset has different attributes and if these attributes can be combined and some of them is used in prediction models for input, less error value could be observed. However, the selection of the best attributes for prediction is important. Therefore, the feature selection in Python was used for choose the best attributes for prediction methodologies. Feature selection is the process of selecting such features that do not reduce accuracy and create subsets of features. Thus, it is possible to move away from the data which has low level of interest. This allows access to a data set free of unnecessary features and models with higher accuracy [11].

The result of feature selection is duff moisture code (DMC). DMC is calculated with many equations and it contains rain, temperature and relative humidity attributes. So we decided to use DMC with wind for predict the area. The logarithm function (6) was applied to the area attribute, then the all dataset was normalized with D Min Max normalization. The structure of neural network was same as Scenario – 1's but only one difference: with two inputs that is DMC and wind. Results for Scenario – 2, error values and the percentage of accuracy are given in Table 2.

Table 2. The results for Scenario – 2.

	Random forest	Decision tree	Linear regression	Neural networks
RMSE	1.3117	1.5650	1.2559	1.3009
MAE	1.039421417	1.2333	1.0093	1.0065
MAPE (%)	57.1830	64.2007	62.0969	56.3935
Accuracy (%)	57	56	54	57

Neural networks model gave better results than the others as in Scenario – 1. In addition, there is a difference for MAPE value. It means that if inputs predicted with more related attributes were selected, it would give better results than usage of the meteorological data directly and generally.

2.3 Scenario – 3

Four meteorological data - temperature, rain, relative humidity and wind were considered again, in addition area data converted into classes in the last scenario. First the area data were converted from hectares to acres and then classified as Class 1 is one acre or less, Class 2 is more than one acre but less than 10 acres, Class 3 is 10 acres or more but less than 100 acres, Class 4 is 100 acres or more but less than 300 acres, Class 5 is 300 acres or more but less than 1000 acres and Class 6 is 1000 acres or more but less than 5000 acres. Then the dataset was normalized with D Min Max normalization. The structure of Neural Network was same as Scenario – 1's. Results for Scenario – 3, error values and the percentage of accuracy are given in Table 3.

Table 3. The results for Scenario – 3.

	Random forest	Decision tree	Linear regression	Neural networks
RMSE	0.8819	1.4466	0.7201	0.7071
MAE	0.5926	1.0556	0.4444	0.4259
MAPE (%)	25.1852	46.3580	21.5741	20.6482
Accuracy (%)	87	28	90	91

Neural networks model gave better results than the others as Scenario – 1 & 2. In addition, there is a big difference between all scenarios about error values. It means that if the area data were classified for prediction, better error values and percentage of accuracy would be observed.

3 Prediction with a New Dataset

Another dataset was obtained and studied with previously defined Scenario – 3 in order to evaluate the performance of proposed prediction models. New dataset for Washington area was prepared by using data from DNR Fire Statistics 2008 – Present [12] and Weather Underground [13]. Again same attributes (temperature, wind, rain, humidity and burned area) for year 2011 to 2019 were used.

First the area data were classified as Class 1 is one acre or less, Class 2 is more than one acre but less than 10 acres, Class 3 is 10 acres or more but less than 100 acres, Class 4 is 100 acres or more but less than 300 acres, Class 5 is 300 acres or more but less than 1000 acres and Class 6 is 1000 acres or more but less than 5000 acres. Then the dataset was normalized with D Min Max normalization. The structure of Neural Network was determined with feedforward backpropagation and multilayer perceptron. Error values and the percentage of accuracy are given in Table 4.

Table 4. The results for the new dataset.

	Random forest	Decision tree	Linear regression	Neural networks
RMSE	0.7698	0.9027	0.6666	0.70719
MAE	0.4444	0.5926	0.2963	0.3519
MAPE (%)	28.09	42.9012	13.272	16.975
Accuracy (%)	89	63	92	93

According to the results, neural network model outperforms among others. Also, there is a big difference between all scenarios' error values. It means that if the method of Scenario – 3 (classified the area data for predict) was used, we could get better error values and percentage of accuracy, usage of this method with a different dataset validate the methods usefulness and effectiveness.

4 Conclusion

In the study, it was realized that different methods, techniques and scenarios can be used in the prediction process and they produce different results and accuracy levels. The aim of this study is to find both the most effective and efficient technique among the different techniques for prediction of the forest fires. Thus, both effective and efficient resource utilization can be ensured and both the costs and losses for the planning and preventive activities due to inaccurate prediction process can be minimized.

The motivation of this study on the forest fires, is the importance of this issue to the whole world, because it is an environmental issue that has continuously increases its importance from the past to the present, and the opportunity to make improvements in this field.

In this study, historical forest fire data and meteorological data were used to make estimations for future fires and this provide an input for effective preventive actions. It can be possible to make an effective planning and prevent possible forest fires with the improved accuracy of this estimation procedure.

Linear regression, decision tree, random forest and neural network models were utilized in this study to estimate the forest fire risk level based on four main meteorological data: temperature, humidity, wind and rain. These methods were applied to two dataset. As we can see from the results, neural networks performed well in all scenarios. The Scenario – 3 (class the area data) is seen more appropriate to predict forest fires as the risk class can be predicted before the fire comes out. Therefore, the methodology of Scenario – 3 was used for second dataset and it gave realistic estimates. By the way, neural networks outperformed among the other methods in all of the scenarios.

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Factors Affecting the Adoption of Technological Service Innovations

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Abstract. The continuous and increasing speed of technology is directly affecting human behaviour. Human nature accepts some innovations and changes as they are, while others are resisting to accept them. It is not possible to use technology effectively in the retail area without knowing the impact of technological innovations on the customers and the perspectives of customers against such innovations. For this reason, it is of enormous importance for employees and customers to adopt this innovation to achieve success and ensure sustainability of the models related to technological service innovations. The objective of this study is considering the complex structure of the adoption process of the technological service innovation by employees and customers in detail. In this context, firstly a systematic literature review was conducted and then the factors affecting the adoption of technological service innovation were identified. The extended form of The Unified Theory of Acceptance and Use of Technology (UTAUT 2), by integrating personal innovativeness (PI) factor, was developed for a technological service innovation.

Keywords: Retailing · Service innovation · Unified Theory of Acceptance and Use of Technology 2 (UTAUT2)

1 Introduction

Nowadays, service innovation implicates non-physical processes and active interactions between technological and people systems. Service innovation is either based on new service to gain more benefit effectively from changes in the new age or it refers renovation of an existing service in the organization. Benefit usually implies the added value that is presented to the customers [1]. While service innovation is recognized as the key to development and prosperity for society and countries, it is also a driving force for economic growth in the community and the sustainable development of different industrial groups [2]. In other respect, when the service innovation is evaluated from an organizational perspective, it is defined as a concept which is produced by using advanced technology compared to the market and country conditions in which the business operates, mostly focused on a different requirement of the society and creating competitive advantage against its competitors [3].

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New technologies that change dynamically and the concept of continuous innovation play a significant role in ensuring competitive advantage in the retail industry [4]. Acceptance of new technologies has always been a major concern within companies and organizations. Although there are many studies on the adoption of technological service innovation in the literature, there is a deficiency of addressing the adopting process of the technological service innovation in the retail industry in detail.

The objective of this study is to examine the complex nature of the adoption process of the technological service innovation by employees and customers in detail. For this purpose, a systematic review of literature is conducted to identify factors affecting the adoption of technological service innovation by investigating the key models related to technology user acceptance.

In the remainder of the paper, first the methodology will be explained. Then, a review of the models related to technology user acceptance will be given and the proposed model will be explained for technological service innovation. By revealing the factors that may be effective in the adoption of technological service innovations, this study also aims to provide guidance to the practitioners in this field.

2 Methodology

In this study, first a systematic review of literature is conducted to identify the factors affecting the adoption of technological service innovations by investigating the models proposed to explain the adoption of new technology by users. Then a modified version of Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) model is developed for technological service innovations by integrating personal innovativeness (PI) factor.

A large-scale systematic literature review was conducted to elucidate the factors affecting the adoption of technological service innovations. The review of literature is focused on identifying the models proposed to explain the adoption of new technology by users. Relevant keywords are used for systematic search and citation analysis is conducted to understand the development of models through time.

2.1 A Key Models Related to Technology User Acceptance

– What does acceptance mean?

On the whole, acceptance is defined as the opposite of the rejection term and the affirmative decision for using of an innovation [5]. Innovation adoption is a process that involves a number of stages leading to achieving decisions to adopt this innovation [6]. The basic conceptual framework of fundamental individual information technology acceptance model, which underlies the basis of lots of research, shows that individual reactions to using information technology not only directly affects the actual use of information technology intentions but also indirectly affects through intentions to use information technology [7].

– Types of user acceptance models of technology

A number of theories and models have been introduced to bring users to adopt new technologies, and these models and theories offer factors that can influence the use of new technologies by users [8]. The main theories and models, which have been developed over the years, are summarized below.

Theory of Reasoned Action (TRA): TRA is one of the most significant theories used to investigate users' adoption behaviour and to reveal critical factors in obtaining full benefits of information technology [9]. The most important factor that determines the behavior according to TRA is intention and it is affected by subjective norms and attitude [10]. Attitudes towards behaviour are affected by beliefs and evaluations. Subjective norm is affected by normative beliefs and motivation to comply.

Technology Acceptance Model (TAM): TAM is a theoretical model that aims to explain why people prefer to use certain technologies in their business activities [11]. In this model, two motivational variables are considered: perceived usefulness and perceived ease of use. These variables are significant for determination of behavioural intention related to use a system or technology. According to the oldest TAM, behaviour intentions are directly affected by perceived usefulness and attitude toward use [12]. In the following studies, "attitude" variable was removed from the model. Eventually Venkatesh and Davis [13] conducted the latest TAM, where behaviour intentions are directly affected by perceived usefulness and perceived ease of use. TAM model was improved by adding subjective norms and has been tested with extended and longitudinal research designs [14].

Motivational Model (MM): MM was used by Davis, Bagozzi and Warshaw [15] to understand the adaptation of new technologies by individuals. The basic components of the model are external motivation and internal motivation [9]. According to Vallerand [16] intrinsic motivation refers to pleasure or satisfaction from a particular activity or situation, and that extrinsic motivation is the behaviour exhibited in order to achieve and complete a specific purpose. Extrinsic motivation examples are subjective norm, perceived ease of use and perceived usefulness. In other respect, intrinsic motivation examples are enjoyment and computer playfulness [14, 15].

Theory of Planned Behaviour (TPB): TPB was developed by Ajzen as an extension of TRA [17]. Attitudes and subjective norms are the same as TRA in determining the behaviours of individuals. In addition to these, Ajzen added perceived behavioural control to the TRA model after a while. The conceptual model of TPB shows the indirect effect of the perceived behavioural control factor on behaviour and the direct effect on intention.

Decomposed Theory of Planned Behaviour (DTPB): Taylor and Todd [18], has put forward DTPB with the purpose of improving the TPB. In the theory, subjective norm, perceived behavioural control and attitude variables were determined by adding new sub-variables to explain the actual behaviour of the consumer. These variables are: ease of use, perceived usefulness, compatibility, peer influence, superiors' influence, self-efficacy, resource facilitating condition, and technology facilitating condition [19].

Combined TAM and TPB (C-TAM&TPB): Although the TAM is one of the most effective and most widely used models, it is recommended that the model be expanded by including new variables including human and social factors. When the literature is examined, it is seen that TAM has limitations and the model has been criticized. In this context, two different variations of the TAM and TPB have been tested to determine which model best describes the use of technology and results were compared. As a result, Taylor and Todd developed the C-TAM&TPB model in 1995 by integrating TAM and TPB models [19]. The main variables of the C-TAM&TPB model include perceived usefulness, perceived ease of use, attitude towards using, subjective norm, perceived behaviour control, behavioural intention and actual use.

Model of PC Utilization (MPCU): This model was developed by Thompson et al. [20] by using the human behaviour theory of Triandis [21] and was adapted to the information systems. The main variables of the model, which are used to predict pc utilization, are facilitating conditions, social factors, affect towards use, long-term consequences, complexity and job-fit [9].

Innovation Diffusion Theory (IDT): IDT was put forward by Everett Rogers in 1962 and has been valid until today. This model based on sociology is used to describe the innovation-decision process in detail. Innovation-decision process has the following stages; knowledge, persuasion, decision, implementation and confirmation. Moore and Benbasat [22] enlarge the factors set to study technology acceptance in the information systems field. The set consist of visibility, compatibility, relative advantage, ease of use, image, and voluntariness of use and results demonstrability. In order to better understand the IDT, it is necessary to understand what innovation and diffusion mean in theory.

Social Cognitive Theory (SCT): One of the most important theories explaining human behaviour is Bandura's Social Cognitive Theory [9]. Compeau and Higgins [23] developed this theory based on the model and implemented applications on computer use. According to SCT, individuals must have the ability and capacity to perform certain behaviour [24]. The main components of the theory are the outcome expectations-performance, outcome expectations-personal, self-efficacy, affect and the anxiety.

The Unified Theory of Acceptance and Use of Technology (UTAUT): UTAUT has been developed by assessing the strengths and weaknesses of eight different theories and models for technology acceptance [9]. In UTAUT, four basic variables are used as determinants of usage behaviour and intention. These variables are performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC). These factors play an important role since they are directly influential in the technology acceptance and use behaviour of individuals. Also, the four moderator variables included in the model are; age, gender, experience and voluntariness of use. In this model, PE, EE and SI directly affect the intention of the behaviour. However, behavioural intention and FC are effective on direct use behaviour [25]. Moderating variables which are added such as the gender and age have an impact on the PE, SI and EE. Also, the experience has influence on the FC, SI and EE. Finally, voluntariness of use only affects SI. UTAUT gave better results than the other models with regression value explaining about 70% of the behavioural intention in organizational context [25].

On the other hand, the other eight models (TRA, TAM, MM, TPB, C-TAM&TPB, MPCU, IDT, SCT) were able to explain the behavioural intention only between 17% and 53% [26].

The Extended Unified Theory of Acceptance and Use of Technology - (UTAUT2): The results of the studies conducted using UTAUT revealed the need of transformation of the individuals working in the institutions from the acceptance and use of technology to the acceptance and use of consumers. In this context, Venkatesh et al. [25] restructured UTAUT and developed the UTAUT2 model by placing the consumer at the centre. The purpose of the new model is to examine the adoption of technology in the context of the consumer. For this reason, the voluntariness of use that is one of the moderator variables included in the first model has been removed from the developed UTAUT2 and three new variables including the Hedonic Motivation (HM), Price Value (PV) and Habit (HB) are added. This new model, explains the variance in behavioural intention and technology usage variables better than UTAUT. In terms of behavioural intention, UTAUT explained 56% of the variance in the context of consumer use, while UTAUT2 explained 74% of the variance. Similarly, the variance value which was 40% in terms of technology usage increased to 52% in UTAUT2 [25]. The theories and models described above help researchers to specify the factors involved in the process of adoption, acceptance and diffusion of an innovation. Many researchers in different fields investigate, use and extend these theories and models.

2.2 The Proposed Model

In the light of the published scientific studies, a conceptual model is proposed based on the UTAUT2 model, which provides a clarification for technology acceptance and use by consumers [25] to examine in detail the complex nature of the process of adoption of technological service innovation by employees and customers. Other factors need to be included to verify the applicability of UTAUT2 in different technologies and

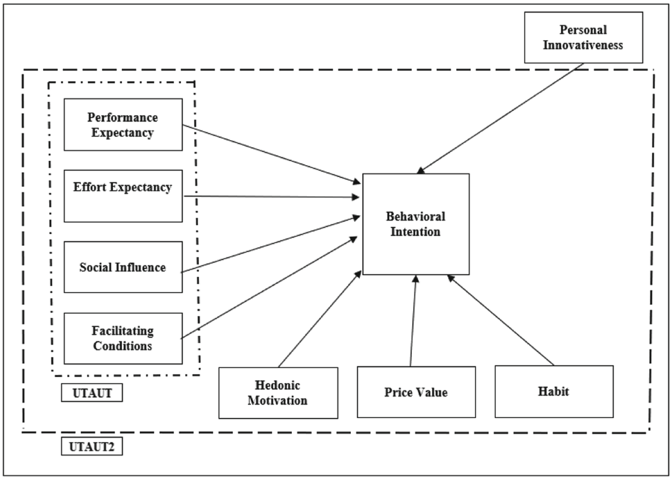

Fig. 1. The framework of proposed conceptual model.

contexts. For this purpose, in this study personal innovativeness (PI) has been added to the model to bring light on the factors affecting the adoption of technological service innovation. The proposed conceptual model is shown in Fig. 1.

Additionally, to complement the current model, moderator variables such as age, gender, income, education, marital status and occupation can be added to investigate the impact of these socio-demographic variables.

3 Conclusion

In the light of the literature a conceptual model was developed in order to present factors affecting the adoption of technological service innovations. In this study, based on the current UTAUT2 model, the factors affecting the complex adoption process of technological service innovations were determined. The conceptual model was formed by extending UTAUT2 model and involved factors such as PE, EE, SI, FC, HM, HB and PV and additionally PI. Since smart technologies provide retail customers with the opportunity to personalise all process steps that are effective in delivering superior shopping performance [4, 27, 28], personal innovativeness (PI) factor has been integrated into the existing UTAUT2 model to reveal the factors that are effective in the adoption of technological service innovations. This study aimed to bring out the factors affecting the adoption of technological service innovations. In addition, the most important factor that determines the amount of investment of companies in relation to technological innovations is the adoption and use of these innovations as planned and targeted by the target users [29]. For this reason, identifying the factors that are effective or not effective in the adoption of a new technological service innovation by store employees or managers and customers, is of great importance in developing and expanding these services to a wider audience for service companies. So, by taking the practical point of view into account, this model can shed light on the process of measuring the impact of potential innovative applications in the service sector. In the future studies, relationships between the factors in the proposed model can be investigated using real-world data.

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Methodology for Assessing Digitalization Readiness and Maturity of Small and Medium-Sized Enterprises

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Abstract. Digitalization is a major trend changing both, business and society. As a result, small and medium-sized enterprises (SMEs) are also facing the challenges of a digital transformation, which is less an evolutionary process, but rather a change that must be actively shaped. However, SMEs are subject to major uncertainties and substantial challenges with regard to this transformational process. This paper proposes an assessment methodology to support SMEs in creating a holistic view of digital maturity, serving a descriptive and prescriptive purpose. The developed methodologies support SME to align strategies and to identify specific fields of action and projects. In contrast to the widespread standardised online self-assessments, the designed QuickCheck Digitalization (QCD) is based on the objective results of a detailed investigation of the enterprise and its existing processes, carried out by external assessors.

Keywords: Digitalization · Industry 4.0 · Maturity model · Change management

1 Introduction

Digital transformation is becoming a necessity [1], that jeopardizes those companies not engaging in the process [2, 3]. Consequently, recent reports revealed, that 95% of business leaders plan investments to gradually increase digital maturity [4]. However, this transformation proofs to be a big challenge. Especially, small and medium-sized enterprises (SME) are currently facing major uncertainties and substantial challenges with regard to digitalization in general [5] and measures to be implemented in particular [6].

Experience has shown that the majority of change processes in companies fail [7]. This is partly because the process often lacks clear objectives as a result of scarce information on the current state [8, 9]. The ever-increasing complexity, exponential technologies as an accelerant and constantly emerging opportunities [10, 11] make it difficult for managers to grasp digitization in total and particular twists hereof [12]. Especially SME manager face major difficulties in determining the status-quo with regard to digitalization and in most cases overestimate their level of digitalization [13]. Therefore, they often fail to identify concrete steps within the digital transformation

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[12]. Consequently, it needs methods, tools or frameworks to provide guidance and the information needed to SME managers. Recently several organizations introduced maturity models, road maps and readiness assessments to increase transparency of the digital transformation process [14]. These methods indeed have certain disadvantages and, in particular, fail to provide satisfactory assistance to SMEs [15]. In particular, SME lack a support for relating the vision of digitalization to their specific domain and individual business strategy [13, 16].

The purpose of this paper is to design an assessment methodology to support SMEs in creating a holistic view of digital maturity, serving a descriptive and prescriptive purpose. The developed methodologies support SME to align strategies and to identify specific fields of action and projects.

The remainder of this research is based on the definition on micro, small and medium-sized enterprises of the European Commission. Accordingly, SMEs are enterprises that employ less than 250 employees and either have a turnover not exceeding 50 million Euro or an annual balance sheet not exceeding 43 million Euro [17].

2 Existing Readiness and Maturity Models

Digital maturity is the goal of the transformational process [18] defining a state of ability to achieve the desired transformation [19]. In order to make this change, it is essential to determine the current state of affairs. A widely used tool to assess digital maturity are maturity models [20]. Maturity models represent a particular class of reference models, which are typically oriented towards the development of organizations or information systems [21]. These models pursue the goal of describing a desirable evolutionary path to a perfect state [22] and to evaluate the degree of progress to reach maturity [23]. In addition to their increasing distribution and purpose, maturity models are characterized by the fact those [22, 24]:

- determine the actual situation of valuation objects in a structured manner,
- derive and prioritize improvement measures based on observed data and
- monitor the successful implementation of specified measures.

As a result, maturity models are not only used to assess skill levels, but also provide incentives and measures to systematically improve or change capability levels. This implies that such models are a suitable instrument to measure the progress of the measures taken [21, 25]. Thus, maturity models constitute a suitable tool to guide enterprises in the digital transformation process.

Meanwhile, both, practitioners and researchers, designed a multitude of maturity models or assessment tools to address the digital transformation. A solid overview of the diversity is conveyed by Göklap et al. [20], Akdil et al. [26], Mittal et al. [27] and Carolis et al. [28]. In general, it can be stated that many maturity models differ with respect to their characteristics, although they share many similarities. The latter is because maturity models are based on a universal framework and many authors build on their predecessors work [29]. The majority resort to instruments and procedures that have already been tested and validated, when it comes to assess digital maturity.

Although SMEs are the backbone of western economies [30], existing maturity models rarely consider their specific perspective and unique requirements, in particular [27]. SME face different challenges and barriers when it comes to digitalization [31]. Consequently, most instruments to assess digital maturity are restricted in their use for SMEs by the lack of considering SME specific requirements [27]. This results in variety of difficulties for SME using these instruments. The following disadvantages with existing maturity models were identified:

– Maturity models promise a certainty of success, although this is not always attainable in practice. On the one hand, most of the existing models specify a gap between an actual and a target situation, but either how to close this gap is left open or the methodology fails to hint on how the transformation process can be completed. SME are less experienced in managing new technologies and often lack a strategy department to work with assessment results [32]. They also struggle to derive measures and to identify concrete steps to be taken [33, 34]. Therefore, it is essential to identify further measures to reach a desired level of digital maturity.
– On the other hand, most maturity models assume that all companies develop in the same way. Situational factors (such as corporate culture, structure, size) are often neglected to reduce complexity [35]. It is also criticized that many maturity models are aiming for a level of development that is not achievable, especially in high levels of maturity [36]. This is especially true for SMEs, which usually lack financial resources to reach levels that are based on pricy high-end technologies [32]. Thus, assessment methodologies should also consider individual situational factors in addition to domains, when defining a suitable digital maturity level.
– Maturity Models capture an area of application with several relevant dimensions and their variable expressions. These are normalized on an ordinal scale, the so-called maturity levels [24]. Mittal et al. [27] argue that most instruments to assess digital maturity "start from a somewhat advanced level that includes connected machines, sensors, and some form of OT/IT integration." However, large enterprises, which are in the focus of these instruments, are often way ahead of SMEs, which have not reached the starting level yet [37]. The transition to this first stage is often associated with much more effort as SMEs, in particular, struggle with the implementation and adaption of these technologies [33].
– A general disadvantage of self-assessment tools and maturity models that are based on questionnaires is that respondents require at least basic knowledge on the concepts of digitalization in order to give proper answers. Especially when it comes to assessing the readiness of high-end technologies, the lack of experts and experiences makes it harder for SME to properly evaluate the level of digitalization [27, 38]. A single person usually lacks the necessary information to answer the questions for all division in detail. Thus, assessment suffer from a poor quality of the provided information. In addition, objectivity is a further cause of objection. In general, respondents have to accurately reflect on both strengths and weaknesses answering the questions. Bley et al. [13] revealed that many enterprises overestimate their level of digitalization.

3 Research Approach

Since Nolan [39] and Crosby [40] introduced the concept of maturity models, a large number have been developed in science and practice [35]. However, most lack a theoretical and methodological foundation in construction [41]. Maturity models are often not well documented and the methodological foundations are not explicated [42]. Nevertheless, various design processes have been established lately, which can be understood as a specializing in the general research process of design-science. Currently, there are five different process models with comparable design steps [43, 44]. In order to design an assessment methodology for digital maturity Becker et al.'s [22] step-by-step procedure, which builds on Henver et al.'s [45] design science approach, was adapted and extended. Accordingly, a multi-methodological development approach was carried out. This includes a systematic comparison of existing maturity models, a systematic literature review, expert interviews and an iterative development of the assessment methodology.

The procedure model by Becker et al. [22] postulates an eight-phase development approach that is illustrated in Fig. 1.

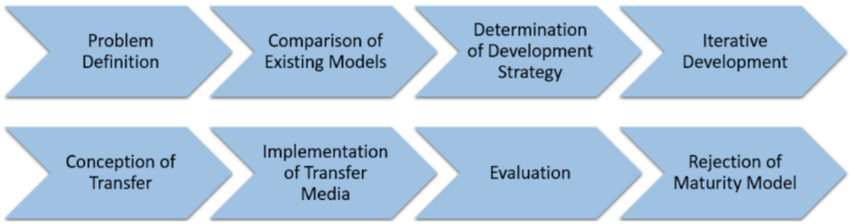

Fig. 1. Eight-phase development approach according to Becker et al. [22].

In a first step, expert interviews with representatives of 38 SME were conducted to identify key problems when it comes to the implementation of digitalization in practice. It proofed that SME face uncertainties on determining their current level of digitalization and lack a clear idea on where to start the digital transformation. This knowledge forms the basis for further development and analysis. Due to the rapidly increasing number of publications on maturity models and digitization in general, a systematic approach to analyze existing literature is indispensable [46, 47]. Therefore, Cooper's literature review process serves as a framework, in order to guarantee high-quality analysis for this paper [48]. The review on digitalization and existing digital maturity models is input to for:

- the gap analysis on digital maturity models,
- the derivation of suitable structures, like assessment mode, dimensions, maturity levels etc.,
- the definition of concrete maturity levels.

4 QuickCheck Digitalization

The QuickCheck Digitalization (QCD) provides a snapshot of the current digital maturity based on a detailed investigation of the enterprise and its existing processes. Therefore, six core dimensions were identified and divided into a total of 16 sub-dimensions with several criteria. Table 1 gives a brief overview of the six dimensions, including a brief review of their key items. Each item undergoes six maturity levels, whereby the first level represents a state of missing all the attributes to constitute to the concepts of digitalization. Level 6 on the other hand represents a reasonable state-of the art with regard to SME specific requirements.

Table 1. The six dimensions of the QCD.

Dimension	Description
Business model and strategy	Adaption of business model, available resources, comprehensive digitalization strategy, cooperation, pioneering spirit
Human capital and people	Competence management, autonomy, openness to new technologies, variation of specifications, digital leadership
Digital production	Digitalization of products, individualization, wearables and mobile devices, existence of ICT, information processing
Digital processes	Decentralization of processes, collaboration, data gathering and analysis, digital support of processes, modelling and simulation
Connectivity	Machine-to-machine communication, modern ICT, real-time fieldbus systems, sensor nodes, cloud computing
Knowledge management	Transparency, documentation, knowledge sharing, open innovation

The QCD consists of five phases: Initiation, Execution, Evaluation of Results, Review of Results and Retrospective (see Fig. 2).

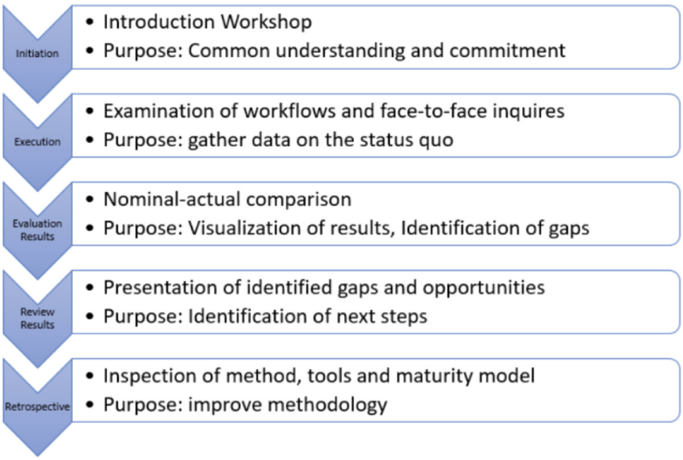

Fig. 2. Methodology to assess digital maturity and readiness.

During initiation, external moderators carry out an introductory workshop with direct clients to reach a common understanding of the assessments' purposes, goals and execution. To be successful, assessments and assessors must be borne by the principal. This includes commitment to the detailed approach and the provision of required resources. In addition, the company's basic concepts and current initiatives regarding digitalization are discussed. This information provides assessors with a first insight and serves their preparation.

Initiation is followed by execution. The designed QCD provides a snapshot of the current digital maturity based on a detailed investigation of the enterprise and its existing processes. Therefore, external assessors observe the companies workflows to get an idea of basic processes of the enterprise under investigation. Particularly critical processes and workflows are examined carefully. Results are complemented by face-to-face inquiry to eliminate ambiguities and a misunderstanding of terminology and technologies. A previously developed interview guideline forms the basis for the semi-standardized interviews. This guarantees a standardized process and comparable results [49]. The guideline builds on the current version of the maturity model. In order to identify the actual situation, these interviews are carried out not only in all areas of the company but also across all hierarchical levels. This allows for a reliable rating of the digitalization level. It has already been shown that the perception of management does not always correspond to reality. For example with regard to the acceptance and actual use of digital tools and methods. This also ensures reliable input to assess the dimensions with regard to the human element in the digital change. Among others, people's recognition of the need to enforce change and their willingness to submit to it are a crucial basis for digital transformation.

During the evaluation phase, results from all interviews are aggregated to identify the status quo of the entire enterprise. A breakdown by functional divisions is also conceivable. The evaluation of individual interviews is based on Mayring's [50] qualitative content analysis. This provides the following sequence: Classification of the conversation, creation of a keyword index, identification of the most important topics, structured summary of the written interviews and an intercoder reliability check. In a second step, experts define a reasonable digital maturity level for the individual SME to deduce target levels for all core dimensions. This is input for a nominal-actual comparison to identify existing gaps and to propose further measures and potentials. It is important to stress that the defined target levels are rather subjective and dependant on the expert's professional experience. For this reason, the experts' assessment is complemented by findings from current literature and experiences from previous Quick Checks. Identified gaps, potentials and the currents status-quo on digital maturity are visualized and discussed with SME managers in a review meeting. A radar chart is used to visualize the overall results and the results within the single dimensions (see Fig. 3). Experts also provide methodological support in prioritizing potentials to help SME managers to getting started.

A final workshop is an opportunity for the assessors to inspect themselves, as well as the method and the instruments used to generate a snapshot of the status-quo of digital maturity. It is crucial to involve the representatives of SMEs into the review process and to evaluate their satisfaction with the presented results and the assessment in general. The representatives are not only regarded as customers but also take on the

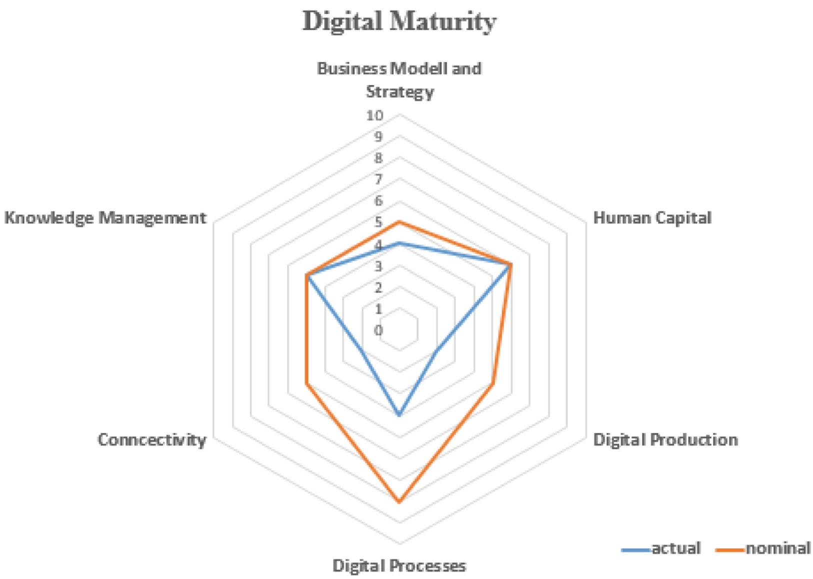

Fig. 3. Radar chart visualizing digital maturity in the dimension "digital processes".

role of experts for SMEs that give valuable hints on the companies' specific requirements and the applicability of the QCD. By the end of the retrospective, improvements on the general procedure, structure of the maturity model and the maturity items are identified and will be implemented before the next assessment.

5 Conclusion

Companies that exploit the opportunities of digitalization will gain competitive advantage. Therefore, digital transformation has become a high priority on management agendas. However, proponents argue that most enterprises are ill-prepared to benefit from digital innovations and its capabilities [51, 52].

The QCD assists SMEs throughout the digital transformation process by providing a holistic view of digital maturity during each transformational phase. With its general applicability and its practical relevance, the proposed methodology supports decision makers based on a much more extensively and intensively investigation than any self-assessment methodology. An individual definition of the digital maturity level is the basis for the identification of gaps and for the proposition of reasonable improvement measures. Thus, the QCD also serves a prescriptive purpose.

The presented method is designed for a determination of the digital maturity in SMEs. Therefore, it already reaches its limits on the edge of the SME definition. The more employees are included in the assessment the more information must be included in the assessment of digital maturity. However, time becomes a crucial factor from a certain number. In order to get a basic understanding of essential processes and work steps and to conduct decent interviews, an average time of 30 min is planned for each attendant. Since the total duration of the data collection phase is limited to two days, limitations of a certain complexity and size are required.

Through agile adaptation, the QCD can be adapted to the observed values and expressions. As a result, the QCD benefits from an increasing number of assessments and new insights from research. In particular, the proposed assessment will benefit from findings with regard to the implementation of digital technologies in SME and the SME specific requirements on digitalization.

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Simulated Annealing Applied to Traveling Salesman Problem: A Case Study

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Abstract. Intelligent computational techniques are being extensively explored and disseminated to solve complex problems in favor of effective decision making12.. This paper describes the use of the Simulated Annealing metaheuristic for the Traveling Salesman Problem - TSP, contained in a dairy distribution company. The objective is to verify the applicability of the metaheuristic and validate its efficiency to solve combinatorial optimization problems, as opposed to an application to the real scenario. The results obtained are compared with the previous studies in the literature, which solve the same TSP by means of Memetic Algorithm and the exact method. With the comparative analysis, it can be verified that the proposed metaheuristic is a method of obtaining good solutions for difficult optimization problems, both in terms of the quality of the solutions obtained and the execution time of the algorithm.

Keywords: Simulated Annealing · Traveling Salesman Problem · Combinatorial optimization

1 Introduction

Many problems in engineering, planning, manufacturing and distribution, can be modeled as minimizing or maximizing a function. This class of so-called optimization, are often identified the daily life of organizations and involve different interrelated variables in a single problem, with several scenarios for analysis and decision-making. The difficulty is to find among all the solutions, the global optimal solution that meets all the criteria involved [1].

Operational Research is an area of interdisciplinary knowledge that brings together algorithms and techniques used to solve real problems for effective decision-making. One form of resolution that encompasses this field of study is the mathematical programming, which allows you to examine numerous feasible configurations of the problem in question e and offer the best solution, respecting a set of restrictions. These techniques are in view of their great utility in solving combinatorial optimization problems; among which we can mention: Problems of Flow in Networks and Logistics

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of Distribution; the Problem of the Traveling Clerk, the Problem of the Backpack, the Transport Problem, and the Allocation Problem, among others [2].

The Problem of the Traveling Salesman – TSP, consists of visiting a finite set of cities, in such a way that starts and ends the route in the same city, going through the others only once at the lowest possible cost [2]. The TSP has wide applicability in the real world, is easy to understand and descriptive, but classified as NP-Hard [3], because the solution space grows exponentially with the dimensions of the problem. Instances connected to n cities have $(n - 1)!$ possible routes and n mathematical operations are processed for each route. Therefore, strategies that use metaheuristics are showing increasingly promising results, without the need to allocate large computational resources. Each metaheuristic has a search strategy, but the common goal is to escape the local minimums, in order to advance exploration in the space of search for even better solutions [4].

Simulated Annealing, is a metaheuristic based on the analogy with the physical process of annealing certain materials (annealing) initially proposed by [5], and [6] suggested its use in the computational environment, the method presents as a criterion of convergence thermodynamic principles. Atomic structures are formed as a function of the heating process, followed by the cooling of the materials. With a slow and gradual decrease in temperature, each setting has an energy level. The process terminates when the solidification point is reached, exhibiting a minimal energy configuration. The process is terminated when the solidification point is reached, with a minimum energy setting.

For mathematical modeling, we have: the state of the thermodynamic system corresponding to the current solution of the combinatorial problem; an energy equilibrium equation for the thermodynamic system represents a goal of purpose; states of the physical system are equivalent to solutions of the search space; a disturbance of a physical state relates to a selection of a nearby solution in the search space; A fast cooling of the physical system is a good location and the fundamental state of a particle system is a global problem of a combinatorial problem [6].

Currently, a large percentage of costs for companies is in the distribution of products through logistics; organizations seek processes to optimize distribution and. This research presents a problem extracted from the routine of a dairy distribution company, which consists in delivering products daily in a set of cities, departing and closing the route in the city of origin, in such a way as to minimize the cost of the trip. The objective function minimizes the cost of travel in terms of both distance and time, since deliveries are carried out on refrigerated trucks. This type of Vehicle Routing Problem (VRP) is a generalization of TSP. The Fig. 1 illustrates the complexity of the problem, locating all cities on the map. The city of origin and destination is Angicos, identified with the location symbol and the letter "A"; the others are with the location point, of the State of Rio Grande do Norte, in Brazil.

The Association of Small Farmers of the backwoods of Angicos (APASA) delivers products daily in a set of cities in the state of Rio Grande do Norte. The problem is to determine the best route for product distribution across a set of n cities to minimize costs, whether using the shortest route or the route that totals the shortest travel time.

Related works address the same PCV, [8] proposed the use of a traditional genetic algorithm (AGT) to find solutions that approximate the optimal results obtained in [9]

Fig. 1. Map showing the location of the problem [7].

via the exact method, and [7], presented a hybrid evolutionary algorithm, the memetic algorithm (AM) that uses GA in the traditional form, except for the genetic operator rate, which includes the mutation in its operation and receives a single value for crossover and mutation execution, and local search operator execution.

In this context, this paper presents an approximate metaheuristic, called Simulated Annealing, to verify the applicability of the algorithm and validate its efficiency through previous studies cited. In its research, [9] finds that the company operates in twelve cities, including the distribution center and the consumption centers. For simulation purposes, the number of cities has been increased by [7], and will be provided by the same distribution center.

2 Objectives

The objectives of this work are: to implement the Simulated Annealing algorithm adapted to the distribution problem in a dairy distribution company; validate the efficiency of the proposed method, considering the computational performance of each execution and the quality of the solutions found in each iteration; to analyze the results obtained, which will be compared with the results of the Memetic Algorithm and the Exact Method, developed by [7] and [9].

3 Method

The computational experiments were performed considering a single route to: 48, 36, 24, 12, 7 and 6 cities, represented by n. As a minimization parameter: the distance traveled (Km) and the time spent (min), totaling the simulation of 12 problems. The algorithm proposed in this work was executed for all instances presented and previously modeled using the Scilab platform, version 6.0 and running on a Dell PowerEdge T130 Server, with Intel® Xeon® Processor Quad Core E3-1220 v6, 8 GB RAM and HD of 1 TB. The operating system is Ubuntu 18.04.1 LTS. The parameters were adjusted according to [6] and are divided into: initial temperature, which determines the amount of processing time (IT) with value 100, the minimum temperature to be used as the stopping criterion of the algorithm (FT), with a value of 0.01; the rate of reduction of temperature (α), with value 0.98; and number of steps at each temperature (NST), with value 5. Moreover, the algorithm was run 100 times. A flowchart to represent the proposed algorithm is presented in Fig. 2 and described below.

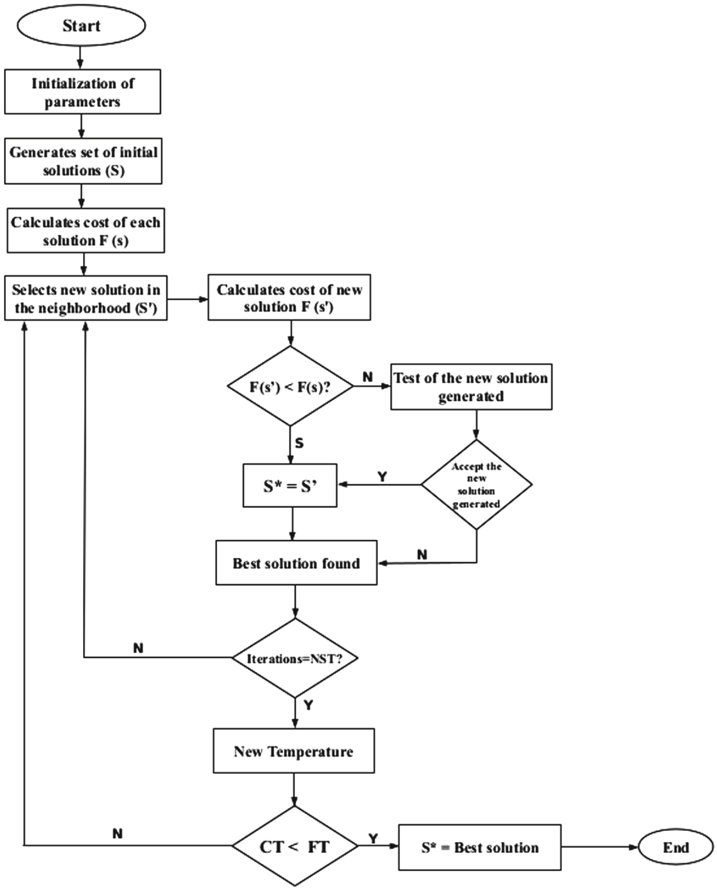

Fig. 2. Flowchart of the algorithm adapted to the SA. (Own authorship)

The algorithm receives as input parameters an instance of the problem, the number of solutions and the parameters of the cooling program. In this work, the initial solution is randomly generated, taking into account TSP constraints that is, not allowing the repetition of the same city. The initial solution is represented by S. After generating the set of solutions, the algorithm calculates the cost of each solution.

Subsequently, a Local Search Shift procedure is started in the solution space. The neighbor solution is represented by S'. The next step of the algorithm is to check the quality of the new solution in relation to the current solution, based on the objective function. If $F(s') < F(s)$, S′ is accepted as the current solution, if $F(s') > F(s)$, the probabilistic factor and the acceptance test, will determine whether the neighbor solution will be accepted as the current solution. This choice for a possible worst solution is the mechanism used by SA as an attempt to escape from great locations. The iterations occur until an equilibrium situation is observed. IT indicates the initial temperature e CT, the current temperature. While CT > FT, a loop of repetition is performed, having as temperature change as a decrease in temperature α, and as a stop condition the parameter that establishes the minimum temperature FT. The repetition loop Iterations have the established NST parameter as the stop condition and determine the number of iterations at each temperature. Finally, the algorithm returns as output, the distance or time of the best route. It is important to highlight that Algorithm is aimed at solving a minimization problem.

4 Results

The computational results are presented in the following tables, with the individual and comparative analysis of the proposed metaheuristics. Table 1 shows the best SA results compared to those obtained by the Memetic Algorithm and by the Exact Method. For each problem, two columns are presented, in this order: the best solution found (Min) and the time spent by the algorithm, in seconds (T(s).

In most of the problems, the SA obtained the approximation of the global optimum, with the exception of problems 7 to 12, where the exact solution returned. In general, the SA obtained results within the expected if we consider the values of the minimum solutions found and the execution time for problems with the larger number of cities.

The Table 2 presents some experiments performed with the SA, changing the parameter Ti (initial temperature) from 100 to 500 and also the size of the solution space (number of executions of the algorithm).* The solver did not find the optimal solution for this problems due to memory limit.

According to [6], the quality of the solution obtained by the SA depends mainly on the initial temperature. A very high temperature, associated with a very slow cooling scheme, can lead to excellent solutions however, with very high processing time. Moreover, a low temperature tends to consume less processing time; however, it can generate rather poor solutions.

Table 1. SA versus AM versus exact. (Own authorship)

Problem	n	S.A.		M.A.		Exact	
		Mín	T(s)	Mín	T(s)	Mín	T(s)
1	48	3014,6	913,5	2070,8	31,2	1942,3	6737,7
2	48	2740	680,6	2154	12,2	1973	5708,5
3	36	2134,9	446,6	1705,6	13,1	1719,2*	86325,3
4	36	2005	554,8	1668	20,9	1676*	85204
5	24	1351	271,4	1321	8,7	1339,9*	85439
6	24	1284	129,5	1223	3,7	1223	73266
7	12	672,7	53,3	672,7	1,5	672,7	0,1
8	12	606	70,29	606	3,3	606	0,1
9	7	438,3	8,49	438,3	0,5	438,3	0
10	7	364	8,91	364	0,5	364	0
11	6	344,9	6,01	344,9	0,4	344,9	0
12	6	305	5,76	305	0,4	305	0

Table 2. IT = 100 versus IT = 500. (Own authorship)

Problem	Number of solutions	Ti = 100		Ti = 500	
		Mín	T(s)	Mín	T(s)
3	25	2351,1	126,3	2104	148,9
4	25	2188	133,9	2104	140
5	25	1447,9	60,9	1443	74
3	50	2356,4	252,9	2040,5	297,7
4	50	1351,9	122,3	1351,4	141,7
6	50	1284	129,5	1241	151,4
5	75	1372,8	169,7	1360	205,2
6	75	1279	193,7	1223	226,1
6	100	1269	265,1	1228	299,5

5 Conclusion

The Traveling Salesman Problem (TSP) is a classic problem and with several works that use it as a basis for studies and solving similar problems that deal with combinatorial optimization. Its variants are present in numerous practical applications. In this perspective, the demand for elaboration, modeling, implementations, and validation of methods for its resolution appears. With the comparative analysis, Simulated Annealing is a method of obtaining good solutions to difficult optimization problems. An observed characteristic is that the algorithm presented sensitivity in relation to the adjustment of parameters, which justifies the accomplishment of more tests of refinement and improvement of the strategy, in order to make it competitive.

The objectives of the work were achieved, the implementation of the metaheuristic adapted to the TSP can contribute to the problem reported in the case study, finding globally optimal solutions in some cases and close to optimal solutions in others, with viable execution times. A characteristic observed with respect to the comparison between the results, shows that the convergence to a globally optimal solution has some dependence on the parameters adjustments and, consequently, it determines the capacity of exploration of minimum solutions, that is, the algorithms present greater sensitivity in relation settings. For the problem in question, it has been exemplified that the initial temperature parameter is, by itself, an experiment object to choose the best initial configuration.

Metaheuristics have a strong characterization of the various possibilities and the flexibility of being developed and improved. Therefore, we suggest as future work, to implement new strategies for the generation of the initial solution, the neighborhood search and the adaptation of all parameters established to execute the algorithm, in order to verify the efficiency and, therefore, the competitiveness of the method. One can combine the strategy of more than one metaheuristic or hybridize an approximate model with an exact one.

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Recent Advances and Challenges in AI for Sustainable Agricultural Systems

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Abstract. Agriculture is a booming market for several decades. Technological advances in this sector have produced promising results that can optimize profitability, productivity and sustainability. A technological revolution has taken place to meet industrial challenges. The development of the IoT has improved its sustainability and profitability by responding to digitization. New techniques emerge to improve the production process. Artificial Intelligence (AI) is presented as a science capable of replicating cognitive skills through machines. In this context, the main objective of this paper is building knowledge to guide researchers on AI advances and challenges in sustainable agricultural systems. It will be possible through the following specific steps: (a) Selecting a relevant Bibliographic Portfolio from the previous search on the Web Of Science database with time delineation of the last 11 years (from 2009 to 2019), and (b) Perform a bibliometric analysis of the bibliographic repertoire using the softwares Endnote X9®, Excel and to correlation analyses graphs will be diagrams with VosViewer®.

Keywords: Agriculture · Artificial Intelligence · Sustainability · Remote agriculture techniques

1 Introduction

In the report prepared by the National Science Foundation of the United States, Convergent Technologies for Improvement in Human Performance, Nanotechnology, Biotechnology, Information Technology and Cognitive Science, the synergy between nanotechnology, information technology, biotechnology and cognitive science was pointed out as a future potential for humanity in the next 20 years. Therefore, more and more, advances in information technology will have a strategic and political character.

In this context, AI is an important science that has contributed to sustainable growth, as described by [1], AI contributes to Japan's sustainable growth and helps solve social problems. It also points out that the AI has attracted the attention of the European Union and the United States as the key to growth. The authors cite that AI has been focused primarily on the development of new information technologies for artificial intelligence and robot technology. Other research shows the use of AI, such

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as: intelligent irrigation systems, precision agriculture involving the application of embedded intelligence, automation and network of local sensors for soil mapping, disease monitoring and meteorological variables. In addition to these applications, there are remote sensing activities that aim to obtain more data on production and environmental and climatic aspects.

Despite the growing technological advances of AI in agriculture and collaboration for sustainable growth, this work also presents the challenges to be overcome by the sector, among them the great concentration of wealth in a small portion of rural properties, there are millions of hectares of degraded soils and pastures, there is a great inefficiency in the use of water in irrigation, and the inadequate use of agrochemicals, posing risks to health and the environment, among other problems.

This paper has as main objective to build knowledge to guide the researchers on the recent advances and challenges of AI in sustainable agricultural systems. The scope of this general objective will be possible through the following specific steps: (a) Selecting a relevant Bibliographic Portfolio from the previous search on the Web Of Science database with time delineation of the last 11 years (from 2009 to 2019), and (b) Perform a bibliometric analysis of the bibliographic repertoire using the softwares Endnote X9®, Excel and to correlation analyses graphs will be diagrams with VosViewer® and finally (c) Present the recent advances and challenges of AI in sustainable agricultural systems.

2 Methods

This paper was carried out by selecting a relevant bibliographic portfolio from the Web Of Science database search, with a time delineation of the last 11 years (from 2009 to 2019) characterized in the sequence. The keywords are used: agriculture, artificial intelligence, sustainability, remote agriculture techniques.

Next, a bibliometric analysis of the bibliographic repertoire was performed using the software Endnote X9®, Excel and the correlation analysis graphs were made with VosViewer®.

The Capes Journal Portal provides, through UTFPR subscription, with Clarivate Analytics access to the main collection of the Web of Science database. Through the Web of Science tools are available for analysis of citations, references, h index, allowing bibliometric analysis. This scientific base includes approximately 12,000 journals that can be consulted in 5 collections with access available from 1945 to the present.

EndNote is an online search tool that provides a simple way to search bibliographic data online and transfer their references directly into EndNote (EndNote can also import information files saved from a variety of online services, CD-ROMs, and database libraries). This is a reference and image database that specializes in storing, managing, and searching for bibliographic references in your private reference library. You can organize images including tables, graphs, figures and equations by directing each image with its own caption and keywords. Reference lists, figures and tables are being created and enriched as citations are inserted in the article. The software also configures the citation according to the standard required for the article.

VOSviewer is a software tool for constructing and visualizing bibliometric networks. These networks may for instance include journals, researchers, or individual publications, and they can be constructed based on citation, bibliographic coupling, co-citation, or co-authorship relations. VOSviewer also offers text mining functionality that can be used to construct and visualize co-occurrence networks of important terms extracted from a body of scientific literature.

Microsoft Office Excel is a spreadsheet editor produced by Microsoft for computers running the Microsoft Windows operating system, as well as Apple Inc. Macintosh computers and mobile devices such as Windows Phone, Android, or iOS. Features include an intuitive interface and powerful table-building and calculation tools that, along with aggressive marketing, have made Excel one of the most popular computer applications to date. Section 3 presents the review of the papers analysed, based on the methodology described in Sect. 2.

3 Review

A theoretical survey was carried out on the Web of Science platform with time delineation of the last 11 years (from 2009 to 2019) with the keywords *agriculture*, *artificial intelligence*, *sustainability*, *remote agriculture techniques*, returning 549 articles. From this articles it will be analysed the 1000 most current words as we can see in the Fig. 1.

Fig. 1. Wordcloud with the 1000 most current words focusing on AI technologies, agriculture management and sustainable systems.

The revised papers were divided in three parts: purpose, innovation and challenges, these are presented in chronological order (from 2009 to 2019), in Tables 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 and 17, according to the proposal of the article: Advances and Challenges in AI for Sustainable Agricultural Systems. The works described in this section present the sum of the words *artificial intelligence* and *sustainable agriculture* in their contents. It will be selecting the 17 most relevant papers.

Table 1. ARIES (ARtificial Intelligence for Ecosystem Services): a new tool for ecosystem services assessment, planning, and valuation.

Purpose	New tool for the planning and evaluation of ecosystem services (ARIES) [2]
Innovation	Web application to evaluate ecosystem services, assists in environmental decision making
Challenges	Only spatial dynamics and carbon storage, aesthetic visions and aesthetic proximity were mapped. The next works will allow the mapping of several other ecosystem services

Table 2. Computing and AI for a sustainable future.

Purpose	A mapping was carried out between 2007 and 2011 on AI and sustainability, obtaining few results at the time. The research focused on evolutionary computing and optimization [3]
Innovation	The Association for the Advancement of Artificial Intelligence (AAAI), 2011, was created to discuss the subject of computational sustainability
Challenges	Clearly, research, education and the application of sustainability will challenge AI over many years

Table 3. Computational sustainability and artificial intelligence in the developing world.

Purpose	Analyzing the impacts of computational sustainability and artificial intelligence on human development [4]
Innovation	Despite difficult problems in developing regions, a period of tremendous changes driven by technology has created new opportunities to deal with poor resource management and improve human well-being
Challenges	New developments are needed to provide new opportunities generated by artificial intelligence and computational sustainability, although new advances have already been created

Table 4. Computational sustainability.

Purpose	To present the impacts of computational sustainability on the three pillars of sustainability [5]
Innovation	To perform a critical analysis of the problems and challenges of computational sustainability in the future, analyzing a literature review
Challenges	The problems of computational sustainability, which exist in dynamic environments with large amounts of uncertainty, provide a variety of unique challenges to artificial intelligence research and the opportunity for a significant impact on our collective future

Table 5. Assessment of the sustainability of agroecosystems in the amazon region using neural artificial networks.

Purpose	Monitoring agroforestry systems in the Amazon region [6]
Innovation	Decision support tool that aims to classify agro systems with agroforestry systems and without forest systems. It was created a methodology that uses an artificial intelligence algorithm based on neural networks (ANN)
Challenges	Apply the model in productive units, arranged in other regions of the Amazon and Brazil. Reaffirm the effectiveness of the model generated with the new tests

Table 6. Recent advances in AI for computational sustainability.

Purpose	A review on computational sustainability applying AI [7]
Innovation	It presents the contribution of computational sustainability in the processes of decision making
Challenges	Few researches point to environmental impacts with the use of technological tools

Table 7. New alternatives for reference evapotranspiration estimation in West Africa using limited weather data and ancillary data supply strategies.

Purpose	To present new alternatives for estimation of reference evapotranspiration in West Africa using limited meteorological data and ancillary data supply strategies [8]
Innovation	The paper investigates for the first time in Ghana, the estimation ability of artificial intelligence-based models (Artificial Neural Networks (ANNs) and Gene Expression Programing (GEPs)), and ancillary/external approaches for modeling reference evapotranspiration (ET0) using limited weather data.
Challenges	Having an alternative battery of ET0 estimation methods is of great interest due to the lack of dense networks of meteorological sensors in West Africa

Table 8. Combination of multi-agent systems and wireless sensor networks for the monitoring of cattle.

Purpose	Combination of Multi-Agent Systems and Wireless Sensor Networks for the Monitoring of Cattle [9]
Innovation	The joint use of heterogeneous sensors and artificial intelligence for the analysis or simultaneous detection of different problems that cattle can present was not addressed
Challenges	The GPS position of the animal allows to find the animal quickly, which is very important in extensive farming where the farmer must search the animal with a vehicle and would normally spend a lot of time at the task

Table 9. A knowledge modelling framework for intelligent environmental decision support systems and its application to some environmental problems.

Purpose	The paper presents a knowledge modelling framework for intelligent environmental decision support systems (IEDSS) by following such a holistic perspective [10]
Innovation	The proposed framework integrates an ontological approach and two data analysis approaches (data mining and Bayesian networks), which are applied for the generation of a knowledge base that is used by an IEDSS for decision making
Challenges	To develop solutions to the three problems presented by the paper: (1) water (river resource management, river water pollution analysis), (2) air (air pollution analysis, ozone prediction), and (3) soil (soil pollution analysis)

Table 10. Computer vision and artificial intelligence in precision agriculture for grain crops: a systematic review.

Purpose	Present the advances through a computational view and artificial intelligence in precision agriculture for grain crops [11]
Innovation	This work presents a systematic review that aims to identify the applicability of computer vision in precision agriculture for the production of the five most produced grains in the world: maize, rice, wheat, soybean, and barley
Challenges	The study of the presented works and the problems that they set out to solve together with the new advances in computer vision and artificial intelligence can lead to new solutions for agriculture bringing gains of production, quality, and food security

Table 11. Energy sustainability in smart cities: artificial intelligence, smart monitoring, and optimization of energy consumption.

Purpose	Create a prototype for Intelligent Monitoring and Optimization of Energy Consumption [12]
Innovation	This paper offers an insight into pilot systems and prototypes that showcase in which ways artificial intelligence can offer critical support in the process of attaining energy sustainability in smart cities
Challenges	Machine Learning approaches will set up new challenges for intelligent energy agents. Sophisticated and complicated modelling of energy consumption will also allow new analytical processing and predicting capabilities

Table 12. Growth, degrowth, and the challenge of artificial superintelligence.

Purpose	Present the growth, the decline and the challenge of artificial superintelligence [13]
Innovation	This paper explores the environmental and social implications of superintelligence emerging in an economy shaped by neoliberal policies. It is argued that such policies exacerbate the risk of extremely adverse impacts
Challenges	The implications of technological innovation for sustainability are becoming increasingly complex with information technology moving machines from being mere tools for production or objects of consumption to playing a role in economic decision making

Table 13. Machine learning in agriculture: a review.

Purpose	This paper presents a comprehensive review of research of machine learning in agricultural production systems [14]
Innovation	The paper presents the advances in the following categories: (a) crop management, including applications on yield prediction, disease detection, weed detection crop quality, and species recognition; (b) livestock management, including applications on animal welfare and livestock production; (c) water management; and (d) soil management
Challenges	In the future, it is expected that the usage of ML models will be even more widespread, allowing for the possibility of integrated and applicable tools

Table 14. Optimized back-propagation artificial neural network algorithm for smart agriculture applications.

Purpose	Develop Optimized Back-propagation Artificial Neural Network Algorithm for Smart Agriculture Applications [15]
Innovation	This paper presents a modified artificial neural networks backpropagation using the Smart Agriculture dataset, using parameters such as temperature, humidity, wind speed, solar radiation and soil water tension
Challenges	The agribusiness-based activities and business will become the main trend in national development. However, this development is not in line with the condition where climate change, soil and irrigation factors are uncertain in almost regions

Table 15. The rise of artificial intelligence under the lens of sustainability.

Purpose	The Rise of Artificial Intelligence under the Lens of Sustainability [8]
Innovation	Five dimensions of to structure the analysis, we explore the impacts of AI in various domains. A significant impact on all five dimensions has been described, with both positive and negative impacts, and value, collaboration, sharing responsibilities
Challenges	Although companies are eager to join the fray of this new AI trend and take advantage of its potential benefits, it is unclear what implications AI will have on society now and in the long term

Table 16. WeedMap: a large-scale semantic weed mapping framework using aerial multispectral imaging and deep neural network for precision farming.

Purpose	Development of a Framework Using Aerial Multispectral Imaging and Deep Neural Network for Precision Farming [16]
Innovation	The main goal of this paper is developing a novel crop/weed segmentation and mapping framework that processes multispectral images obtained from an unmanned aerial vehicle (UAV) using a deep neural network (DNN)
Challenges	Development of reference tools to evaluate variants of crop classifiers, weeds

Table 17. Combined life cycle assessment and artificial intelligence for prediction of output energy and environmental impacts of sugarcane production.

Purpose	Combined life cycle assessment and artificial intelligence for prediction of output energy and environmental impacts of sugarcane production [17]
Innovation	This study uses two artificial intelligence (AI) methods, namely, artificial neural networks (ANNs) and adaptive neuro fuzzy inference system (ANFIS) model, for predicting life cycle environmental impacts and output energy of sugarcane production in planted or ratoon farms
Challenges	Development of tools to assist decision makers in solving the sustainability problem from different perspectives

Section 4 presents the results and discussions of the papers analysed, based on the methodology described in Sect. 2.

4 Results

We found 549 articles that add up to the number of citations of 6875, with an average of citations per item 12.52, of which only 34 are indexed. Figure 2 shows the correlation of the main keywords, that is, representation of two or more words in the same work. AI has contributed for several decades to the various areas of knowledge. In agriculture, intelligent irrigation systems, precision agriculture involving the application of embedded intelligence, automation and a network of local sensors for soil mapping, monitoring of diseases and meteorological variables. New possibilities arise when analysing the advances of AI in agriculture, as well as the challenges faced by

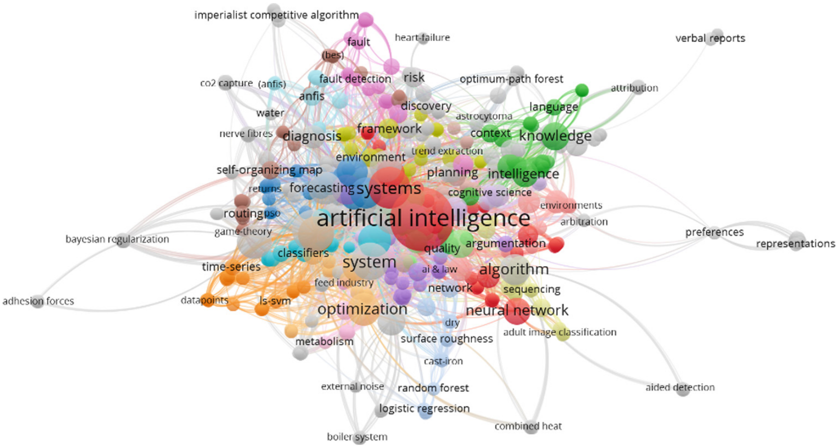

Fig. 2. Correlation of the main keywords.

this segment, great concentration of wealth in a small part of rural properties, there are millions of hectares of degraded soils and pastures, there is great inefficiency in the use of water in the irrigation, and improper use of agrochemicals, posing risks to health and the environment, among other problems. The 10 most cited articles for discussion were listed as can be seen in the Table 18.

It was noticed that the word sustainability, 199 occurrences, came close to the artificial word 172 occurrences, followed by data 158 occurrences and intelligence 156 occurrences. These factors relate to *artificial intelligence* and *sustainable agriculture*.

In response to the evolution of *artificial intelligence* and *sustainable agriculture*, there is a growing number of publications on the subject, starting in 2009 and generating a larger increase in production in 2018, as presented in Sect. 4. In terms of *innovation*, in the year of 2018 we have observed research that is aligned with:

– A set of heterogeneous sensors and artificial intelligence for the analysis or simultaneous detection of different problems that the cattle can present.
– The development of a framework that integrates two approaches to data analysis (data mining and Bayesian networks), used in decision making.
– A systematic review to identify the applicability of computational vision in precision agriculture for grain production.
– The development of a prototype that shows how artificial intelligence can provide critical support in the process of achieving energy sustainability in smart cities;
– With the environmental and social implications of emerging superintelligence in an economy shaped by neoliberal policies, citing that such policies exacerbate the risk of extremely adverse impacts.
– Technological advances in the following categories: (a) crop management, including applications in productivity prediction, disease detection, weed detection, crop quality and species recognition; (b) livestock management, including applications in animal welfare and livestock production; (c) water management; and (d) soil management.

Table 18. The 10 most cited articles for discussion.

Title		Author	Source	Year	DOI	Cited
1	Future paths for integer programming and links to artificial-intelligence	Glover	Comput. Oper. Res.	1986	https://doi.org/10.1016/0305-0548(86)90048-1	1694
2	Deep machine learning – a new frontier in artificial intelligence research	Arel et al.	IEEE Comput. Intell. M.	2010	https://doi.org/10.1109/Mci.2010.938364	272
3	Knowledge warehouse: an architectural integration of knowledge management decision support, artificial intelligence and data warehousing	Nemati et al.	Decis. Support. Syst.	2002	https://doi.org/10.1016/s0167-9236(01)00141-5	148
4	Creativity and artificial intelligence	Boden	Artif. Intell.	1998	https://doi.org/10.1016/s0004-3702(98)00055-1	122
5	A comparative survey of artificial intelligence applications in finance: artificial neural networks, expert system and hybrid intelligent systems	Bahrammirzaee	Neural. Comput. Appl.	2010	https://doi.org/10.1007/s00521-010-0362-z	109
6	Knowledge Management And Its Link To Artificial Intelligence	Liebowitz	Expert Syst. Appl.	2001	https://doi.org/10.1016/s0957-4174(00)00044-0	103
7	Conflicts versus analytical redundancy relations: a comparative analysis of the model based diagnosis approach from the artificial intelligence and automatic control perspectives	Cordier et al.	IEEE T. Syst. Man. Cy. B	2004	https://doi.org/10.1109/tsmcb.2004.835010	99
8	Open information-systems semantics for distributed artificial-intelligence	Hewitt	Artif. Intell.	1991	https://doi.org/10.1016/0004-3702(91)90051-k	97
9	Artificial intelligence - personal view	Marr	Artif. Intell.	1977	https://doi.org/10.1016/0004-3702(77)90013-3	96
10	The coming of age of artificial intelligence in medicine	Patel et al.	Artif. Intell. Med.	2009	https://doi.org/10.1016/j.artmed.2008.07.017	90

– A backpropagation of artificial neural networks modified using the Smart Agriculture database using parameters such as temperature, humidity, wind speed, solar radiation and soil water stress.
– Five dimensions of to structure the analysis, we explore the impacts of AI in various domains.
– A novel crop/weed segmentation and mapping framework that processes multi-spectral images obtained from an unmanned aerial vehicle (UAV) using a deep neural network (DNN).

From this analysis we can see in the Fig. 3 on the left the publications by year and on the right the citations by year.

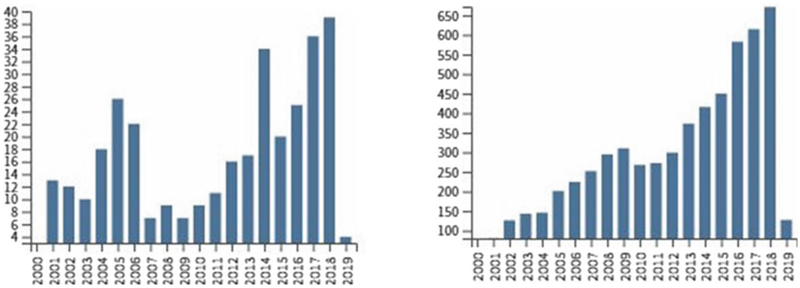

Fig. 3. Publications per year (left) by citations per year (right).

It was also evaluated in the works, through the authors vs occurrences, Fig. 4, which presents the correlation of the researched subjects with the produced works, creating a list of the most cited and most used words within these researches.

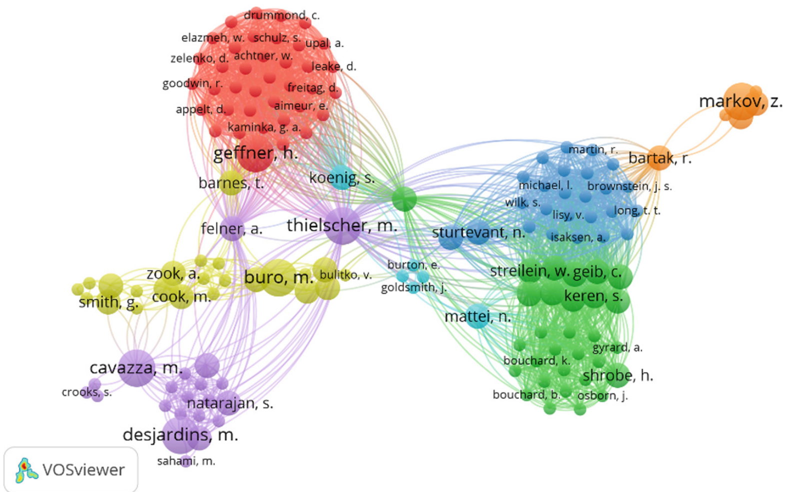

Fig. 4. Correlation from authors.

In terms of challenges, in the year 2018 it was realized that such research shows:

- The GPS position of the animal allows to find the animal quickly, which is very important in extensive farming where the farmer must search the animal with a vehicle and would normally spend a lot of time at the task.
- To develop solutions to the three problems presented by the paper: (1) water (river resource management, river water pollution analysis), (2) air (air pollution analysis, ozone prediction), and (3) soil (soil pollution analysis).
- The study of the presented works and the problems that they set out to solve together with the new advances in computer vision and artificial intelligence can lead to new solutions for agriculture bringing gains of production, quality, and food security.
- Machine Learning (ML) approaches will set up new challenges for intelligent energy agents. Sophisticated and complicated modelling of energy consumption will also allow new analytical processing and predicting capabilities.
- The implications of technological innovation for sustainability are becoming increasingly complex with information technology moving machines from being mere tools for production or objects of consumption to playing a role in economic decision making.
- In the future, it is expected that the usage of ML models will be even more widespread, allowing for the possibility of integrated and applicable tools.
- The agribusiness-based activities and business will become the main trend in national development. However, this development is not in line with the condition where climate change, soil and irrigation factors are uncertain in almost regions.
- Although companies are eager to join the fray of this new AI trend and take advantage of its potential benefits, it is unclear what implications AI will have on society now and in the long term.
- Development of reference tools to evaluate variants of crop classifiers, weeds.

5 Conclusion

Some of the latest AI innovations promise to leverage agricultural research, generating new technologies and new products. Its great potential resides in its transversely, being able to add value and benefit to the different areas of business, market, agriculture and environment. Analysing the advances of AI in sustainable agricultural systems guiding the future, as well as analysing their challenges open up gaps for further research.

Precision agriculture has been proposed to improve agricultural sustainability and address environmental soil pollution. In the precision agriculture process, water and fertilizer management is done in agricultural operation units. Therefore, acquiring accurate soil nutrient distribution information is a key step in applying precision agriculture and digital soil mapping is an effective technology.

The high resolution remote sensing images provide basic data for the realization of this idea and the development of AI technology provides technical support for it. In the future, we will experiment with larger areas to further optimize this method and key technologies for applications in more complex environments.

This approach can update the expert system by adding the knowledge base's ability to learn and adapt according to the descriptive and predictive model. The possibilities of passing knowledge of experienced farmers to younger generation are discussed. This paper presented the advances and challenges of AI performed through a literature review.

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Towards the Integration of the Production Function in Strategic Management of Industrial Organizations to Avoid the Efficiency Trap

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Abstract. Excessive focus on operational efficiency and devaluation of the strategy can compromise the sustainability of industrial organizations. However, these two perspectives are not antagonistic, on the contrary, they should complement and enhance each other. This article analyses the role of the production function in strategic management of an industrial organization based on Hayes and Wheel-wright's four-stage model. The study has a qualitative nature. The data collection occurred through semi-structured interviews and non-participant observations in a small manufacturing company that is already starting the most advanced stage of integration of the production function within the company's strategy. Data analysis occurred through content analysis using Atlas.ti 5.0 software. This study allows us to understand how the production function can and should be a strong source of competitive advantage and assist in organizational growth in industrial companies. The results indicate the existence of organizational peculiarities of the production function throughout the various stages of the strategic process namely, in terms of aspects related to the competitiveness and sustainability of the organization and with the characteristics of the business strategy itself. In addition to these results it was possible to identify that the modification of a position in the evolutionary stages of the model does not occur linearly, as it can also maintain characteristics of other stages.

Keywords: Production function · Operations strategy · Strategic management · Hayes and Wheelwright four-stage model · Case study

1 Introduction

Skinner's pioneering warning [1] claimed that the production function appeared to be a missing link in the organizational structure because it was predominantly concerned with purely operational issues, not offering adequate responses to market and industry demands. Thus, since that time that studies on business strategy have been the object of great interest in business management research. Several models and concepts as well as relevant and deep discussion have been produced but it seems that the studies that relate the functional areas with the organizational strategy are lacking in academia [2–5].

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Furthermore, studies on the production function tend to be focused and limited on its operational specificity. In general, the goal of operational sectors is the search for productivity, quality and speed. In this sense, already alerts to the fact that operational effectiveness is not strategy, even if a sine qua non condition for the generation of competitive advantage [6].

The proposal to link strategic management and the production function, in addition to the pioneering proposal and analytical model of Hayes and Wheelwright that was used in this research, has been strongly proposed in several articles [7, 8]. These articles consider operations as a factor generating competitive advantage from the good use of resources and organizational practices, without ignoring environmental aspects.

Thus, the production strategy refers to the pattern of decisions and strategic actions that defines the role, objectives and activities of production [9]. It seems to be important for the knowledge in the field of production management and strategy research, the development of studies on the role of the production function in generating competitive advantage. States that operational effectiveness is necessary but not sufficient – operational effectiveness and strategy are both essential to be achieved a superior performance [6]. Actually, he also suggests the intertwined role of strategy and the production function in the success of the company when states that activities are the basic units of competitive advantage.

In this paper, the model developed by [10] was used to evaluate the role and contribution of the production function in the company's strategy from the perspective of the organization's competitiveness, sustainability and strategy. The model traces the evolution of this role from a negative contribution (Stage 1) to becoming a central element of the competitive strategy (Stage 4).

This article begins by presenting the theoretical resources that supported the research namely, a literature review on the four-stage model and an analysis of the strategic evolutionary models, particularly in the area of operations management. Following, we present an explanation of the methodological option adopted and the operationalization of the data analysis process. The article continues with the analysis and discussion of the results and the production of the main conclusions of the case study that show and support the possibility of different alternatives and perceptions of evolutionary models in the context of strategic management of operations. The article concludes with the presentation of proposals for future research resulting from the conclusions obtained.

2 The Four-Stage Model

One cannot deny the importance of the seminal work [1] who highlighted the strategic importance of operations management in the strategic organizational logic and consequently in the generation of competitive advantage, as well as the resulting theoretical evolutions presented in further literature.

One of the theoretical models arising from this pioneering article is the model of the four stages [11] that identifies four distinct and evolutionary forms of the contribution of the production function to the generation of competitive advantage. This model can be summarized as follows:

- in stage 1, where the role of operations is considered "Internally Neutral", it is assumed that the objective of the production function is to avoid making mistakes and minimize the negative impacts of operations, especially through corrections of operational problems, seeking to achieve the minimum acceptable results. The managerial autonomy of the production sector is almost nil since decisions are almost entirely taken by the top management, which considers operations as a "necessary evil".
- in stage 2, the role of the operations is still "Internally Neutral", and the objective of the production function is to achieve competitive parity with competitors through the search for the best practices obtained by benchmarking. The managerial base occurs in the search for production scale and in the search for the implementation of similar capacity to company's competitors.
- in stage 3, where the role of the operations is "Internally Supportive", the objective of the production function is to provide to the business strategy reliable support and be recognized as a benchmark in its sec-tor. From a managerial perspective, the production function has its own actions, decision-making autonomy and is integrated with the company's strategic objectives.
- in stage 4, where the role of operations is "Externally Supportive", the objective of the production function becomes to provide the source of competitive advantage through a long-term, innovative and sustainable vision that is the provider of the competitive advantage of the organization, i.e., at this stage, the production function drives the organizational strategy. Managerially, the production function has decision-making autonomy. It can also be said that at this stage the company contributes to redefine the global expectations of the production function in the industry.

The authors describe the different organizational resources as tangible and intangible assets that the company controls and that can be used to create and implement the strategy [2], but which may not be in the same stage of evolution. They also warn of the possibility of there being changes in both the rise and fall between the stages.

In other words, the model presents arguments regarding the strategic orientation of an organization regarding operations [12], enabling the analysis of the level of participation and the characteristics of production in the organizational strategy. It can be said, therefore, that the model has been used to analyze the use of the organizational structure for a more proactive strategic management and that increases the effectiveness of production [13].

Still on the four-stage model, [14] state that this provided a significant advance in thinking about the strategic management of operations with the analytical structure of the four stages. The production function should not merely support the corporate level strategy, but rather actively contribute to the initial design and development of the corporative strategy itself. In this sense, the four stages model [15] proposes a trade-off logic between strategic issues and aspects of operational nature [16].

Given the above, it can be understood that the evolutionary analytical models in strategic operations management suggest a process of linear improvement. However, the models that present such stages tend to present incremental flows influenced by internal and environmental factors and not the historical perspective of organizations [13].

Thus, this article seeks to analyze an evolutionary analytical model of strategic operations management, thus highlighting the importance of the production function in strategic management and how such importance evolves using the model proposed by [1] based on the seminal work of about role of operations in the competitiveness, sustainability and strategy of an organization. A deep understanding of the process of integration of operations and the production function in the strategy of the organization as well as about its facilitators, catalysts and obstacles is important for both academics and practitioners.

3 Research Methods

To operationalize this research, a single case study approach was followed. The methodological choice is justified due to the fact that the organization studied presents an appropriate dimension for a study of this nature and is a benchmark company assuming the leadership of the Brazilian market of containment trunks and scales. This company has approximately 50 years of existence and is known as highly innovative, both in terms of products and in terms of management, especially in a sector characterized by companies that employ low technology in their products and are managed in a very amateur manner. Another reason for choosing this company is also the significant level of investments in technology and training which put it in the current production frontier of the industry. It is, in fact, a benchmark company in its industry characterized by mature production and business processes and a very strong strategic orientation.

Another important element in justifying the choice of the company for the present study is that it was identified a priori the existence of characteristics in the production function that suggested that the company contained simultaneous characteristics of all the stages presented in the four-stage model, which was later proven.

Given the above, the case study enables the understanding of the role of the production function in the logic of the strategic process, which entails several possibilities of analysis and theoretical contributions both for the analysis of the importance of the production function in strategic management and in the development of the model itself [17].

The case study also offers the possibility of the use of multiple sources of evidence and establishment of a logical sequence of events that allow the validation of data according to different aspects, enabling a good understanding of the characteristics of the phenomenon studied.

Thus, this methodological choice is justified, since the use of qualitative research helps the researcher to overcome initial conceptions and to generate or review the theoretical structures adopted previously, providing a basis for very rich descriptions and explanations in specific contexts, as well as in understanding a specific phenomenon with the aim of developing or improving theories [9, 18].

The main source of primary data were 15 semi-structured interviews with highlevel managers in the various areas of the company's organizational hierarchy summing up a total of 17 h:32 m from which resulted 374 transcribed pages. Another source of data were the 38 research memos that were written in the various visits made to the company. This primary data was supplemented with secondary data obtained from internal reports, legislation and equipment user manuals, which pro-vided 103 documents with approximately 500 pages and 4 videos. The analysis was initiated by the codification of the transcribed data. At this stage, the Atlas.ti 5.0 Software was used to help the coding process, from which resulted 198 codes in the first phase of categorization and 56 in the last one, divided according to the stages of the model. Thus, 18 codes were created in Stage 1, 11 in Stage 2, 14 in Stage 3 and 13 in Stage 4.

After the operationalization of the coding (which is presented in Table 1) it was developed the analysis itself, especially through the construction of four semantic relationships (networks) and a semantic relationship of the whole project (super family), as well as three conceptual sets (sustainability, competitiveness and strategy) that helped in the understanding of the strategic phenomenon taking the operations sector as the origin of the organizational competitive advantage.

Table 1. Distribution of coding among interviews and internships.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	Total
Stage 1	5	0	2	11	2	4	2	2	0	7	3	0	4	1	0	43
Stage 2	1	2	8	7	0	3	3	3	0	3	4	0	0	0	0	34
Stage 3	3	1	28	3	0	1	1	3	2	0	2	2	0	2	0	48
Stage 4	4	3	50	17	8	14	10	7	3	19	16	2	2	1	1	157
Total:	13	6	88	38	10	22	16	15	5	29	25	4	6	4	1	282

In addition to the interviews, which by the methodological essence of this research constitute the main body of the data, research memos, internal reports, legislation and equipment user manuals were also coded, but those are not presented here due to limitations of space.

4 Results and Discussion

The results of this article are presented in the following sections in which the role of the production function is analyzed from the perspective of the organization's competitiveness, sustainability and global strategy that guide the present analysis in function of being the most present elements in the management process of the company studied.

The production function can be understood by the use of resources and by the process of conversation of inputs into outputs in order to meet the needs of the consumers [1]. The production function was identified as the most important element for the generation of competitive advantage in the company studied. In this case study, it was possible to analyze and understand the strong support that the production function can give to the company's strategy.

4.1 Competitiveness

The relationship between the competitiveness, of the company, understood as the ability to compete on at least the same terms as its competitors, and the production function was identified in this case study through different dimensions. The set of codes that shown the production function as an element that supports the organizational strategy; contributes to organizational development; understands the strategic objective of the company; contributes to organization's creativeness and innovativeness; as well as provides condition to consolidate the competitive advantage and success of the organization. Competitiveness was also analyzed under the codes that highlighted the alignment of new ideas, organizational strategy and a clear vision of the competition. These ten codes were identified in a total of eighty-seven times in the primary data of the research.

From the thematic grouping of the codes that provided the analysis of the company's competitiveness it was possible to create three groups of codes that provided a better understanding of what is sought to understand. The first group was named competition and it deals with issues related to the relationship between the strategic logic of the organization and the production function through the understanding of the ways in which the strategic organizational elements are conceived. This group was strongly influenced by the relationship between the production function and the competitive advantages of the organization, with nineteen citations with positive statements. Also, in this codification it was found that the production function understands the strategic objective of the company (seven citations) and has a clear view of the competition (six citations).

The second set shows the capacity of the production function to adapt to the strategy of the organization, because this it is called adaptive. The code that was the greatest influencer of this group demonstrates that the production function is innovative, with fourteen positive citations that referred to this understanding. The second most mentioned code in this group is related to the innovative capacity of the production function, with twelve citations.

The third and last group of codes was named assistance and it presents the issues related to how the production function contributes to the structural and administrative development of the organization as a whole. This conceptual set has the largest influenced code what deals with the provision of the production factor contributes to the success of the organization, with twelve references and that this contributes to the organizational development, with seven citations.

It is important to highlight that the codes that integrate the conceptual set of competitiveness originate from stages 3 and 4 of the 4-stage model, i.e., despite the theoretical structure used as a basis in this article suggest that the production function directs the strategy in stage 4, i.e., that it is the provider of the competitive advantage of the most advanced stage organization, the research data provided an understanding that the competitive advantage can be generated with a group of peculiarities of different stages, or even that the characteristics of one stage are not completely eliminated when one goes to another. In this sense, we can understand that the process of evolution through the different stages towards the most evolved one does not eliminate characteristics of the previous stages.

4.2 Sustainability

The perspective of sustainability was observed under the logic of the perennial maintenance of business, especially through the production function. Thus, the existing relationship between sustainability and the production function occurred through the use of ten codes that formed three conceptual sets. The codes dealing with sustainability are those that sought to observe actions to prevent errors and meet external demands, both through complaints and after-sales; comparison with companies in other markets as well as with similar companies and the use of benchmarks; the development of new raw materials and inputs; standardization of the production function; and the autonomy of decision of the production function, among others.

The first conceptual set that was possible to determine was called informative, which in essence seeks to portray how the production function obtains knowledge subsidies for the development of its managerial activities. The main influence found in this group was the search for the development of new raw materials that had twelve indications that dealt with the subject in an affirmative manner, that is, that placed this element as a strategic action developed by the production function. The second element of greatest impact in this set is related to the previous one and deals with the development of new production inputs, with eight references. The other two codes used dealt with meeting external demands and were mentioned only a few times. The first one, which dealt with the search for information through customer complaints, was cited three times, or said that the information came through the after-sales service, was cited twice.

The second set of concepts created was called comparative, because it is broadly aimed at the strategic actions that somehow serve for the company to compare its actions. In general, the codes that make up the group were mentioned a few times, but the analysis of the statements that were made shows a fundamental strategic importance of this type of action. The code that most influenced this group is that it deals with the use of benchmark with six positive citations, followed by the comparison with other companies from other markets with four citations that suggest the comparison of the company studied with others outside the market where the company operates. The codes that deal with the observation of the autonomy of the production function, in the data cited as a way to compare the management of the production function of the company with others in the market with two citations and that is related to the comparison with other similar companies with only one citation contribute to the understanding of the strategic sustainability of the company analyzed.

Finally, the conceptual set called corrective has as its main objective to understand how corrective actions play an auxiliary production function. Roughly speaking, the codes related to this group obtained few but significant citations. The one that deals with strategic actions in order to prevent operational errors was the most cited, with three mentions and the one that shows the search for standardization in operations with two mentions.

Regarding the codes that make up the item, the presence of items from all four stages of the model is observed [11], that is, the strategic sustainability is not achieved only with elements that make up the stages considered more advanced, but with the presence of characteristics of all phases that make up the model. This under-standing is contrary to what the model suggests that the characteristics of a stage cannot be transferred to the next stage.

4.3 Global Strategic Logic

The global strategic logic of the production function was observed from its importance in the formulation and implementation of the strategy. Thus, we found twelve codes in which it was possible to group them into three conceptual sets. The codes that gave rise to the analytical logic of the global strategy are those that portray the production function with aspirations to be the best in its sector and is recognized as the best in the sector; it has a clear vision of competition, as well as compared with other companies in other markets and supports organizational strategy; there are also codes that show the production function as innovative, driving organizational strategy, ready for change and with autonomy of decision; finally the codes that indicate that the production function contributes to organizational development and provides the competitive differential and success of the organization.

The first among the three possible conceptual sets that help the strategic understanding of the production function, called referential, proved to be the strongest of all in relation to positive citations. This conceptual set presents the role of the production function to be exemplary with the other sectors of the company studied. This can be illustrated through the code that shows that the production function is always ready for change. This code was the one that received the highest number of citations (twenty-four) in this research. The second most cited code in this set (fifteen citations) shows that the production function is recognized as the best in the sector in which the company operates.

The second group was called support and shows the strategic importance of the production function in sustaining the competitive advantage of the company. This conceptual set presented the greatest presence of positive citations in the data set. The main code cited (nineteen citations) in this conceptual set shows that the production function provides the competitive differential of the organization. Added to this is the idea that the production function provides the success of the organization (twelve citations) has, along with the other codes the second strongest conceptual set among all analyzed.

The third and last conceptual set that was created to explain the strategic logic of the production function was called administrative, since it relates the formulation and strategic implementation to typically managerial issues. The main codes of this set show the clear vision of competition by the production function and the constant comparison of the company's indicators with companies in other markets.

The global strategic perspective in the company studied, therefore, was formed through codes that the literature [2] present in the three highest stages, which is an indicator that the generation of competitive advantage [11] happens with elements and characteristics of more evolutionary stage and not only with conceptual elements of the highest stage. In other words, the evolution process does not occur sequentially, but is also incorporated into the overall organizational strategy recursively.

5 Conclusion

The results indicate that the company is strongly supported by the production function. It can be stated, from the collected data, that the organization under analysis is between the upper part of Stage 3 and the beginning of Stage 4.

The results indicate that the company studied is strongly supported by the production function which contributes decisively with robust operational actions that support the internal forces of the organization - corresponding to Stage 3. However, the production function starts to actively support the competitive sustainability of the organization, namely at the level of market changes and in the offer of new products and inputs, acting in an innovative and creative way so that the company is always ahead of its competitors.

On the other hand, the evolution through the different stages of the model occurred in a non-linear manner. This fact allowed to deepen and extend the model itself used as a basis for this research. In particular, because the influence of stake-holders and the changes in the organizational structure, there were periods of progress and setbacks in the evolutionary process towards Stage 4, resulting in a cyclical evolution according to the influence of the various actors and factors, both internal and external.

For example, internally, the highest levels of contribution of the production function was achieved even without the full internalization of the processes. Externally, for example, aspects related to market demand can influence the relationship between the production function and strategy. The various elements and paths that supported this evolution were analyzed in detail and strategies are suggested to take advantage of the catalysts of the process and avoid or counteract the blocking factors, enhancing the transition to the most advanced stage of integration of the production function and operations with the company's strategy.

This paper was focused on the analysis of the impact and the integration of the production function with the strategic management of an industrial organization. The production function should be considered an important source of competitive advantage and this role may evolve towards a strong integration with the company's strategy.

In this investigation it was found that this process can occur in a non-linear way and that the production function can be strategic for the sustainability of the organization even when there is not such explicit intention from the company, in other words, it can be said that the positive or negative change from one stage to another maintains characteristics of elements and situations that the theory treats as typical of the previous stage, that is, it contradicts the evolutionary logic suggested by the model used as a basis for the analysis that when passing from one stage to another, the characteristics of the previous stage are abandoned [11].

The application of the model in other industrial organizations will allow to continue strengthening the academic knowledge on these issues and will bring tangible practical benefits for companies and for the recognition of the role of the production function.

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Product-Service System Modularization: A Systematic Review

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Abstract. The continuous progress of the globalization of manufacturing industry and competition between manufacturing companies is becoming stronger. Nowadays, the simple product's production does not fully meet the market demands. That is why manufacturing companies are being forced to create new strategies for survival and development. As a result, many manufacturers began to seek benefits by adding services to the final products, which means moving from selling products to selling products and services (PSS) systems. PSS enables innovations for products and business processes, and its result is the growth of business activities with new and current customers. In addition, modularized PSS can solve conflicts between customization and low cost. Therefore, this article analyze the techniques used for PSS modularization and the advantages it brings to companies and customers. This study allowed observing that current techniques and/or methods for PSS modularization are house of quality approach, fuzzy logic, clustering method, correlation analysis, mathematical optimization models and other qualitative-empirical models described as well.

Keywords: Modularization · Servitization · Product-service system (PSS) · Modularization methods

1 Introduction

Servicing, which is the growth of services and solutions built into the manufacturers' business model, has been addressed by a growing number of scientific studies. The literature agrees this transformation can bring many benefits, such as economic, organizational, environmental, etc. [1, 2]. Another trend is the introduction of digital technologies that allow new opportunities to develop deeper relationships with customers, to customize product and service offerings, to value creation [3]. These technologies are seeing as services change-facilitators as they radically reshape how companies create value through new and current digital services [4, 5].

Li et al. [6] have argued that modularization of physical products and services can solve conflicts between customization and low cost. By establishing a series of standard physical and service modules, it can simplify the product internal structure and reduce

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production cost and environmental impact; through the module combinations, it can be obtained a variety of physical products and services that meet the customers' personalized needs [7].

Thus, a research question is defined as follow: how can PSS be modularized and which are the advantages it brings to companies and customers? The aim of this paper is to investigate the existing methods for PSS modularization in the literature and its advantages for companies and/or clients.

2 Methodology

The analysis carried out implied the use of a systematic literature review (SLR) software known as StArt, developed by LAPES/UFSCAR [8]. Table 1 presents the structured protocol followed to develop the SLR based on Kitchenham and Charters [9] guidelines and according to the StArt phases, such as, planning, execution and summarization. The protocol is a fundamental element for SLR planning phase.

Table 1. Protocol followed for SLR.

Search protocol	
Keywords' definition	Servitization; servitisation; servitizing; modularization
Search strings's definition	("servitization" OR "servitisation" OR "servitizing" AND "modularization")
Inclusion (I) and exclusion (E) criteria	(I) Journals' articles (I) Journals' articles published between 2009–2018 (E) Articles not written in: English, Portuguese or Spanish (E) Articles not related to this research purpose (E) Duplicated articles

2.1 Planning

In this phase, the keywords were defined to create the search strings in selected databases and the inclusion and exclusion criteria, as presented in Table 1. Several forms of writing the term "servitization" in English language were used in order to obtain a greater return of the bibliography search using the Boolean connectors: *OR* and *AND*.

The databases used were Science Direct, Emerald, Web of Science and Scopus. The first two databases were chosen because they contain the 5 most relevant articles obtained in a first search made in Brazilian journal portal CAPES (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*), the other two, were selected by the availability of published studies related to the engineering field.

2.2 Execution

In the execution phase, the papers obtained from the databases that indicate high relevance with the study were grouped. In addition, was done a manually insertion of some articles of interest quoted as bibliographical references in the articles obtained (process known as snowballing). In total, 413 articles were grouped. Figure 1 shows the amount of articles by each of the databases.

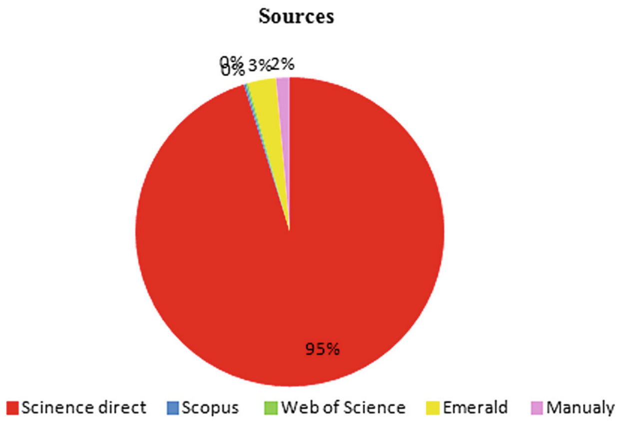

Fig. 1. Amount of papers found in databases. Source: StArt.

Papers selection, according to the inclusion and exclusion criteria defined in the previous phase was done. Duplicated papers detected by the software were excluded. Selection of the papers that fulfill these criteria and address the main research interest was made by further reading of the introduction and conclusion, and if necessary, reading the full text of the article. Figure 2 shows the amount of papers accepted and rejected.

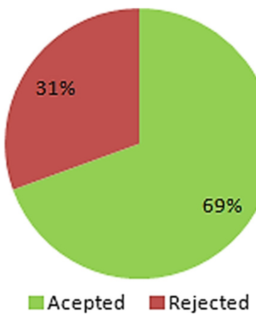

Fig. 2. Accepted and rejected articles. Source: StArt.

Thus, the literature analysis was done with 25 articles selected and presented in Table 2. Papers were organized by year of publication from oldest to recent.

Table 2. Articles chosen for literature review (Source: StArt.).

Title	Authors	Year
Flexibility in industrial product-service systems and use-oriented business models	Richter et al. [10]	2010
Framework for modularity and customization: service perspective	Bask et al. [11]	2011
A comprehensive framework for the evaluation of ontology modularization	Oh et al. [12]	2012
Designing a reverse logistics network for optimal collection, recovery and quality-based product-mix planning	Das and Chowdhury [13]	2012
Modularizing services: A modified HoQ approach	Geum et al. [14]	2012
Module partition process model and method of integrated service product	Li et al. [6]	2012
The human dimension of modular care provision: Opportunities for personalization and customization	De Blok et al. [15]	2013
A learning-based module extraction method for object-oriented systems	Erdemir and Buzluca [16]	2014
Developing a Modular Service Architecture for E-store Supply Chains: TheSmall- and Medium-Sized Enterprise Perspective	Bask et al. [11]	2014
A modular approach for integrated inventory management in distribution logistics	Kamphues and Hegmanns [18]	2015
From business model to business modelling: modularity and manipulation	Aversa et al. [19]	2015
Modularizing product extension services: An approach based on modified service blueprint and fuzzy graph	Song et al. [20]	2015
Moving towards the incomplete: a research agenda for the development of future products in the digital economy	Davies and Ng [21]	2015
A customization-oriented framework for design of sustainable product/service system	Song and Sakao [22]	2017
Adopting a platform approach in servitization: Leveraging the value of digitalization	Cenamor et al. [23]	2017
Creating service modules for customizing product/service systems by extending DSM	Sakao et al. [24]	2017
Evolution of modularity literature: a 25-year bibliometric analysis	Frandsen [25]	2017
Exploring modularity in services: cases from tourism	Avlonitis and Hsuan [26]	2017
Modularization of Product Service System Based on Functional Requirement	Sun et al. [27]	2017
Service modularity and architecture â€“ an overview and research agenda	Brax et al. [28]	2017
The integration of core cleaning and product serviceability into product modularization for the creation of an improved remanufacturing-product service system	Fadeyi et al. [29]	2017

(*continued*)

Table 2. (*continued*)

Title	Authors	Year
Through Life Analysis for Machine Tools: From Design to Remanufacture	Gao and Wang [30]	2017
Leveraging the benefits of modularity in the provision of integrated solutions: A strategic learning perspective	Salonen et al. [31]	2018
Modular product platforming with supply chain postponement decisions by leader-follower interactive optimization	Xiong et al. [32]	2018
Towards a framework to design upgradable product service systems	Khan and Wuest [33]	2018

2.3 Summarization

This last phase is dedicated to analyze and summarizing the data obtained from the bibliographic search. Keywords were analyzed by mention frequency. The word with higher mention was *modularity*. From greater to less mention appear the keywords *service-oriented-architecture*, *cloud computing*, *internet of things*, *ecosystem service*, *modularization*, *modular-design*, as others shown in Fig. 3. The keywords *cloud computing* and *internet of things*, even if they do not appear as keywords used in this search, were obtained among the higher frequencies because of the use of these concepts for referring to the connection and use of connected devices to address the modularity strategies in PSS.

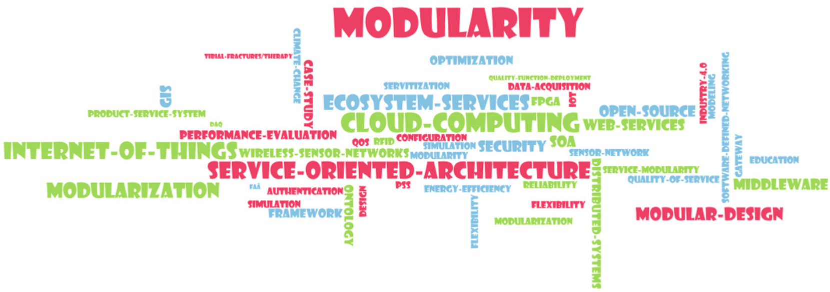

Fig. 3. Accepted and rejected articles. Source: StArt.

An analysis of authors over the years surveyed was made as shown in Fig. 4. It can be observed that in 2015 the amount of researches was gradually increasing, which demonstrates the growing interest of the academy to develop researches in the area. The crossed lines represent authors who have published in several years on the same topic.

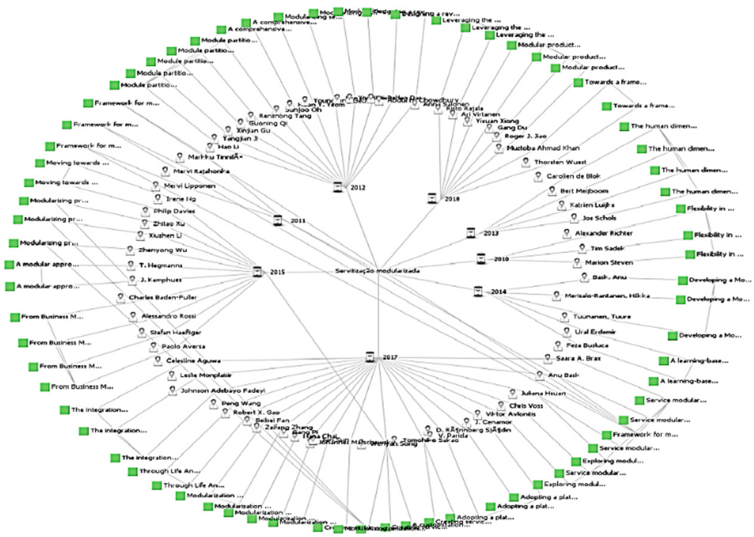

Fig. 4. Radial chart of publications per year. Source: StArt.

3 Methods and Techniques for Modularization in PSS

By deeper reading and analysis of selected articles, were found several techniques for modularization of the product-service or servicing systems. According to Sun et al. [27], the PSS framework is structured of many different types of physical and service modules. They also state it is necessary to identify the appropriate module partition to facilitate the personalized design of the PSS. The relationships between PSS modules are more complex and mixed [33]. According to these complex relationships, the PSS can be modularized and then configured based on the physical structure and the customized service model to better meet customer requirements [6]. The modular design method has its own unique performance in the analysis of the mode of product composition, optimization of the mechanism and decomposition, reorganization and coordination of the system. The following are some of the techniques found.

Li et al. [6] presented the three-stage module partitioning processes and methods, including mainly the service module partition processes based on the Top-Down and Bottom-Up methods. In the process of partitioning the Top-Down module, the service modules can be divided into related functions, related to related classes and processes according to the relationship between services. A comprehensive correlation matrix is configured by calculating the correlation between services and the split modules can meet the maximum demand. Service modules, such as maintenance service and spare parts, have close correlation with specific physical modules, but the content of the service cannot be accurately determined prior to the realization of the physical design of the product. When the finished physical module is used to determine the specific service module, this process move from bottom to top in the so-called "Bottom-Up" method. In the Bottom-Up method, according to the divided physical module, the completeness of the basic services of the product and other special services that provide the customer physical products are evaluated, if not present, adding the service modules required by the "physical-service module mapping module".

Song et al. [20] proposed a modularization approach of product extension services (PES) based on a modified service model and a diffuse graph. The PES diagram is used primarily to represent the entire PES scenario and identify all relevant components of the service. Next, the diffuse graph theory is used to partition the module based on the results of the correlation analysis of the service components. In the proposed PES partition partitioning approach based on fuzzy graphs, k is introduced to partition the graph. The lower the k, most independence is considered. Then the number of PES modules is smaller and the number of service components in the PES module obtained is larger. The proposed PES plan considers the interactions between the physical product using behavior and other service operations.

Song and Sakao [22], proposed a method where, first, all related PSS components are identified. The modified service plan [19] is used to identify all related PSS components, including service processes, service objects, and service resources. The components are grouped into PSS modules with clustering methods, such as the diffusion-based tree-based approach [19], which can visually show interdependence forces between various PSS components.

Fadeyi et al. [29] have created an optimization model for analytically integrating product and remanufacturing service systems. The optimization model was developed to determine the module variants that should be included in one product among several available module variants. The modules are evaluated in pairs and the compatibility indices of the module pairs are obtained via the fuzzy inference system.

Sun et al. [27], defined principles of division of the PSS module: Independent principle of product and service characteristics; Principle of correlation of functions of products and services; Principle of correlation of categories of products and services; Principle of correlation of processes of products and services; Structural principle of product similarity. According to the authors, all these principles are effective in the process of preliminary establishment of components of products and services, identification of functional requirements and cluster and final division of the PSS module. This can provide a collating result for sorting the PSS into multiple modules from a new functional requirements aspect.

Khan and Wuest [33], proposed an upgradable PSS design framework to facilitate the integrated modular development of PSS and provides a systematic design process built around four distinct phases, from requirement identification to PSS concept generation. The proposed structure takes into account the dynamic change in customer requirements in relation to the PSS operation. The updatable PSS needs to be regulated by continuous interactions between the consumer (user) and the PSS provider. This interaction can be intensified by making the PSS intelligible and connected via IoT sensors, or simply, by encouraging consumers to interact with PSS providers. Table 3 synthesizes the main techniques of modularization for PSS studied in the literature analyzed.

Table 3. Modularization techniques for PSS.

Authors	Modularization techniques for PSS
Li et al. [6]	Three-stage module partitioning method, mainly including service module partition processes based on the 'Top-Down' and 'Bottom-Up' methods
Song et al. [20]	Modularization approach to product extension services based on a modified service model and a fuzzy graph
Song and Sakao [22]	Identification of related PSS components. The components were grouped into PSS modules with clustering methods in order to visually show interdependence forces between various PSS components
Fadeyi et al. [29]	Optimization model for analytically integrating product and remanufacturing services systems. The optimization model was designed to determine the module variants that must be included in a product among several available module variants in order to ensure improved product maintenance and core cleaning
Sun et al. [27]	Grouping method to classify the PSS into several modules from the functional requirements. They proposed five division principles for function requirements and PSS modularization. They then propose to group the products and services into a PSS using the correlation intensity values between each item with the function requirement modules
Khan and Wuest [33]	They proposed an upgradable PSS design framework for the integrated modular development of PSS, as structured by the following phases: 1. Identification of PSS requirements. 2. Modularization of the PSS. 3. PSS configuration. 4. Generation of the PSS concept

4 Advantages and Disadvantages of PSS Modularization

As highlighted in the literature, the PSS modularization is applied mostly because of the advantages that it brings to manufacturing enterprises. Figure 5 presents the advantages and disadvantages of PSS modularization.

Advantages

- Help realize customization, increase flexibility, reusability of service modules and simplification of complex PSS [20].
- Can reduce the number of modules by diversifying the combination of internal PSS modules, which helps reduce production costs and environmental impact and achieve sustainable development [34-36].
- Improves the manufacturer's ability to adapt to changing requirements and reduce design costs [29].
- When failure occurs in service delivery, the modular design of the product extension services makes it easy for the manufacturer to quickly find the problem service module [20].
- Help to service provider achieve flexible, optimized personalization [22]
- It facilitates customization, flexibility, frequent reuse of design, as well as easier identification of design flaws, and therefore an overall increase in design efficiency [33].

Disadvantages

- Negative economic consequences associated to a super or sub-modularization [37].
- Due to the need for universal connectivity and sub-housing, it can often result in a comparatively higher material consumption [38].

Fig. 5. Advantages and disadvantages of PSS modularization.

5 Conclusions

Modularization is considered a technique that significantly improves product lifecycle management, including ease of product disassembly, improving ease of maintenance and product cleaning processes. The modular PSS framework facilitates customization, flexibility, frequent design reuse, as well as easier identification of design flaws and therefore an overall increase in design efficiency. I n this research it was possible to fulfill the stated objective. The main techniques and methods used for the modularization of PSS were analyzed as well as their advantages and disadvantages.

The analysis of the literature allowed us to define that the most used techniques for the modularization of PSS are quality house, fuzzy logic, clustering method, correlation analysis, mathematical optimization models, and other qualitative-empirical models.

In addition, the modularization in the PSS has advantages and disadvantages. Among the main advantages, the most outstanding are helping to perceive personalization, increase flexibility, reusability of service modules and simplification of complex PSS. Disadvantages in the literature indicate that there may also be negative economic consequences associated with a modular design, as in the case of a super or sub-modularization.

From this research, it is proposed as future work, the analysis of other techniques, which have not been applied yet in the modularization of PSS, which can further optimize this process.

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Risks of Contractual Fines for Failures in the Industrial Production Process and the Relation with the Importance of the Qualification of the Work in the Maintenance

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Abstract. Industrial failures are associated with poor maintenance planning, directly affecting organizational productivity. When equipment failures occur, established contracts allow fines to be imposed on organizations, sometimes due to delivery delays or product failures due to poor quality. The aim of this paper was to perform a literature review on the elements that cause risks of contractual fines due to equipment unavailability. To perform this work, a literature review was made based on published scientific articles on topics of predictive maintenance, preventive maintenance and corrective maintenance, production planning and control (PPC), financial risks for contractual fines and availability of machinery in industrial processes, as well as maintenance workforce qualification. Maintenance and operation, as the most important administrative and operational functions of production, are responsible for meeting the following requirements: quality, speed, reliability, flexibility and cost. As a result, it was found in the literature that a well-trained and motivated maintenance team performs higher quality short-term tasks, reducing machine repair times, and reducing the number of fines for failure to meet contractual deadlines. These results were corroborated by verification in four supply chain companies in the agricultural and construction machinery sector.

Keywords: Maintenance planning · Contractual risks · Maintenance workforce

1 Introduction

Industrial failures are associated with poor maintenance planning, directly affecting organizational productivity. When production equipment failures occur, the established contracts allow fines to be imposed on organizations due to possible delivery delays or product failures due to poor quality, leading to possible downtime due to poor maintenance planning. This can negatively affect customer demand, requiring operations

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managers to make emergency decisions to reinstate downtime for corrective maintenance.

The aim of this paper was to review the literature on the elements that cause contractual fines risks due to equipment unavailability, as well as a brief description of four cases of companies that supply parts and material parts.

The justification for this work was the difficulty of finding enough literature to address why many companies fail to meet contractual deadlines and its correlation with the qualification of the labor used in the maintenance of machinery and equipment of the production process, resulting in fines contractual.

As a hypothesis, verify if, in the literature, the availability of equipment can guarantee the fulfillment of the required demands, through a synergy of the workforce qualification between production planning and control (PPC) and maintenance planning and control (MPC).

2 Research Design

This article was structured based on a literature review based on published scientific articles on predictive, preventive and corrective maintenance, production planning and control, quality, financial risks by contractual fines and machine availability in industrial processes, as well as the qualification of maintenance workforce. These elements are represented in Fig. 1.

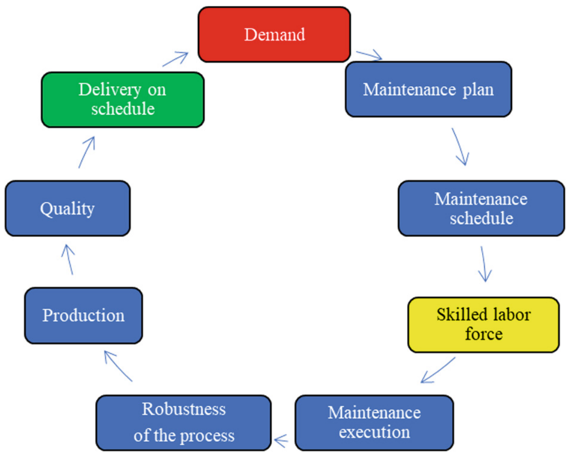

Fig. 1. Research structuring and its central elements.

The first step was to establish a theoretical basis with material that addressed the concepts needed to support the research. For this, the searches were made with keywords divided into groups:

– Group 1: maintenance planning and contractual risks;
– Group 2: contractual risks and maintenance workforce.

The keywords were searched in the Scopus database. The justification for the use of this database is the fact that it makes available the largest range of qualified scientific articles with access made available to researchers. The research was limited to scientific and review articles published since 2001. In all 520 articles were found. The second step consisted of deleting repeated articles and restarting the selection process. The first selection was made by reading the titles of the articles. The second selection occurred from reading the abstracts, selecting only those that fit the research theme. The third selection occurred from the complete reading of the full text of the articles.

Most of the articles found were not aligned with the research theme, as they did not address maintenance planning, contractual risks and maintenance workforce. Some articles dealt with maintenance planning only, but not contractual risks or maintenance labor.

In addition to the literature review on maintenance planning, contractual risks and maintenance work, we also searched for articles on predictive maintenance, preventive maintenance and corrective maintenance, PPC, quality and availability of machines in industrial processes. Finally, there were 14 articles that stood out in the research and followed the desired search terms. Thus, Sect. 3 will present the results obtained, as well as a brief case report of supplier companies and their characteristics regarding the theme presented in this paper.

3 Results and Discussions

3.1 Literature Review Results

From reading the articles, Table 1 was prepared, presenting a chronology of the evolution of the discussion of the subject by the most cited authors, highlighting the title and journal where they were found on the topics researched in Sect. 2.

Table 1. Most cited authors in the survey conducted at the Scopus.

Author	Title	Journal	No. of citations
Hui *et al.* [1]	Optimal machining conditions with costs of quality and tool maintenance for turning	Int. J. Prod. Res.	30
Ahmad and Schroeder [2]	The impact of human resource management practices on operational performance: recognizing country and industry differences	J. Oper. Manag.	972
Khan and Haddara [3]	Risk-based maintenance (RBM)	Process Saf. Prog.	90
Alsyouf [4]	The role of maintenance in improving companies' productivity and profitability	Int. J. Prod. Econ.	321
Al-Najjar [5]	The lack of maintenance and not maintenance which costs: a model to describe and quantify the impact of vibration-based maintenance on company's business	Int. J. Prod. Econ.	136

(*continued*)

Table 1. (*continued*)

Kans [6]	An approach for determining the requirements of computerised maintenance management systems	Comput. Ind.	85
Lee and Scott [7]	Overview of maintenance strategy, acceptable maintenance standard and resources from a building maintenance operation perspective	J. Build. Apprais.	73
Ma *et al.* [8]	A survey of scheduling with deterministic machine availability constraints	Comput. Ind. Eng.	329
Simões *et al.* [9]	A literature review of maintenance performance measurement: a conceptual framework and directions for future research	JQME	160
Peng *et al.* [10]	Competitive priorities, plant improvement and innovation capabilities, and operational performance. A test of two forms of fit	Int. J. Oper. Prod. Man.	85
Jabbour *et al.* [11]	Environmental management in Brazil: is it a completely competitive priority?	J. Clean. Prod.	107
Choudhari *et al.* [12]	Configuration of manufacturing strategy decision areas in line production system: five case studies	Int. J. Adv. Manuf. Tech.	21
Fitouhi and Nourelfath [13]	Integrating noncyclical preventive maintenance scheduling and production planning for multi-state systems	Reliab. Eng. Syst. Safe.	97
Lu *et al.* [14]	Integrated production and preventive maintenance scheduling for a single machine with failure uncertainty	Comput. Ind. Eng.	42

Maintenance planning decisions need to be linked to production and quality plans [6]. Strategically designed maintenance planning can improve machine availability and reliability by reducing the failure rate and potential threats to meet demand. As soon as equipment defects are detected, the repair will be minimal and at the lowest cost to get it back to normal operation [1].

If, on the one hand, managers are concerned with meeting required demand and managing costs to avoid potential contractual fines, it is necessary to identify how this can be avoided and monitored in order to achieve planned results. In this context, the integration of maintenance performance information systems with the organization's overall performance management information system can facilitate the necessary alignment [9, 15].

Competitive priorities such as cost, quality, delivery performance, flexibility and reliability are the basis for developing distinct production system capabilities [3, 10, 12, 16]. Although many studies have been conducted to identify competitive priorities in different countries [2, 17–20] there is still some consensus on six priorities that should be considered in the operating system: cost, quality, delivery, flexibility, service and environmental protection [11, 21, 22].

Daily production activities, such as planning, scheduling, procedure assignment, and quality control, have been improved through the effective integration of maintenance activities to increase process reliability. On the other hand, production, procedures and policies such as the quality management approach can help improve maintenance performance and, consequently, deliveries within the customer's desired timeframe [4, 7, 13, 14, 23–26].

Failure to execute the request received or planned by maintenance may result in the risk of wasted hours beyond the planned or even production of non-compliant parts, directly affecting the demand fulfillment performance. Market conditions force organizations to have fewer and fewer raw materials inventories, work in process inventories and finished goods inventories. In some cases, the customer requires the supplier to maintain a small security inventory to avoid potential recurring service threat issues. The size of this stock is scaled by the history of reliability of its suppliers' machines and equipment. This safety stock is not financed by the customer but is also a determining factor when signing the supply contract for a certain period. Inventory is a contractual requirement to ensure supply accuracy as planned and may be reduced or increased as equipment and process reliability maintain a desired level of performance [3].

Planned maintenance inspection activities have priority as they can reduce the risks of process reliability [27]. These inspections aim to answer the following questions like [28]: What could happen wrong? How can it go wrong? What is your probability of going wrong? What would be the consequences? Organizations determine strategies that aim to minimize the likelihood of failures and learn from failures when they occur [21]. The deterioration of machinery and equipment and the lack of quality in the maintenance workforce are the main causes of reduced production capacity and unreliability in production processes. As a result, this causes delays in customer order fulfillment and possible contractual fines in industries [29].

Therefore, using additional data to obtain detailed information on maintenance and production activities and thus maximizing the number of customer orders delivered within the customer's desired timeframe is a challenging problem. The importance of integrated MPC has been addressed, but modeling of integrated maintenance concepts for PPC is not as common in the maintenance literature [8].

Thus, as described by the main authors highlighted in Table 1, it can be inferred from the flow shown in Fig. 2.

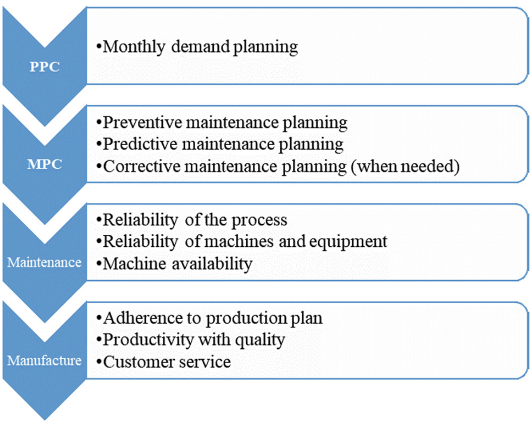

Fig. 2. Process systematization between PPC and MCP.

Figure 2 establishes a relationship between PPC and MCP to ensure demand. If production planning fails for corrective maintenance purposes, this will compromise all production planning. In addition, corrective maintenance presents some risks, including unpredictability of repair time, as well as sometimes difficulty finding spare parts or even emergency freight to restore equipment that is unavailable, and loss of equipment. planned production. Thus, the cost of corrective maintenance will be greater than the cost of preventive maintenance [30].

Production planning on bottleneck equipment does not foresee possible interruptions, beyond what has already been planned. If corrective maintenance due to unplanned shutdown occurs and this equipment is part of a continuous process, i.e. a process dependent on another, it will certainly result in losses, for which contractual fines for production delay may be imposed [30, 31].

3.2 Results of a Brief Study in Four Brazilian Companies

In Brazil, there is a competitive market in the manufacturing of parts and components for agricultural and construction machinery. Large automakers offer a one-month service warranty in their supply chain, expected to last 12 to 24 months. However, it requires delivery performance with targets of up to 95% and quality, 98% performance, with defined delivery and quality policies.

The desired delivery date criteria with a variation of about two days from the desired date by customers for situations when the supply chain fails to reach the desired goal, these customers establish a finished items safety stock so that any oscillation in the process and possible shortages of parts in the production lines of the automakers. Thus, safety stock is calculated based on the reliability and availability risk of the supplier's production process, as well as its capability.

For deliveries outside the agreed policy, a financial penalty is automatically imposed on the supplier, i.e. a rebate on the receivables the supplier has to the automaker. The non-compliance tolerance for each item is around 3 to 5% per year. Any deviation above this goal, authorships are performed in the production process in order to verify the capability, reliability and availability of the processes. Thus, positive or negative results directly influence the prospecting of new business.

All supply chain performance management studies are reviewed on a monthly basis and feedback from the indicators is sent throughout the supply chain. For this, a classification is made, in which the supplier is evaluated and, according to his performance, his classification, established in three levels, can be considered 3 as the worst and 1 as the best. In this way, the worst supplier rating is prevented from receiving new business opportunities or may even be disconnected from the supply chain.

Annually, a 3% cost reduction is required for each item. This reduction refers to the goal of improving the production process, whose value is automatically adjusted after 12 months. If, if the supplier fails to make the improvements mentioned above, the reduction is still required as agreed in the supply contract. Continuous process improvement is the sole responsibility of the supplier.

To illustrate the relevance of this work, four companies from the southern region of Brazil were surveyed. These companies are suppliers to assemblers of agricultural machinery, producing tractors and harvesters, construction machinery, used in earth-moving and tractor, backhoe and loaders.

Of the four companies surveyed, two have been suppliers to automakers for over ten years, one of them eight years old and one the fourth company for nine years. Regarding the area of activity, the four companies supply only to the Brazilian market, with an average annual revenue of approximately 12 million dollars each company.

Companies have safety stock with finished parts. However, one of the companies has a smaller safety stock because its maturity level is higher. Technologically, they all have modern two- and three-dimensional laser cutting machines and equipment, welding machines such as robots. But one of the companies stands out for having a welding robot in three dimensions. Both companies provide laser cut parts, folds, and welded assemblies.

The supply policy for automakers is based on Kanban and deliveries are scheduled according to the demand of the automakers. It was also found that automakers keep their stocks for only three days of production. However, it requires the four companies to have an inventory of finished and semi-finished parts internally. Suppliers receive daily updated Electronic Date Interchange (EDI) orders from the automakers, ensuring the four weeks of confirmed orders. However, in some cases, automakers require some deliveries within four weeks. To avoid paying fines, this is negotiated between the planning areas in advance.

For certain types of assembled assemblies, welding or forming tools or devices are required. The automakers pay for the manufacture of this tooling in the development of the samples. It has been evidenced in the 24-month history that at some point all companies paid for any quality or deadline failure, and these penalties provided for in the supply agreement are automatically made to suppliers' receivables.

4 Conclusions

Operations and production managers are constantly concerned about the reliability and availability of processes and equipment. It was observed that a well-trained and motivated maintenance team performs higher quality short-term tasks, thus ensuring that the equipment is restored, leaving it in its normal operating condition. This ensures the productivity, quality and demand required.

Increasing competitive pressure requires reliable processes from organizations, which helps them increase their own competitiveness in their market. This confirms the proposed hypothesis, evidencing in the literature that the availability of equipment can guarantee the required demands, through a synergy of workforce qualification between PPC and MCP, based on the works mentioned in Table 1.

Therefore, it is considered that the objective of this work was achieved by the literature review, which presented the elements that cause risks of contractual fines due to the unavailability of equipment and how this can be avoided in order not to generate contractual fines and possible damages to companies and your image. This corroborated with a brief account of how it happens with some organizations mentioned in the study.

Robust processes help maintain stable productivity, reducing operating and maintenance costs. These processes can also contribute to a reduction in material inventory in processes and finished products, thereby reducing the need for safety stocks to support eventual unavailability in the production process. It can also reduce operating and maintenance costs.

For future work, a possibility of theme to be explored is related to process reliability and flexibility in operations due to demand volatility.

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A Model for Cost Deviation Analysis and Prescriptive Analytics

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Abstract. A cost variation within an acceptable range is considered an "event under control" and does not require investigation or action. Nevertheless, often, managers investigate cost variations based on historical data and subjective judgments or empirical rules. Both, positive and negative cost variations may represent a problem, for example, if service levels and quality standards are not achieved. This paper presents a model and a methodology that allows establishing the acceptable range for cost analysis towards a predictive analytics approach. Monte Carlo simulation is used to compute the inherent variability in the processes. This methodology was tested in a case study, obtaining, as a result, the range of standard values which serve as a basis for operational and tactical decisions in the organization. Potential applications and opportunities for further developments and research are also discussed. Namely, the use of simulation that allows obtaining results in a short time for day-to-day decisions within the organization.

Keywords: Cost deviation · Costing systems · Prescriptive analytics · Monte Carlo simulation

1 Introduction

Good cost estimation has a direct bearing on the performance and effectiveness of a firm because overestimation can result in loss of business and goodwill in the market, whereas underestimation may lead toward financial losses to the enterprise. Because of this sensitive and crucial role in an organization, cost estimation and control has been a focal point for the design of operational and strategic plans and a key agenda for managerial policies and business decisions [1].

Prescriptive cost models support optimized decision making going beyond the analysis of ex-ante data. To perform an application of a prescriptive cost models it is necessary to use mathematical cost models, mathematical algorithms or parametric equations which can be used to model and estimate cost behavior in order to optimize certain objectives constrained by a set of relevant conditions. Relationships and patterns within large volumes of data can be used to predict behavior and events. Business analytics can be put into practice through three different phases of analysis:

– descriptive, which uses business intelligence and data mining to ask: "What has happened?",

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- predictive, which uses statistical models and forecasts to ask: “What could happen?” and, finally, the most sophisticated of these approaches,
- prescriptive, which uses optimization and simulation to ask: “What should we do?”.

Managers use feedback on cost deviations to initiate corrective actions. A fundamental question is for what level of variation it makes sense to initiate such actions and which variations can be considered normal in production and business processes. Usually, this is done empirically, however, analytical techniques can be used to set such limits considering the inherent characteristics of the process as the expected variability of the production or business system.

To determine these variations, we developed a model based on Activity-Based Costing (ABC), used to calculate more accurately and allocate better indirect costs which are an increasingly important component of the total cost [2]. By focusing on the activities, ABC offers, among others, the following advantages: it identifies the activities that do not add value, identifies expensive or inefficient processes, facilitates continuous improvement, and reduces costs.

2 Standard Costing

The standard costing system is a costing system that essentially measures the effectiveness and efficiency of manufacturing. Standard costs are predetermined costs. However, not all predetermined costs are standard costs. In companies, in addition to actual and effective costs, so-called theoretical costs are assumed on a regular basis and with different objectives. These costs are called basic costs or conventional costs. For the basic cost of each resource one can consider its market price, the average cost of previous periods, the cost of reproduction or the standard cost.

The standard costs are obtained based on the results of previous periods and assume a set of conditions that reflect the normal efficiency of the factors. According to [3] standard cost is the base cost of a product, according to current and/or expected operating conditions. It is based on normal or ideal conditions of efficiency and volume mainly related to indirect costs. Direct costs, such as labour and materials, can be calculated taking current conditions into account. In [3] the authors high-light two essential components in a standard cost: the existence of a standard and a cost. By default, we refer to the physical characteristics inherent in a given operation, which in turn necessarily imply a cost. They may be the hours of required work or the quantity of a given material. Basically, it can be said that behind a standard cost there is always a physical standard. Determining this physical standard is an engineering job.

The authors [3] highlight two essential components in a standard cost: the existence of a standard and a cost. By default, we refer to the physical characteristics inherent in a given operation, which in turn necessarily imply a cost. They may be the hours of required work or the quantity of a given material. Basically, it can be said that behind a standard cost there is always a physical standard. Determining this physical standard is an engineering job.

According to [4] standard costs can be of three types: ideal or theoretical, basic (or normal) or current. The ideal standard cost corresponds to the case in which the production is carried out in the best possible conditions. When quantities, prices and degree of utilization are normal, the standard cost is normal. In this situation, information from past experience is considered. The current standard cost is based on the planned production for the period in question and takes into account the current conditions.

The authors [3] distinguish standard costs into only two types: the basic standard cost and the current standard cost. The basic standard cost is the one that reflects the conditions of productive efficiency, so it is also called ideal cost. The current standard cost considers the particular conditions of the period in question and may therefore differ from previous ones.

Standard costs are not calculated on a historical basis, but on the basis of the technological limitations of production and the knowledge of production processes. As predetermined costs, they indicate how much should be spent, thus allowing cost control. The standard cost would be that which would exist if a set of hypotheses in production are fulfilled. It is different from a budgeted cost that is essentially a forecast and a much more high-level governance tool. In this system, costs are calculated the opposite of what is done in process and order costing systems. The costs of each cost center are calculated first and only then the unit costs are obtained. In the standard costing system, first the unit costs are calculated and, at a later stage, the total production costs are computed.

In highly diversified production enterprises, the standard cost system may be the only practical possibility for determining the cost of products. This occurs when, in a cost-benefit analysis of alternative costing systems, it is discovered that it is not economically feasible to use methods based on actual quantities of inputs. In these cases, the criteria of operability and economic rationality are contrasted with the calculation of costs with greater precision.

Methodologically, standard costing is carried out in five stages. In the first stage, the standard costs of the production factors are defined, taking into account the technology used and the history and experience accumulated. In the second phase, standard consumptions are calculated. In the third phase, activity levels are calculated and in the fourth phase, the manufacturing overhead budget is included. Finally, overloads of defective products are taken into account. In other words, first the technological costs are calculated, knowing the normal consumption of inputs (physical standards) and then the respective costs are calculated (standard costs). The standard cost of a product is obtained by multiplying the standard unit consumption by the standard cost per factor. Once the actual costs have been calculated, they can be compared with the standard costs by analysing the deviations. In this sense, standard costs are assumed as efficiency measures. Typically, this is calculated by breaking down the standard cost into its three main components: materials, labour and manufacturing overheads.

The analysis of deviations is done at two levels: price and quantity. In addition to these two types of deviation (quantity deviation and price deviation), the total deviation can also be obtained, which is no more than the sum of the other two as shown in Eqs. 1 to 6.

$$\text{Total Deviation} = \text{Actual Cost} - \text{Standard Cost} \tag{1}$$

$$\text{Total Deviation} = \text{Actual Quant} \cdot \text{Real Price} - \text{Standard Quant} \cdot \text{Standard Price} \tag{2}$$

$$\text{DT} = \text{RQ} \cdot \text{RP} - \text{SQ} \cdot \text{SP} \tag{3}$$

Adding and subtracting RQ · SP, the total deviation must be equal to:

$$\text{DT} = \text{RQ} \cdot (\text{RP} - \text{SP}) + \text{SP} \cdot (\text{RQ} - \text{SQ}) \tag{4}$$

where:

$$\text{Price deviation} = \text{RP} - \text{SP} \tag{5}$$

$$\text{Quantity deviation} = \text{RQ} - \text{SQ} \tag{6}$$

The model adopted in this research is an activity-based cost model and thus it is not necessary to consider the traditional distinction in the aforementioned three types of deviations: materials, labour and manufacturing overheads. The analysis of deviations in direct and indirect costs can always be done at the level of quantity (e.g., kilograms consumed, hours worked) and price (of inputs) or unit cost calculated for the activities (in this case, in the formula, price is replaced by unit cost). Activity-based costing is a full costing system but in our model we may not consider, for the purpose of calculating the standard cost, certain costs (for example, fixed or general costs which can be allocated to the structure). Or, on the other hand, highlight the non-utilization of resources through the accounting of idle capacity (in the logic of Time Driven ABC) or activities without added value associated with inefficiency and waste (in the context of Lean accounting).

Standard costs are especially important for companies with a long production cycle that manufacture a single product or for those that manufacture a small number of different products in series. However, standard costs are also useful in other situations. Using a standard costing system allows us to understand the production cost and its components. On the other hand, also allows for a more detailed analysis of manufacturing processes. They can be used also for the definition and analysis of pricing policies and strategies for the organization and for production management purposes namely, in terms of productivity.

Standard costs are often used as instruments for the decentralization of responsibilities. Because a standard costing system makes it easier to identify the causes of abnormal costs and to identify or indicate causes. And finally, its adoption considerably simplifies the exercises of management control and the different evaluations that the company must carry out periodically.

In [5] list other benefits associated with a standard costing system. First, it is a less costly method than the permanent calculation of actual costs. On the other hand, it allows to define goals at the operational level. It is often a valuable cost control tool. Last but not least, standard costs can support decision-making, particularly, performance analysis.

3 Model and Methods

Let, n resources, m activities and/or products. For the estimation of costs, the following matrix model was used, taking into account the following parameters:

$CR := \left(cr_{ij}\right)_{n\times 1}$ = Cost of resources used,

$AR := \left(ar_{ij}\right)_{m\times m}$ = Relation activity resource, where $\sum_{i=1}^{m} ar_{ij} = 1\,\forall j$,

$CA := AR \cdot CR = \left(ca_{ij}\right)_{m\times 1}$ = Cost of each activity,

$PA := \left(pa_{ij}\right)_{o\times m}$ = Activity products relationship, where $\sum_{i=1}^{o} pa_{ij} = 1\,\forall j$,

$CP := PA \cdot CA = \left(cp_{ij}\right)_{o\times 1}$ = Cost for each of the products or services.

To build the model that recognized de variability, it is assumed that ar_{ij}, pa_{ij} are uncertain parameters. A sample ar^{e}_{ij}, pa^{e}_{ij} are generated for each input parameter ar_{ij}, pa_{ij} using their probability density function (PDF) Which is derived from the fit analysis of each parameter (i.e. the Anderson-Darling test or The Kolmogórov-Smirnov (K-S) test). The expected result must be calculated for the result or output (the cost of the product or services), the value of cp^{e}_{ij} are the outcome variable, which is calculated considering:

$$cp^{e}_{ij} = f\left(ar_{ij}, cp_{ij}\right) \tag{7}$$

The procedure is repeated for s number of iterations. Finally, the outcomes are analyzed using statistic criteria, histograms, confidence intervals, among others statistics. Using the logic of the Decision-analytical modelling (DAM) the proposed model was applied in a real case [6]. One of the methods used to understand and to manage uncertainty is the Monte Carlo Simulation. A Monte Carlo simulation was made and interesting results were obtained. Indeed, probabilistic costing models are tools that can be used to turn costing systems more relevant, contributing to improve decision making. This new model can be used to deal with uncertainty in an extended ABC model (which includes uncertainty) that offers additional and very valuable information for budgeting and cost management. The model was applied in a textile company and allowed to determine the limits for which a deviation in the cost of the product can be considered normal and when a deviation warrants a preventive, corrective or improvement action. The deviations in the production cost of two types of yarn were analysed considering a production process based on 12 resources (including raw material) and 5 main activities.

4 Application and Analysis

The model was applied in a textile company that allowed to use it to determine the limits for which a deviation in the cost of the product can be considered normal and when a deviation justifies a preventive, corrective or improvement action. The deviations in the production cost of two types of yarn were analysed by considering a production process based on 12 resources (including raw material) and 5 main activities.

The textile company A is specialised in home textiles, especially in the bedspread subsector. In 10 years, the industrial surface increased from 840 m^2 to 11.340 m^2, distributed in 3 buildings. The turnover has tripled in 3 years, which reflects the great growth of the company in recent years.

The company exports to 24 countries and the U.S. market accounts for about 70% of sales volume. In terms of human resources, it employs 220 workers in the factory, with an average age of about 35 years, which allows it to present itself as a company with solid, properly updated and capable of achieving high productivity rates. The company produces yarn through its spinning unit. The activity-based costing methodology was used to estimate the production cost of two types of yarns (P1 and P2 products) produced in a given period. The following tables provide information on the costs of the resources employed and on the process. Table 1 represents the consumption of resources by each of the activities required to produce the products. Table 2 represents the consumption of the activities by each one of the products.

Table 1. Resource consumption by activity.

Resources	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
Loading		5,05				76.431			15%	150		76.431
Combining		2,00	5,18	100%					15%	180	20%	
Twisting		2,00	51,41		100%				40%	270	80%	
Emplasticize			0,04					1	20%			
Storing		4,95				75.668			10%			75.668
Raw materials	100%											
Cost driver	Direct	Workers	Kw	Direct	Direct	Kg	Direct	%	m^2	m^2	%	Kg
Cost	111.05	10.802	2.348	235	2.648	265	69	1.224	1.091	329	191	19

R1: Raw Materials, R2: Direct Labour, R3: Energy, R4: Combing, R5: Twisting, R6: Forklift, R7: Emplasticizer, R8: Indirect Labour, R9: Air-Conditioner, R10: Building, R11: Compressor, R12: Scale.

Table 2. Activities consumption by product.

Activity	Loading	Combing	Twisting	Emplasticizer	Storing	Raw materials
Yarn 4/2	44.389	12.682	23.040	106	43.946	66.583,49
Yarn 6/2	32.042	12.588	23.040	76	31.722	50.466,75
Idle capacity		650				
Cost driver/units	Hours	Hours	Hours	Pallets	Kg	Euros

The information in Tables 1 and 2 was standardized to produce Tables 3, 4 and 5, which were used in the cost model presented before to compute activity and product costs.

Table 3. Resource-activity matrix.

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
A1	0,00	0,36	0,00	0,00	0,00	0,51	0,00	0,15	0,25	0,18	0,00	0,51
A2	0,00	0,14	0,09	1,00	0,00	0,00	0,00	0,15	0,30	0,21	0,20	0,00
A3	0,00	0,14	0,91	0,00	1,00	0,00	0,00	0,40	0,45	0,32	0,80	0,00
A4	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,20	0,00	0,00	0,00	0,00
A5	0,00	0,35	0,00	0,00	0,00	0,49	0,00	0,10	0,00	0,29	0,00	0,49
A6	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table 4. Activity-product matrix.

	A1	A2	A3	A4	A5	A6
P1	0,58	0,49	0,50	0,58	0,58	0,57
P2	0,42	0,49	0,50	0,42	0,42	0,43
P3	0,00	0,03	0,00	0,00	0,00	0,00

Table 5. Resource-product matrix.

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
P1	0,57	0,56	0,50	0,49	0,50	0,58	0,58	0,53	0,52	0,54	0,50	0,58
P2	0,43	0,44	0,50	0,49	0,50	0,42	0,42	0,46	0,48	0,46	0,50	0,42
P3	0,00	0,00	0,00	0,03	0,00	0,00	0,00	0,00	0,01	0,01	0,01	0,00

With this information, using the costing model we obtain the standard cost for each of the activities, their distribution in the products and the cost for each product, as shown in Table 6, allowing also to evaluate the profitability per product.

Table 6. Product costs.

	Yarn 4/2	Yarn 6/2	Inactivity	Total
Loading	2,646	1,910		4,556.12
Combing	1,279	1,269	66	2,613.46
Twisting	3,692	3,692		7,384.36
Emplasticize	184	132		361.54
Storing	2,426	1,751	66.54	4,176.46
				19,046.94
Raw material	66,583.49	50,466.75		117,050.24
Total	76,810.37	59,221.27	65,54	136,097.18

Once analyzed in the model, it was found that several production factors have variability in the production process, which introduces variability in the cost of the products. Analyzing the production factors, the cost of raw material is the one that most affects the cost of the products and this is in turn related to the twisting activity because the dimension of the yarn spools, which in the deterministic model is 3.5 kg, however by practical experience it is considered that this can vary between 3.1 kg and 3.85 kg. Taking into account this information, it was considered that this parameter could be modeled by a triangular distribution, which is commonly used in cost analysis with uncertainty [7]. For the development of the model we used the software @risk 7.6 and 10,000 simulations of the deterministic model were run. Once the simulations were run, the probability distribution of each of the product costs could be obtained, from which, taking as a reference a tolerance limit of 20% above and below the average, tolerance limits could be obtained as shown in Figs. 1 and 2.

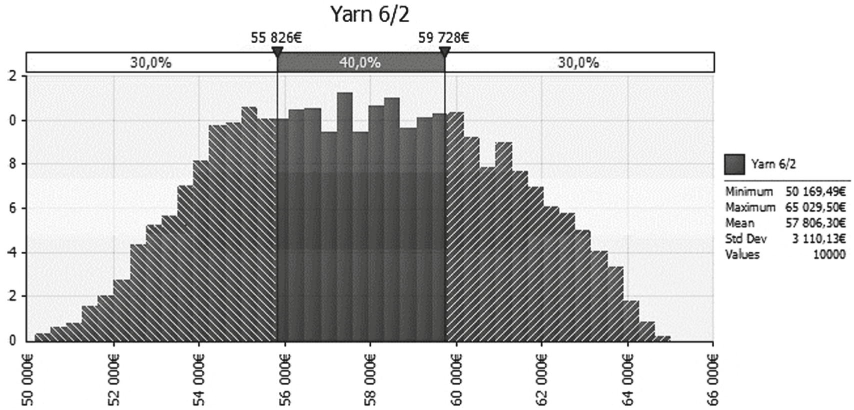

Fig. 1. Tolerance limits for yarn 6/2.

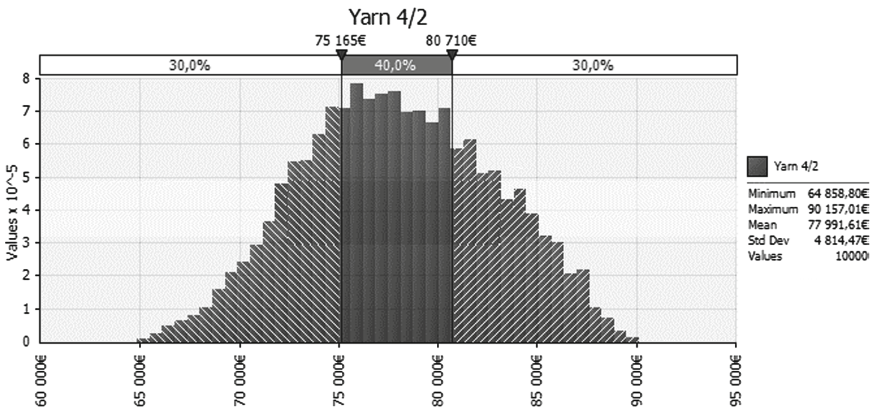

Fig. 2. Tolerance limits for yarn 4/2.

As can be seen in each figure the analysis is as follows with the current conditions there is an expected average value of the cost for each product, the company accepts a variation more or less than 20% of its average, any variation that is below or above that value must be investigated, if it is within that value is accepted as within control.

A cost variation within an acceptable range is considered a "controlled event" and does not require investigation or action. However, managers often investigate cost variations based on historical data and subjective judgments or empirical rules. Both positive and negative cost variations can be a problem, for example, if service levels and quality standards are not met. This paper presents a model and methodology for establishing the acceptable range for cost analysis toward a predictive analytical approach. Monte Carlo simulation is used to calculate the variability inherent in the processes. This methodology was tested in a case study, resulting in the range of standard values that serve as the basis for the organization's operational and tactical decisions. Potential applications and opportunities for future development and research are also discussed.

Decision makers analyze variations to evaluate performance after decisions are implemented, in order to activate the process of learning about the cost behavior of the organization and make continuous improvements. Variations serve as a timely warning system to alert managers to existing problems or potential opportunities. Variation analysis allows managers to evaluate the effectiveness of actions and performance in the current period, and refine strategies to achieve better future performance.

To ensure that managers correctly interpret variations and make appropriate decisions based on them, they need to recognize that variations can have multiple causes, that variations must be quantified, and that not all variations merit corrective action, this will depend on the limits set for a deviation to be considered normal or out of control. In the era of large data, artificial intelligence, automatic learning and business analytics, must be done before costs occur, supporting effective predictive analytics in practice, here Monte Carlo simulation can be considered an effective tool for such analysis.

This article proposes a model that allows these limits to be established taking into account the production process and the factors that generate costs. Simulation allows results to be obtained quickly, at low cost and useful for decision making. The potential of the method presented here is that it can be adapted to any type of organization and the use of simulation allows results to be obtained in a short period of time for daily decisions within the organization.

5 Conclusion

An adequate management of the variability in production processes allows companies not only to understand their production processes but also the impact that variability has on production costs and therefore on the profitability of the company. Traditionally, standard costing has been used to analyze the variability in costs. In this article we propose to see the standard as a range of possible values where being within that range is considered normal and outside that range, abnormal. This point of view allows us to really concentrate on analyzing the relevant variations and creates awareness that variability is inherent in most production processes.

This analysis is important. Indeed, decisions makers analyse variations to evaluate performance after decisions are implemented, in order to activate the learning process on the organization's cost behaviour and make continuous improvements. Variations serve as a timely warning system to alert managers to existing problems or potential opportunities. The analysis of variations allows managers to evaluate the effectiveness of the actions and the performance in the current period, and to refine the strategies for achieving better future performance.

In the era of big data, artificial intelligence, machine learning and business analytics we should do this before costs happens supporting effective predictive analytics in practice. Thus, we propose a model that allows to set those limits taking into account the production process and the drivers that generate costs. Simulation allows to obtain results quickly, at low cost and useful for decision making. The potential of the method presented here is that it can be adjusted to any type of organization and using simulation allows obtaining results in a short time for day-to-day decisions within the organization.

An opportunity for future work is taking advantage of the potential of the Monte Carlo simulation namely, for the analysis of the correlations between the production factors, between the consumption of resources by activities and of the activities by the different products. In traditional standard costing this is not taken into account since only deviations are evaluated whether of price or quantity.

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A TD-ABC Model for the Computation of the Total Cost of Ownership of Spare Parts

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Abstract. The costs of spare parts represent an important share of the operation and maintenance costs of capital goods. Spare parts may remain in depots and warehouses for long periods of time, and, many of them require logistics activities. There are several life-cycle cost estimation models for capital-intensive production systems however, commonly, they do not consider logistics costs adequately. Thus, to incorporate all these aspects into the computation of the cost of ownership of spare parts, a time-driven activity-based costing model is proposed in this paper. Furthermore, since the dynamics of spare parts management are based on the reliability of the components, the Weibull's function is integrated into the model. An application is presented considering a logistics distribution center. The presented approach allowed the costs estimation besides the idle capacity estimation, two important information inputs in logistics management. The results show the usefulness of the proposed model. The opportunities for further research and applications are also discussed.

Keywords: Total cost of ownership · Time-driven activity based costing · Spare parts

1 Introduction

In the last years, two approaches for long-term economic analyses have been proposed: Life Cycle Costing (LCC) and Total Cost Ownership (TCO). Maisenbacher et al. [1] point out that both, the TCO and the LCC methodologies are reliable models that allow a precise and complete evaluation of all the costs related to the purchase and operation of any productive investment. In the last 20 years a series of approaches have been proposed to estimate life cycle costs in complex industrial facilities. Some of them are quite generic, such as Woodward and Woodhouse models [2, 3], and others more specific for certain types of facilities, but in general terms, their results cannot be considered satisfactory. In the same way, a series of standards for the estimation of life cycle costs have been proposed, such as [4], and others more specific for certain types of facilities, [5] for industries of oil and natural gas, [6] for the semiconductor industry, [7–9] in the construction sector, and, [10] in the military sector.

According to Roda and Garetti [11], TCO provides a specific perspective of the LCC. Unlike LCC, TCO refers to the perspective of ownership of the productive asset and considers all costs incurred during the useful life of the equipment. Still according

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to the authors, TCO has a more strategic connotation that supports structural and long-term decisions, both in terms of investment and operational decisions such as supplier selection. Indeed, LCC typically presents the Net Present Value of a series of future cash flows based on more aggregated cost items namely acquisition, operating and maintenance costs, some of them, not unusually presented as a proportion of the initial acquisition cost.

Regarding any productive physical asset, it is a priority to carry out economic analyses to measure the long-term effects of the decisions related to their use and exploitation, including availability and utilization levels. One of the main aspects to achieve a higher level of availability of an asset is its maintainability. Maintainability is an asset inherent characteristic which denotes shorts downtimes with ease, accuracy, safety and economy in the execution of maintenance actions [12]. According to [13], spares availability is one of the most important aspects to ensure higher levels of maintainability. Inventory management policy, in addition to providing the correct supply of spare parts for maintenance activities, has a significant impact on the total cost of ownership (TCO) of any physical asset [14].

In a TCO analysis, different costs at different points in time are assumed. Therefore, it is necessary to calculate and report potential further costs using a discounted formula approximating the value of money in time. Various costing techniques have been used to estimate the TCO and LCC. Some costing techniques have recently emerged that simplify the calculation and allocation process without significantly affecting the accuracy of the results. Among these techniques we can highlight those based on Activity Based Costing (ABC). Despite being recognized as a useful tool for life cycle costing (e.g., [15]) ABC presents, as a main disadvantage, the difficulties in its implementation. The excessive number of activities and drivers makes it difficult to obtain satisfactory results in its implementation. Thus, the Time-Driven ABC (TD-ABC) emerged as a more simplified alternative for calculating costs of processes and cost objects [16, 17]. In this new approach, a single driver is used, the time required for the execution of each activity, and through this driver, the differences between the different cost objects are taken into account.

As far as the literature has shown, no TCO model satisfactorily incorporates or ponders the influence of spare parts management costs on overall ownership costs. If we consider that spare parts management costs can reach up to 30% or 40% of operational and maintenance expenditures (OPEX), and that many physical assets have long useful lives, their economic effect on ownership costs must be considered critical [18].

The objective of this work is to propose an innovative costing model that incorporates the life cycle perspective and the activities that support operations through the management of spare parts based on TD-ABC. Indeed, given the complexity and scope of the operations related to the spare parts management, we should agree that it is necessary to create a new tool for the quantification of these costs and their inclusion in the OPEX along the useful life of a physical asset.

2 Methods and Model

A time-driven activity-based costing model is proposed. Representative processes were defined to represent what takes place inside a warehouse of spare parts. Representative categories or groupings of spare parts have also been established. The life cycle is considered to be a given duration of years. The main features of this model are: multiperiod (life cycle), multi spare parts, and reliability oriented (Weibull distribution [13]). The TD-ABC consists in the estimation of two parameters: the unitary cost of the supplied capacity and the time required to perform each transaction or activity. In other words, the procedure consists of two main steps: first the capacity cost ratio is calculated by dividing the total cost by the practical capacity supplied. The result is the cost per unit of time (Eq. 1).

$$CCR_t = \frac{RC_t}{C_t} \tag{1}$$

The second is devoted to the definition of the time equations that reflect the demand for resource capacity using activity durations as the driver. These equations reflect the allocation of costs to the cost object by multiplying the cost per unit of time by the time necessary to carry out the activity (Eq. 2).

$$T_{j,t} = \beta_{1,t,j} \cdot X_{1,t,j} + \beta_{2,t,j} \cdot X_{2,t,j} + \beta_{3,t,j} \cdot X_{3,t,j} + \ldots + \beta_{K,t,j} \cdot X_{\mathrm{K},t,j} \tag{2}$$

Where:

$T_{j,t}$ – time required for executing the activity j in period t,
$\beta_{i,t,j}$ – time consumed per unit of time driver i for activity j in period t,
$X_{i,t,j}$ – time driver i in period t for activity j (binary).

The capacity cost rate in a given period of time (CCR_t) is defined as the rate between the total cost of the resources (RC_t) and the capacity supplied in the period (C_t). Note that, for each period, both resource costs and practical capacity may vary, and this should be reflected in the model by the sub-index t representing the specific life cycle period (Eq. 3).

The TD-ABC technique considers that the time consumed by the different activities regarding the different categories of cost objects (i.e., spare parts) differ according to a set of K attributes. In spare parts logistics activities, such attributes can be constituted by, for instance, its weight, volume or fragility among others. These differences are expressed by the $\beta_{i,t,j}$ coefficients, in minutes (see Eq. 2). On the other hand, each category could present or not the aforementioned attributes. If a given category of spare part presents the attribute i, $X_{i,t,j} = 1$; else $X_{i,t,j} = 0$.

Logistics transactions are triggered by the failure rate of the components in period t (λ_{tp}). Such failure rates are modelled through the bathtub curve and the Weibull probability distribution function. Considering β^w and η as the form and scale parameters of the Weibull distribution function, λ_{tp} can be expressed as shown in the next equation:

$$\lambda_{tp} = \left[\frac{\beta^w}{\eta} \left(\frac{t}{\eta} \right)^{\beta^w - 1} \right]_p \tag{3}$$

The activities and processes considered in this model are transactional ones. In this way, we have considered that the time drivers of each process are expressed in lots of spare parts ($L_{p,j}$) (number of units on which each activity j is carried out). In addition, it should be noted that for each activity, the batch size of a spare class may be different, therefore for each spare p, there may be a different $L_{p,j}$. To quantify the number of times a given activity is performed in a given period, the driver will be obtained by the following ratio:

$$X_{i,t,j} = \frac{\lambda_{tp}}{L_{p,j}} \tag{4}$$

The model assumes that total demand in a period is fulfilled by the logistics process. That is, no shortages are allowed. Therefore:

$$\lambda_{tp} = \sum_{p=0}^{p} L_{p,j} \tag{5}$$

Substituting Eq. 4 in Eq. 2 we have:

$$T_{j,t} = \beta_{1,t,j} \left[\frac{\lambda_{t1}}{L_p} \right]_{1,t} + \beta_{2,t,j} \left[\frac{\lambda_{t2}}{L_p} \right]_{2,t} + \ldots + \beta_{k,t,j} \left[\frac{\lambda_{t3}}{L_p} \right]_{k,t} \tag{6}$$

Finally, substituting Eq. 3 in Eq. 6 we have:

$$T_{j,t} = \beta_{1,t,j} \left[\frac{\frac{\beta^w}{\eta} \left(\frac{t}{\eta} \right)^{\beta^w - 1}}{L_p} \right]_{1,t} + \beta_{2,t,j} \left[\frac{\frac{\beta^w}{\eta} \left(\frac{t}{\eta} \right)^{\beta^w - 1}}{L_p} \right]_{2,t} + \ldots + \beta_{k,t,j} \left[\frac{\frac{\beta^w}{\eta} \left(\frac{t}{\eta} \right)^{\beta^w - 1}}{L_p} \right]_{k,t} \tag{7}$$

If we consider the effect of inflation throughout the periods of the life cycle, we have that the value of the resources can be adjusted by a capitalization factor ι. As it is shown in the Eq. 8:

$$RC_t = RC_1 (1 + i)^t \tag{8}$$

Finally, the Capacity Supplied for period t is generically given by:

$$C_t = T_{1t} \cdot RC_1(1+i)^t + T_{2t} \cdot RC_1(1+i)^t + \ldots + T_{nt} \cdot RC_1(1+i)^n \quad (9)$$

Equation 7 can be factorized as the following:

$$C_t = RC_1(1+i)^t \sum_{i=1}^{n} T_{it} \quad (10)$$

The Present Value of Supplied Capacity for the Life Cycle (C_o) will be given by:

$$C_0 = \sum_{t=1}^{T} T_{it} \frac{1}{(1+\delta)^t} \left[RC_1(1+i)^t \sum_{i=1}^{n} T_{it} \right] \quad (11)$$

Or, in full:

$$C_0 = \sum_{t=1}^{T} T_{it} \frac{1}{(1+\delta)^t} \left[K_1(1+i)^t \sum_{n=1}^{n} \sum_{p=1}^{p} \left(\frac{\frac{\beta^w}{\eta} \left(\frac{t}{\eta}\right)^{\beta^w - 1}}{L_p} \right) \right] \quad (12)$$

where δ represents the discount rate to obtain the present value of the logistics costs.

3 Case Study

To illustrate the use of the model and to validate its usefulness, a simplified example based on a real case applied in a spare parts distribution center is presented. For this, three main logistics activities and three types of spare parts were considered. These three types of spare parts represent different families of parts that differ by their sizes and complexities which demand a different use of the warehouse resources. The life cycle comprises an extension of 11 years. Four categories of resources are considered: labor, handling equipment, other fixed costs and other variables costs. The category of handling equipment has been subdivided into three sub types, depending on the load capacities of each one. Table 1 presents the main characteristics and initial values related to each one of the resources categories.

Table 1. Resources details.

	Resource category	Quantity	Depreciation (years)	Annual costs	Prices index
R1	Labor	6	NA	15,000.00	5%
R2.1	Handling equip.	1	20	20,000.00	NA
R2.2	Handling equip.	1	10	15,000.00	NA
R2.3	Handling equip.	1	5	5,000.00	NA
R3	Other costs (fixed)	NA	NA	8,000.00	4%
R4	Other costs (variable)	NA	NA	2,000.00	6%

Table 2 shows the computations of the practical capacity cost rates along the life cycle (10 years). Note that the values of the resources were projected using the price index as a tentative of considering the inflation and other price variability over time.

Table 2. Cost capacity rates and cost of the supplied capacity.

Year	Cost of supplied resources	Capacity cost rate
1	\$ 28,500.00	4.07
2	\$ 29,690.00	4.24
3	\$ 30,937.50	4.41
4	\$ 32,245.32	4.60
5	\$ 33,616.42	4.80
6	\$ 35,053.90	5.00
7	\$ 35,561.02	5.07
8	\$ 37,141.22	5.30
9	\$ 38,798.08	5.54
10	\$ 40,535.38	5.78

Considering 24 hours per day, 365 working days per year and an 80% of efficiency we have approximately 7,000 h as the total capacity. Table 3 presents the estimated quantity of spare parts for each category, estimated through the Weibull parameters for the total extension of the life cycle.

To define the time equations, the time consumed per unit was established for each spare category ($\beta_{i,t,j}$). These values are shown in the matrix of Fig. 1. In such matrix, columns represent each attribute associated to the spare part. In our case, we considered 5 different attributes. Each row represents the coefficient of the time equation associated to each one of the three activities. For simplifications ends, the same value for all the periods t was considered.

$$\begin{pmatrix} 5 & 5 & 5 & 20 & 0 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 2 & 0 \end{pmatrix}$$

Fig. 1. Coefficient matrix of the time equations.

Secondly, the $X_{i,t,j}$ values for each category of spare parts are presented in the 3 matrixes of Fig. 2. In each matrix, columns represent each attribute and rows represent each one of the activities. As it was mentioned before, we considered 5 different attributes and three activities. For simplifications ends, such values do not change along the life cycle.

$$\begin{pmatrix}1&1&1&0&0\\1&1&0&0&0\\1&0&0&0&0\end{pmatrix}\begin{pmatrix}1&0&0&0&0\\1&0&1&1&1\\1&1&1&1&0\end{pmatrix}\begin{pmatrix}1&0&0&1&0\\1&0&0&0&0\\1&1&0&1&0\end{pmatrix}$$

Fig. 2. $X_{i,t,j}$ values by category of spare parts.

Table 3 shows the projected demand of the three categories of spare parts.

Table 3. Demand forecast in units by spare part category.

Years	1	2	3	4	5	6	7	8	9	10	11	12
Spare part 1	100	90	70	60	50	40	40	40	50	60	80	100
Spare part 2	40	40	40	40	30	30	30	30	40	40	50	50
Spare part 3	120	110	100	94	82	70	70	120	140	160	180	200

Table 4 presents the used capacity in minutes by each activity along the entire life cycle.

Table 4. Used capacity by activity.

Years	1	2	3	4	5	6	7	8	9	10	11	12
Inbound logistics (min)	4700	4300	3750	3450	2950	2500	2500	3750	4450	5100	5950	6750
Internal logistics (min)	480	450	400	374	302	270	270	320	400	440	540	600
Outbound logistics (min)	780	730	670	636	528	470	470	670	810	900	1050	1150

Table 5 presents the idle capacity in minutes and as a cost along the entire life cycle. Negative numbers denote overloaded capacity.

Table 5. Used and idle capacity by period.

Years	1	2	3	4	5	6	7	8	9	10	11	12
Used capacity (min)	5960	5480	4820	4460	3780	3240	3240	4740	5660	6440	7540	8500
Idle capacity (min)	1048	1528	2188	2548	3228	3768	3768	2268	1348	568	−532	−1492
Idle capacity ($)	4262	6474	9659	11724	15484	18847	19120	12020	7463	3285	−3215	−9105
Used capacity ($)	24238	23216	21278	20521	18132	16206	16441	25121	31335	37250	45573	51872

Finally, and considering the demand values of the three spare parts categories (Table 3) and that $L_{p,j} = 1$ for all the spare parts categories and activities, we are able to estimate de Net Present Value of the supplied capacity using Eq. 12 and a discount rate of 10% per year.

4 Results and Discussion

Table 6 shows the comparison between the net present values of the total costs computed through the time driven activity-based system and the traditional costing system (based on the volume of parts handled in the warehouse) during the entire life cycle.

Table 6. Actual costs computed by the traditional costing system and the TD-ABC.

	Traditional	TD-ABC
SP 1	$ 69,591.38	$ 39,340.76
SP 2	$ 41,402.74	$ 17,624.97
SP 3	$ 121,510.39	$ 114,973.63
Idle capacity	$ –	$ 60,565.15

Comparing these values, some important differences must draw our attention. These differences can be better observed in Figs. 3 and 4.

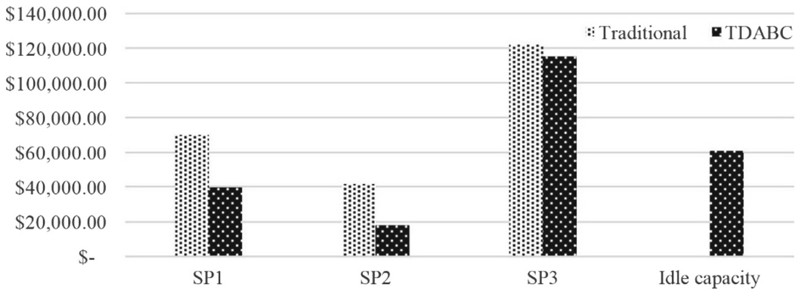

Fig. 3. Comparison between the two costing systems (in actual costs).

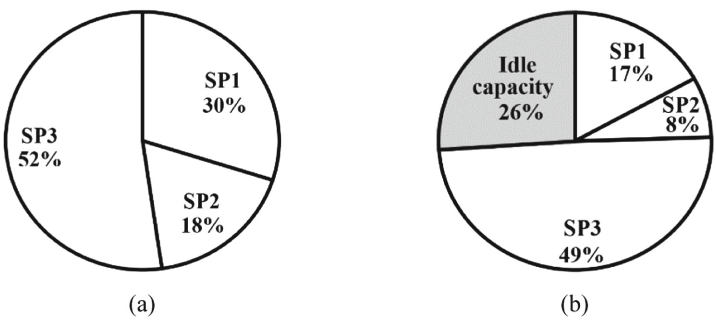

Fig. 4. Comparison between the two costing systems: (a) traditional and (b) TD-ABC.

Figure 4a shows the percentage of the costs per spare part category using the traditional costing system and Fig. 4b, shows the comparison of the values obtained through the TD-ABC. Note that, in such method, the idle capacity is also considered in the comparison. Spare part 3 almost does not change its relevance in both systems, however, the fact that the idle capacity is considered (in TD-ABC) make that the other two categories diminish significantly its importance in the context of the total costs. Also, such approach shows that there is a certain capacity (i.e., resources) that will not be used and that should not be allocated to spare parts costs.

The use of the proposed model can lead decisions about the following aspects:

– Define which are the spare parts to keep in the warehouse. This model allows to incorporate in the analysis the reliability and consumption of resources within the warehouse. Notice how the traditional cost system does not distinguish between the three categories of parts and their characteristics, such as weight, volume and special needs for care. Such characteristics influence in an important degree the use of resources, and finally the costs of the logistic structure.
– The information obtained by the proposed method can be useful to develop life cycle budgets and plan the appropriate use of the capacity and volumes of resources allocated for logistics management.

5 Conclusion

In order to validate the proposed model, several experiments were carried out. The results of the simulation experiments show the validity of the model. Particularly, the comparisons between the results from the application of a traditional costing model show that, first, it is possible to use the TD-ABC approach to estimate the costs of ownership in a spare parts warehouse and distribution center. Second, the use of the TD-ABC allocation bases results in a more accurate cost analysis supporting better decision making. The analysis made demonstrate the usefulness of the proposed model. Future developments point to its application in a real scenario. Besides, there is a need to assess the influence between the level of detail in which the processes developed in the warehouse must be mapped to and the accuracy of the obtained results. Further research may focus on developments of this model and its implementation in different companies. Namely, modelling with more detail the consumption of the resources in internal logistics (within the warehouse), combining the proposed model with other cost models such as those based on equivalence methods which share some aspects of the TD-ABC model, analyzing unitary costs and product profitability to support decision making, comparing investment alternatives, managing capacity and optimizing resources considering a LCC perspective, etc.

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Lean Production in a High Fashion Garment Company: Challenges and Solutions

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Abstract. This paper describes the results of a Lean project developed in a high fashion garment manufacturer company. In this case, the project intended to promote Lean Thinking on the company by starting implementing some Lean Production tools. The use of these tools allowed to solve identified problems and to reduce wastes. The main wastes identified were confused materials flow and a high number of movements due to an improper layout, operators' skills lack, and a high number of stops, among others. The most challenging aspect of this work was the resistance to change. However, it was outweighed by involving the employees and showing them the benefits obtained. The main results achieved were the layout reconfiguration that resulted in simpler flow and fewer movements. In addition, better monitoring of performance indicators, more knowledge of employee skills and a better-organized warehouse were achieved.

Keywords: Lean Production · Lean Thinking · Layout · High-fashion garment

1 Introduction

The textile and garment industry (TGI) is one of the sectors that, probably, shows many improvement opportunities since many companies are still disorganized, have low productivity and have a large amount of wastes [1]. Companies live in an extremely competitive environment, and they are forced to differentiate from competition in order to assure the loyalty of the existent clients and captivate new ones. This is, often, accomplished through meeting their deadlines, best quality, and costs reduction and, at the same time, provide a good work environment, for people and planet. In addition, TGI worldwide is extremely volatile since it can be affected by unstable factors such as weather and fashion guidelines. Due to this, companies must be agile and have great adaptability to the changes that this sector constantly faces. If companies are well organized, they will surely benefit throughout the constant process change and keep up with the evolution of the industry.

It is in this type of industry with these characteristics that Lean Production [2] has a major impact as a solution to improve productivity and reduce costs, by eliminating mudas of all kinds [3]. Muda is a Japanese word for waste. It means any activity that

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consumes a resource without creating value for the client, in his/her own point of view and he/she is not willing to pay for, such as, the seven wastes identified by [4]: (1) transports, (2) inventory, (3) motion, (4) waiting, (5) overproduction, (6) over-processing; and (7) defects. Additionally, untapped human potential is considered the eighth waste [5]. To implement Lean Production, Lean Thinking principles must be followed [6]: (1) specify value; (2) identify the value stream; (3) create flow; (4) pull production and (5) pursuit perfection. To achieve them, many tools must be used and production system must be diagnosed and redesigned as this is, many times, the source of many wastes, being a matter of business sustainability [7].

This paper presents some results of a project developed in a high fashion garment manufacturer to implement Lean Thinking principles. In this type of company, production quantities are, usually, small (between 50 to 1000 parts per style) which implies a deep knowledge of value for the client. Moreover, the high fashion style is characterized by a garment high level of production difficulty and must have the best quality, without any defects. The Lean Thinking principles start with specifying value for the client. Attending to the specific of the high fashion garments and small quantities produced, anyone could think that this principle was assured in this company but this was not so simple. Nevertheless, the company was falling in the other four principles: the value stream was not correctly known, there was no flow due to an unsuitable production system layout, push production was in place instead pull and perfection by continuous improvement was not pursued. In order to achieve these, company's production system must be effective, must have continuous flow and muda should be as low as possible, and this was not happening.

These challenges drove the main objective of the work developed in the company that it was to improve the production system of this high-fashion company using Lean Thinking principles and tools. The improvement proposals using such tools had to assure the value for the client was correctly understood, to allow knowing exactly what activities add value and the ones that did not add value, to implement continuous flow, to create suitable mechanisms for effective communication with the client and to establish a continuous improvement mind-set. When doing this, it was also intended to improve some performance indicators (such as productivity), as well as to simplify material, people and information flows, to improve lead-times and reduce costs.

This paper is divided into five sections. Firstly, an introduction to the theme is presented. This is followed by a brief literature review about Lean Production in Sect. 2. Section 3 presents the research methods. The fourth section presents the diagnosis, improvement proposals and results. In Sect. 5, some conclusions are wrap-up.

2 Lean Production Brief Literature Review

Lean Production have been implemented in many companies of good and services. These case studies could be founded in many published papers in the literature [8]. In such case studies plenty of benefits are presented due to Lean implementation: less process waste and rework; reduced lead-time and inventory and increased process understanding and financial savings [9] and, ultimately, environmental benefits to achieve global development [3].

In the particular case of TGI sector, there are also many cases studies showing the benefits in this specific sector that must lead to motivation and commitment to Lean implementation. For instance, Eira et al. [10] examined some sectors from a garment company and he found losses of time due to transports, long distances traveled and mixed material flows. Then, he proposed to rearrange the layout leading to a reduction of the distances traveled daily by the employees and a reduction of the transport activities. Maia et al. [11] also applied lean tools to improve three case studies. At the same time, they were trying to validate a methodology to implement Lean in TGI. TGI companies were needing a methodology to implement Lean [12, 13].

The resistance to the changes and the skepticism are still the main resistance strengths to Lean. Especially on the garment industries, it's not easy to implement Lean due to the lack of organization and the mindsets of people as the main obstacle to change. Also, some companies understood in the worst way that the isolated application of Lean tools or techniques do not lead to a sustainable improvement [14].

3 Methods

The Action-Research methodology was used to research and solve the problems in the company. This methodology includes five stages that should be taken as a guideline: diagnosis and definition of the problem, action planning, action implementation, evaluation of the results and learning specification [15].

According to the Action-Research methodology, the first phase of the project started with the description of the current situation: the actual production layout, the department characterization and flow of materials, people and information. Based on this characterization, a critical analysis was performed in order to diagnose and identify the existing problems. In this methodology, the employees were included in the research of problems and were recognized as team members that may propose actions and changes that can improve work processes [16].

The critical analysis was carried out through informal surveys to the employees of each department using a question guide from a methodology to implement Lean Production in TGI developed by [17]. Company administrators of each department and top management were also questioned using another guide from the same authors. Finally, considering the data obtained, an action plan was drawn up in which the proposals for improving the identified problems were developed.

4 Diagnosis, Improvement Proposals and Results

As the project begins, the company administrators did not know the amount of waste related to production activity. So, to draw up an implementation plan of improvement proposals, the diagnosis and problem identification was a mandatory phase.

Then, during and after the implementation, some results were collected in order to evaluate the impact of the change of a Lean implementation in this high fashion garment manufacturer.

4.1 Diagnosis and Problems Identification

The first step was to diagnose production processes through the analysis of information and material flows, production layout in general, employees' skills, quality procedures, characterization of the productive activity for each sector and a review of the collection management procedures.

The client specifies the clothing collection to produce using a product paper datasheet, nevertheless, this specification was done in an old-fashioned way with the client sending more details by phone or email that someone adds manually to the datasheet. If someone lost this datasheet, all information related to the garments is lost.

Concerning the quality procedures, the control of the materials, the intermediate product or final product was fallible since the quality criteria were not the same from person to person. This means that sometimes one person considered a situation acceptable and another person it might not be acceptable. In addition, in order to avoid losing time and to rush the production, sometimes the control points were skipped and this could report to a huge loss since the production goes over with a defective item.

A large number of activities that did not add value to the final product were found. In order to quantify them, all the activities performed during a general production process were classified. Six categories were identified: operation AV (activities that add value to the final product), operation NAV (activities that do not add value to the final product but that are important to assure the good functioning of the production system), transport, control, waits, and stocks. For the transport category, the traveled distances, in meters, was registered. The results collected are shown in Table 1.

Table 1. Results obtained for the activities that add or did not add value to the final products by the company sector.

Activity	Warehouse	Cut	Control	Packing/Finishing	Shipping	Total		%
Operation AV		2		1		3	AV	13
Operation NAV	1	3	1	1	1	7	NAV	87
Stocks		1			1	2		
Control		2	3			5		
Waits	1	3	3	1		8		
Transport	1	7	8	2	3	21		
Travelled distance (m)	13	61.7	100.7	70	80.9	326.3		

Through the analysis of the table, only 13% of the activities refer to activities that add value to the final product. From the 87% of the activities adding no value to the final product, the highest one is the activity related to the transport, since while the production process occurs, more than 325 m were traveled. Although it was not possible to remove certain routes, some ways to reduce the distance traveled as well as the time spent by the employees while traveling were considered. All of the sectors of the company were disorganized due to the lack of space and storage facilities and the absence of cleaning and arrangement procedures.

Another problem found was the non-existence of performance measures for the sectors and the absence of encouragement policies for productivity and improvement suggestions. The diagnosis stage had a special focus on the sewing department, leading to a review of this sector layout and their machines. It was also searched the causes for workplace stoppages. For this, it was used an Ishikawa diagram as shown in Fig. 1.

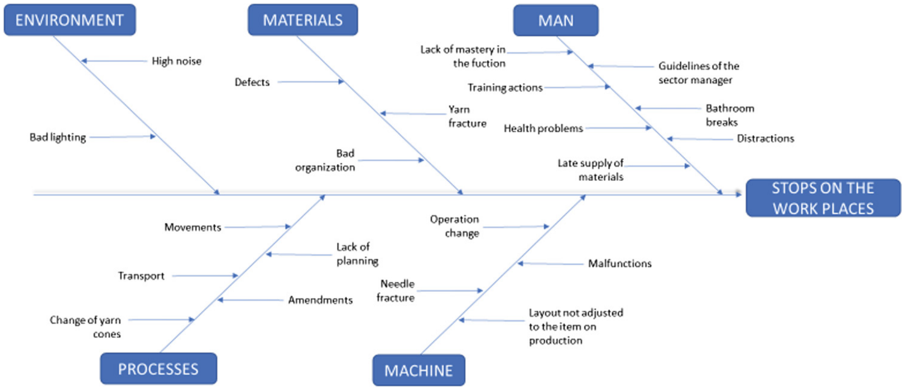


Fig. 1. Stops on the workplaces on the confection sector.

In general, the company has a medium level of organization, but this is not enough for a company with a high demand for quality in production. Also, due to the company growth caused by increased demand, the company had to increase the production area and reorganize all the departments. The main problems found were poor departments' organization, lack of visual management, high stops in production and high movements due to production layout, several inactive sewing machines included in the sewing layout, absence of collection management procedures, lack of quality control practices, non-existent performance indicators, lack of technical skills and motivation. Figure 2 shows examples of disorganization in the warehouse and accessories sector.

Fig. 2. Examples of disorganization in company sectors.

4.2 Improvement Proposals

The action plan was designed to solve the referred problems. This plan includes a collection process management that provides collaborative solutions developed for design and product development teams (Fig. 3a). It was created a label to approve client changes (Fig. 3b). Such solutions allowed better communication with the client, producing what he/she really needs.

(a) (b)

Fig. 3. Software platform for collection process management (a) and Label for approval management (b).

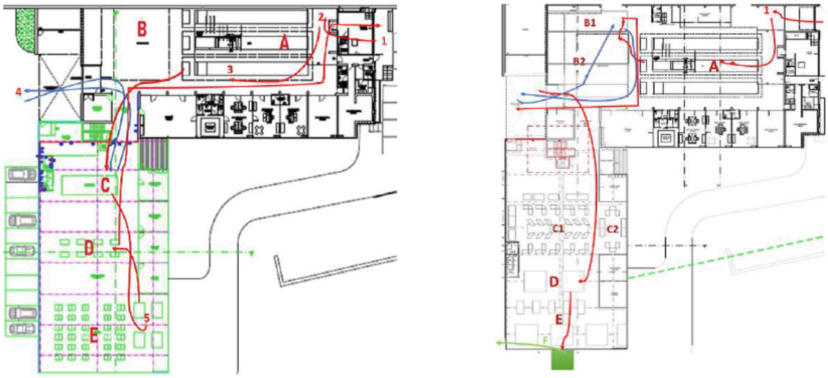
Other proposals were related to the defect control processes, the creation of a sheet to register stops in production, layout rearrangements, and 5S, visual management and an incentive program to improve the productivity and organization of the company. Also, it was necessary to make an inventory of all the machines and equipment as well as its state (active, non-active) to know what were the available equipment.

The creation of a Kanban board was proposed in order to help the management of the collection process (samples development) in the confection department. Using this board, a daily plan and a daily goal was structured, which motivates the employees of this department. The tasks can be easily prioritized and it is also a way of visual management.

Following the Ishikawa diagram developed with the workplace stoppages, it was developed a file to record the times associated with non-productive activities and, also, with the productive activities. Through this, it was possible to inform the coordinators of each sector, about the time spent with activities that did not add value to the final product, in order to find solutions to minimize them and improve continuously.

The company administrators developed a layout for production but since the project has been developed at the same time as production increased, it was considered relevant to build another layout proposal since some flaws were found on the first one. Both proposals are presented in Fig. 4. The administrators' layout (adm.s' layout) proposal is on the left (Fig. 4a) and the one developed on this project is on the right (Fig. 4b), including their material flows.

The first step was to compare both layouts and movements (in meters) when a generic production process was in progress. In Table 2 it is possible to understand that the adoption of the layout developed on this project results in almost 60 m less in movements (which means that some time has been associated with activities that didn't add value to the final product).



(a) (b)

Fig. 4. Materials flow on the company: (a) adm.s' layout and (b) layout developed on this project.

Table 2. Comparison of the movements (in meters) for each layout.

Movements (m)	Fabric storage	Cutting	Control	Finishing	Shipping	Total
Adm.s' layout	13	79.4	108.5	45.6	81.5	328.0
Proposed layout	13	35.7	129.7	30.3	60.8	269.5

However, the evaluation should be made based on other factors while analyzing both layouts, so the weighted factor analysis method has been used. This method consists of giving a weight for each factor according to their importance in order to give more weight in the evaluation to the most important factors and then assign a score for each factor on each layout. The results are shown in Table 3.

Table 3. Weighted factor analysis method for both layouts.

Factor	Weight	Score	
		Administrators' layout	Proposed layout
Flow linearity	25%	40	75
Movements	25%	60	80
Initial investment	15%	75	40
Organization	15%	45	70
Use of the available space	10%	50	80
Ease of supply	10%	60	50
Weighted factors score	100%	54%	68.3%

In the administrators' layout proposal, the material flow was chaotic because it crosses several times, which becomes confused. There were more movements too. The organization was worse, and the use of the available space was not optimized since some areas were overused. However, the initial investment of this proposal is smaller, and the ease of supply had a higher score.

Besides the ease of supply and the initial investment, the layout developed on this project reached a higher score due to the better organization and optimization of the available space, less movement and simpler and linear flow of the material with fewer crosses.

A layout for the sewing sector was designed as well, considering the machines owned by the company (in order to reduce the investment as much as possible). The proposal presented in Fig. 5 was developed considering the available space for this sector and, also, seeing each worker as an individual cell. In the left area (C1), large quantities will be produced and each workspace would be considered as an individual cell, having two main machines (cut and sew and topstitch which are the most common ones). The special machines (used not so frequently) would be placed in the central isles. These machines will have wheels, so they would be easily moved to the individual cells. In the right area (C2), only prototypes and samples should be produced, so it is an area designed only for two workers. As well, those cells should be reconfigured and adjusted according to the product in "hands".

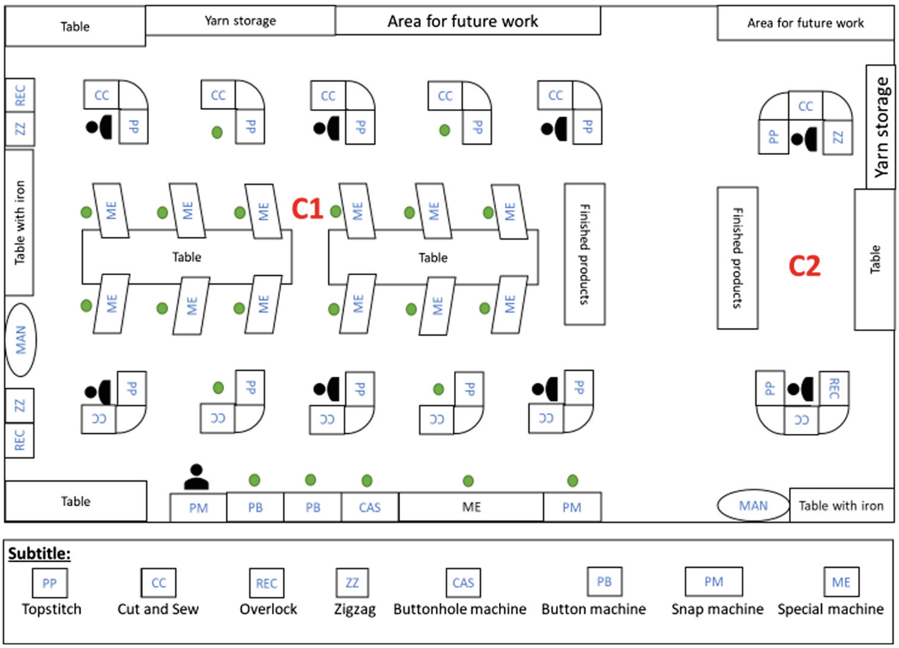


Fig. 5. Layout proposed for the sewing sector.

The main advantage of this layout is its high adaptability and flexibility since it is possible to adapt the cells according to the needs of the products to make, which results in a reduction of the movements and in an improvement of the productivity of the sewing sector.

In the new facilities of the material warehouse, a section for each client (visibly identified) should be designed to reduce the time spent while searching for the items and reduce the waits to go for the production.

Another proposal is to separate the materials for production from the ones that are production surplus. Also, in order to improve the organization of the material warehouse, it was proposed a method of identification of the material by coordinates (develop an exact location information for each material), so the material can be easily found and picked by any employee.

Concerning visual management, the development of placards was proposed since they are good to promote visual management due to their accessibility to the employees. The placard should contain the goals to achieve, the achieved goals, and a dashboard with production indicators as shown in Fig. 6.

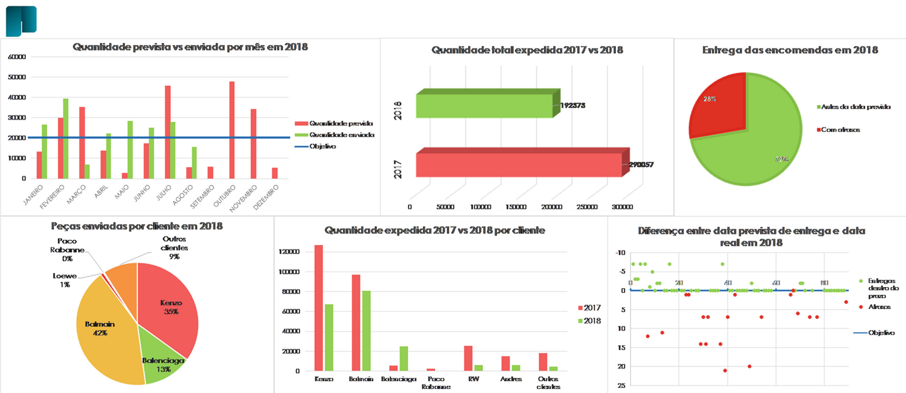


Fig. 6. Annual dashboard with performance indicators (in Portuguese).

On the first graph, it was shown the planned quantities versus the shipped quantities in that year. The second graph made a comparison between the shipped quantities in the current year (2018) and the previous year (2017). The third graph refers to the deadline accomplishments, and the last graph (the sixth) refers to the comparison of the planned delivery date and the real delivery date. The fourth graph shows the weight of shipped pieces per client and the fifth graph shows the growth of each client comparing with the previous year. Additionally, it was developed a placard for each department with their goals and productivity indicators for each month.

4.3 Results Analysis and Discussion

Some of the results obtained were a better alignment with client needs and value, better flow of information, people and materials (with fewer movements), better performance indicators monitoring and simplification of the collection process. It is also expected to improve the organization and defect control, as well as accelerate the task management process and increase employee engagement.

When the placards were shown to the employees, an immediate spirit of competitivity and results orientation was felt almost immediately. The employees started to make comparisons between them and tried to improve the deadlines of the orders and, also, they tried to succeed in the aspired goals of the company.

With the implemented proposals, the employees were focused on continuous improvement. The defect control is an activity that did not add value to the final product, however, it was needed since the minimization of defects found in intermediate and final products results in low losses for the company.

It is expected an improvement of the task management using the Kanban board, which is a visual management tool. It also improves the collaboration between all team members accomplishing the need to involve all employees and helping them to proceed with their tasks in the sewing activities. Additionally, this becomes a tool of communication between employees and administrators, which makes them proud as they felt that the company values their opinion and their work, increasing their self-esteem.

The main difficulty and the major challenge found through the development of the project was the resistance to change. This is extremely common with people that perform the same task for several years. This difficulty was found at the beginning while performing the informal surveys to the employees and administrators because they were less interested in cooperation. This initial difficulty was outweighed by explaining the benefits to the workers and good receptivity of the improvement proposals was reached. By the moment they understood that the questions were regarding possibilities for change, their behavior changed.

5 Conclusion

This paper presents a project developed in a high-fashion garment company. High-fashion garment produces, most times, one-of-a-kind styles without repetition, what is by itself a challenge. Nevertheless, Lean Thinking is a way of life and their application does not have limits, as the objective to make things well is important in any company. What is important is the mindset, whenever achieved, it is just a matter to select the suitable tools to the company structure and apply them in order to reduce wastes. When this mind-set is reached, the main challenge is overcome and all difficulties and problems become to be seen as improvements opportunities.

The clients want to see the company as a high-quality supplier that knows exactly what is his/her value without wasting his/her time and in which they can trust their production. To achieve this, the goal is to improve continuously the production processes and promoting a mindset of the employees, involving them in the process as well as searching continuous improvement.

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The Impact of Merged Data in Big Data Platform: A Case Study

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Abstract. Handling big data is a challenging task, which, in some cases, may raise performance issues. How data are collected and stored has a high impact on performance, when, for example, some data analysis is needed, or when an organization needs to run some queries on the data. In this paper, we study the impact of the block size in a big data environment and especially in HDFS, by presenting a special use-case that illustrates and compares four possible scenarios, distinguished by the organization of the data (multiple files vs. a single merged file) on a big data environment. We perform our comparison by running a query on each scenario, and observing the running times. As expected, the results show that working with a single file in a multiple-node environment yields the best results.

Keywords: Big data · Hadoop · HDFS · Block

1 Introduction

The world's data have experienced a compound annual growth at an exponential rate [1]. As a result, data are stored in a computing cloud linked to billions of distributed devices [2]. The growth has not only been defined in terms of analysis and storage, but also in the fact that new technologies are required to meet these computational challenges [3, 4]. A prime example is social media. Social networks such as Facebook (www.facebook.com) and Twitter (twitter.com) are becoming increasingly widely used. Currently, Twitter [5] generates 500 million tweets a day. The growth rate of tweets is around 30% per year, a rate projected to increase to 1.2 billion tweets per day by 2025, that is, 1.36 petabytes per year.

With this increase comes the need for companies to deal with the challenges of collecting, storing, and analyzing a huge amount of data, with an aim to identify patterns and trends, as well as to provide forecasts in order to create valuable insights [6].

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1.1 Big Data

Big data is an evolving term that has various definitions whose common denominator is the volume of data [3]. However, the volume is not the only challenge [7]. Big data is often defined using additional dimensions (known as the 5 V's): variety, velocity, veracity, volume, and value [8]. Big data is the voluminous amount of structured and unstructured data with the potential to use and produce insights through analysis and complex queries [2, 9]. It challenges statistical models and computational methods [10]. Hence, techniques for handling big data vary, for example, spatial data mining, classification, clustering, neural networks, meta-learning algorithms, genetic algorithms, networks, and predictive models [11–13].

Big data creates new opportunities, while creating new challenges of optimizing runtimes, data storing, and analysis [14]. Data analysis can become a very complex process, especially when data come from multiple sources and can be stored in various ways [15, 16]. A popular choice of utilities that support engines for storing and querying warehouse data is relational database management systems (RDBMS). Such data warehouses need to be able to execute complex SQL queries as efficiently as possible against very large databases. Several popular frontend applications for databases are based on the table model that uses SQL, such as Oracle MySql (www.mysql.com) and Microsoft SQL Server (www.microsoft.com) [17].

Big data analysis requires an appropriate platform that can manage the data. To analyze parallel RDBMS systems, exploration using such platforms is growing rapidly, aided by the availability of the open source Apache™ Hadoop®! (hadoop.apache.org), which has become another viable option for big data analytics in addition to systems developed for RDBMS [18].

1.2 Hadoop Platform: An Overview

Apache™ Hadoop®! is an open source supports big data platforms, designated to process data efficiently [19]. This platform is based on a distributed file system and uses the MapReduce runtime. The Apache™ Hadoop®! software library is a framework that enables parallel processing of large volumes of structured and unstructured datasets, as well as high flexibility and reliability for managing and efficiently processing big data [7]. The system allows the usage of many servers, both hosting directly attached storage and executing client application tasks, within a cloud infrastructure [20]. The Apache™ Hadoop®! framework includes several modules, the two main ones being Apache™ Hadoop®! Distributed File System (HDFS) and MapReduce.

The Hadoop Distributed File System (HDFS) is a Java-based file-system component of Apache™ Hadoop®. This component is responsible for storing and distributing the big data files in the system. HDFS is based on Google File System (GFS), is designed to handle and store huge amounts of data, and allows for distributed processing across many servers [21]. Data platforms based on the MapReduce paradigm support analytics on unstructured data by enabling execution of custom Map and Reduce functions [22]. MapReduce is a framework for parallel processing of big data [23]. MapReduce implemented on Apache™ Hadoop® helps shift processing tasks to other connected nodes and reduces sub-processes [24]. This component is responsible for parsing the tasks and merges all the intermediate values into one simplified result, the answer back to its master name node [25].

Before HDFS stores the files, it divides them into a series of blocks for parallel computation to improve operational efficiency [26]. Block size can be configurable in HDFS to 64 MB, 128 MB, 256 MB, 218 MB, and so on. Each block can be duplicated several times (e.g., three times), in an aim to support data recovery in case of damage. Companies are storing files in various categories: per customer, per date, per transaction, and so on [27, 28].

1.3 The Small-Files Problem

Storage is the preliminary process of big data analytics. HDFS stores the data in a distributed manner when a large file is divided into several small files. The memory of NameNode is limited and consumed by the metadata of small files, and hence, NameNode becomes a bottleneck [29, 30]. To minimize load on NameNode and improve the efficiency of storing and accessing the small files on HDFS [31], many researchers have proposed solutions to storing different small files in HDFS. The following provides a short overview of the relevant articles for our proposed research.

The innovative method for the small-files problem is the implementation of map tasks that produce intermediate output, which is given to a reducer that gives the output [32]. The Apache™ Hadoop® platform has limited memory. In [33] it is shown that memory usage reduces by 36% and file read time decreases by 94% using a file-access-pattern algorithm to handle files from heterogeneous users.

A common solution is to merge similar large small-size files into one big file. In [34] the authors propose classifying the files based on their type or size and merging them. In this situation, the NameNode memory overhead reduces to a greater extent. In [35] the authors present a merge strategy based on hierarchy that improves the correlation of small files in the same block. Other solutions are a combination of the file-merging method and indexing mechanism, that defined to access the small files from the corresponding combined file; see, e.g., [36–38].

2 Methods

The assumption is that in different originations/companies, procedures for the capture and storage of data (per business needs) do not always consider the block size and/or the big data architecture (e.g., the HDFS structure).

This research presents a case study with suggestions for the capture and storage of data. Specifically, in this case study, a semi-structured capturing-and-storing dataset (CSV format) is divided into multiple files, which illustrates a company's/organization's capturing-and-storing "internal rules" procedures that may not be based on the properties of the big data environment. Instead, these procedures are based on different business needs/logic, for example, capturing the data per date, per customer, per size, per user, per action, and so on.

Figure 1 presents the proposed solution examined in this research (note the procedure of when and how to merge the datasets into a single merged dataset is studied in separate research).

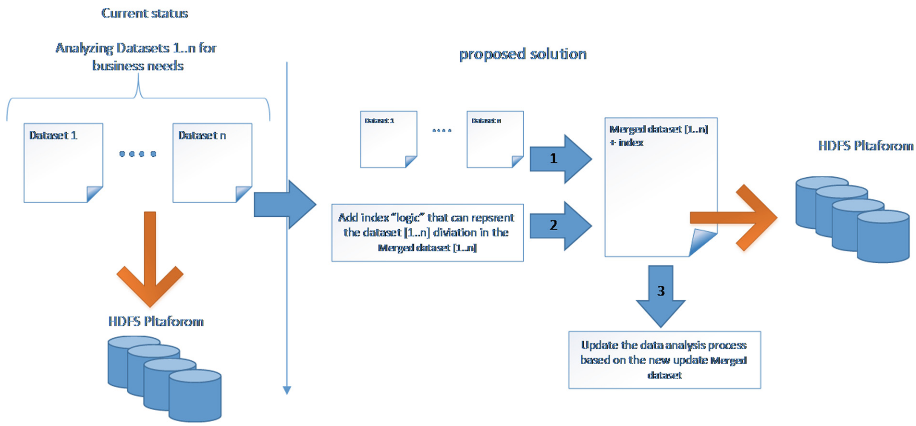

Fig. 1. Proposed solution.

The left side illustrates the current status in some cases, where data are captured and stored in multiple datasets (e.g., files and/or other formats), sometimes ignoring the impact of big data architecture. On the right side of Fig. 1, we propose a solution (examined in the sequel) that may be suitable in some cases, with the following steps:

1. Allocate and find whether multiple datasets exist with the same structure and characteristics, which may require similar data-analysis procedures. These selected datasets may be good candidates for merging into a single dataset (the questions of how to merge, the criteria for merging, and so on are beyond the scope of this paper and are studied in additional research).
2. Add a key/index to maintain the logic behind the original dataset separations (as described in the sequel).
3. Update the data logic, queries, and/or algorithms based on the structure of the new merged dataset.

Based on this concept, we design and test a use case in which we merge semi-structured 12 datasets/files into one. However, to preserve the company/organization business capture and save/store rules, we add an index to represent the "logic" of the company's/organization's capturing procedures. This index can illustrate business "rules" such as customer ID, date, business parameter, or any other functionality.

In the merged dataset file, we use this index parameter so the data analysis considers the business needs.

To investigate and analyze the impact of merged files in big data environments, we create four scenarios and test them by performing various operations and examining their running times, in two different big data environments: single node and multi-node. Table 1 describes the different scenarios.

Table 1. Research scenarios.

Scenario	Environment	Dataset	No. of runs	No. of files	Size	No. of records
1.1	Single-node	Divided	31	12	~43 Mb per dataset/file	499,998 records per dataset/file
1.2	Single-node	Merged + index	31	1	~587 Mbytes	5,999,976 records
2.1	Multi-node	Divided	31	12	~43 Mb per dataset/file	499,998 records per dataset/file
2.2	Multi-node	Merged + index	31	1	~587 Mbytes	5,999,976 records
Total	2	2	124			

The basic data in all four scenarios are the same, except the index (on our use case: the file number), which was added in the merged file (in scenarios 1.2 and 2.2) per each record. We also compare the storage-outcome sizes between all four scenarios, as described in Table 2.

Table 2. Outcome comparison.

Scenario	Environment	Dataset	Outcome size
1.1	Single-node	Divided	1.8801 GB in 25 different files
1.2	Single-node	Merged + index	1.8801 GB in 25 different files
2.1	Multi-node	Divided	1.8801 GB in 25 different files
2.2	Multi-node	Merged + index	1.8801 GB in 25 different files

Note that in scenarios 1.1 and 2.1, outcomes for the divided-files use case that run on different environments (single-node and multi-node) are the same, whereas scenarios 1.2 and 2.2 indicate the case of merged files running on single-node and multi-node environments. The analysis performed on the data is similar in all scenarios, whereas the dataset records are different between the divided datasets and the merged dataset (e.g., the merged dataset has an additional index per each record). In this research, we only compared the outcome sizes between the divided datasets and the merged datasets, whereas the outcome records have differences between 1.1/2.1 and 1.2/2.2.

We performed all 124 tests via bash loop script with a one-minute delay between each run (in all scenarios). We used Apache Pig! (pig.apache.org) both in the divided and the merged datasets in order to examine whether the various scenarios differed in performance. Note the entire data (datasets) were generated randomly. A full detailed description of the scenarios is presented in the following sections.

2.1 Single-Node Environment

We test scenarios 1.1 and 1.2 in a single-node environment in order to compare the performance between divided files and a merged file.

Scenarion 1.1. We create 12 different files, where each file contains ~43 MB of data (CSV format) and 499,998 records. The five-field structure is presented in Table 3. We store the 12 datasets/files in the HDFS, creating 12 different blocks. Then, we upload the 12 files and analyze them using Apache Pig!. On each file, we perform numeric and text analysis that contain: load, generate new structure that contain numeric and text process, such as: STRSPLIT, LOG10, SQRT, SIZE and more fields, then group, generate new structure and union. This query run 12 times – per each load dataset (in the same Apache Pig! script) per each dataset file. Then, we store the union of all 12 loaded files (to the HDFS). The time duration of this scenario is presented in Table 5.

Table 3. Scenario 1.1: divided dataset structure.

#	Field name	Type	Note
1	trx1	float	Transection number
2	num11	integer	
3	num11	integer	
4	nickname1	chararray	
5	note11	chararray	Long string

Scenarion 1.2. We merge the 12 different datasets/files (as described above) into a single merged dataset/file. To preserve the logic of the files (for business needs), we add a field per each record as an index (e.g., it can be a file index, as we used, or a date, or any other relevant key, depending on the business needs). Table 4 describes the dataset. The time duration of this scenario is presented in Table 5.

Table 4. Scenario 1.2: merged dataset structure.

#	Field name	Type	Note
1	grpID	integer	Index ID (in this case – file number: 1–12)
2	trx1	float	Transection number
3	num11	integer	
4	num11	integer	
5	nickname1	chararray	
6	note11	chararray	Long string

The merged file contains the data of all 12 datasets/files with an index per each record (in our case, the index is the file number per each record). The merged file size is ~587 Mbytes and 5,999,976 records. The process and operations in this scenario contain: load (the one merged file), filter the file by the grpID (repeated 12 times, this was done to maintain/illustrate the original business logic as done in the multiple 12 datasets), then per each filter (filter of 12 indexes 1–12), we run the above analysis (that described above which contains numeric and text process etc.). Then, we store the union of all 12 processes in the HDFS.

2.2 Multi-node Environment

We test two scenarios, i.e. divided files (scenario 2.1) Vs. a single merged file (scenario 2.2), on the Big Data Apache™ Hadoop®! multi-node environment (we used six data nodes). The time durations of both scenarios are presented in Table 5.

Table 5. Dataset scenarios results.

Run number	Scenario 1.1 duration	Scenario 1.2 duration	Scenario 2.1 duration	Scenario 2.2 duration
1	0:06:46	0:04:58	0:02:46	0:01:33
2	0:06:37	0:04:17	0:02:45	0:01:27
3	0:06:08	0:04:04	0:02:48	0:01:33
4	0:06:29	0:03:29	0:02:49	0:01:28
5	0:06:26	0:03:54	0:02:41	0:01:27
6	0:07:24	0:03:44	0:02:42	0:01:28
7	0:06:32	0:03:25	0:02:50	0:01:27
8	0:06:17	0:03:36	0:02:49	0:01:28
9	0:06:20	0:03:35	0:02:45	0:01:32
10	0:06:15	0:03:22	0:02:44	0:01:27
11	0:06:38	0:03:27	0:02:51	0:01:25
12	0:06:28	0:03:47	0:02:46	0:01:22
13	0:07:00	0:03:48	0:02:43	0:01:33
14	0:07:00	0:04:05	0:02:51	0:01:28
15	0:07:09	0:03:43	0:02:42	0:01:27
16	0:07:10	0:03:49	0:02:46	0:01:27
17	0:07:08	0:03:37	0:02:42	0:01:28
18	0:07:05	0:03:42	0:02:40	0:01:28
19	0:07:00	0:03:38	0:02:39	0:01:27
20	0:06:30	0:03:35	0:02:47	0:01:23
21	0:06:31	0:03:59	0:02:43	0:01:32
22	0:07:43	0:03:43	0:02:49	0:01:27
23	0:06:37	0:03:35	0:02:46	0:01:27
24	0:06:29	0:03:20	0:02:45	0:01:33
25	0:06:19	0:03:16	0:02:48	0:01:29
26	0:06:13	0:03:46	0:02:31	0:01:32
27	0:07:10	0:03:49	0:02:41	0:01:32
28	0:07:19	0:03:47	0:02:40	0:01:32
29	0:06:36	0:03:35	0:02:49	0:01:32
30	0:06:37	0:03:48	0:02:46	0:01:23
31	0:06:48	0:03:53	0:02:48	0:01:32

3 Results Analysis

First, we present some descriptive statistics of the runtimes within the different scenarios. Table 6 presents the results, which are grouped by the four scenarios. The best performance (short running times) is clearly achieved when working with a single file under a multi-node environment. This result is also shown in the means plot presented in Fig. 2 (total N = 124).

Table 6. Descriptive statistics of running times.

Scenario	N	Mean	Std. deviation	Std. Error	Minimum	Maximum
1.1	31	00:06:44	00:23.74	00:04.26	00:06:08	00:07:43
1.2	31	00:03:44	00:19.23	00:03.46	00:03:16	00:04:58
2.1	31	00:02:44	00:04.27	00:00.77	00:02:31	00:02:51
2.2	31	00:01:28	00:03.18	00:00.57	00:01:22	00:01:33

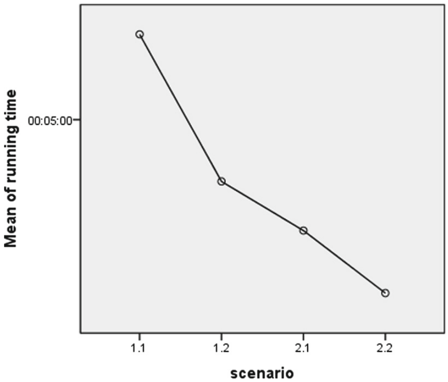

Fig. 2. Means plot for the running times of the various scenarios.

We perform an analysis of variation (ANOVA) test to examine whether the differences between the means of the running times of the four scenarios are statistically significant. The results given in Table 7 show a significant difference, with a p-value equal to 0. Furthermore, an LSD post-hoc test shows a significant difference in the running times between each pair of the four scenarios, as seen in Table 8.

Table 7. ANOVA table.

	Sum of squares	df	Mean square	F	Sig.
Between groups	1678902.476	3	559634.19	327.778	.000
Within groups	28849.871	120	240.416		
Total	1707752.347	123			

Table 8. LSD multiple comparisons output.

Scenario	N	Mean	Std. deviation	Sig	Minimum	Maximum
1.1	1.2	02:59.29	00:03.94	.000	00:02:51	00:03:07
	2.1	03:59.09	00:03.94	.000	00:03:51	00:04:06
	2.2	05:15.32	00:03.94	.000	00:05:07	00:05:23
1.2	1.1	−02:59.29	00:03.94	.000	−00:03:07	−00:02:51
	2.1	00:59.81	00:03.94	.000	00:00:52	00:01:07
	2.2	02:16.03	00:03.94	.000	00:02:08	00:02:23
2.1	1.1	−03:59.09	00:03.94	.000	−00:04:06	−00:03:51
	1.2	−00:59.81	00:03.94	.000	−00:01:07	−00:00:52
	2.2	01:16.27	00:03.94	.000	00:01:08	00:01:24
2.2	1.1	−05:15.32	00:03.94	.000	−00:05:23	−00:05:07
	1.2	−02:16.03	00:03.94	.000	−00:02:23	−00:02:08
	2.1	−01:16.27	00:03.94	.000	−00:01:24	−00:01:08

The results in Table 8 show that when working on a single file, running times become significantly shorter than when working on multiple files, both on single nodes and multi-nodes. Figure 2 depicts these differences between the running times; that is, the mean running time of scenario 1.2 is less than the mean running time of scenario 1.1 (single node), and the mean running time of scenario 2.2 is less than the mean running time of scenario 2.1 (multi-node).

4 Conclusions

The impact of the block size in a big data environment and especially in an HDFS platform is tested in this case study. In some instances, an organization may use a platform for collecting and storing data that creates multiple data files, without being aware of its effect on performance. We examined a special-use case and a possible solution, where all files (CSV files with the same properties) are merged into a single file with an additional critical requirement: to maintain the logic of the original files (by assigning an index per file) in the merged-file structure.

We run a query on the stored data, before and after the merging of the files (the merging process is beyond the scope of this paper), and tested the performances in terms of running times. We analyzed four scenarios: multiple files on a single node, a single file on a single node, multiple files on multiple nodes, and a single file on multiple nodes. Evidently, working with a single file in a multi-node environment yields shorter running times than all other scenarios. Also, working with a single file improves the running times, both in single-node and multi-node environments.

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Factors Influencing Students Usage of an e-Learning System: Evidence from IT Students

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Abstract. In the institutions of higher education, the utilization of a wide range of electronic frameworks has become an ordinary thing, from computerized showcasing approach frameworks (e.g. Facebook, Instagram) to e-learning frameworks, electronic diary and such. Since e-learning frameworks are getting higher consideration and potential in various researches within the past decade, authors of the paper have been motivated to explore students' point of view of an e-learning framework utilization. This research represents an empirical study of factors influencing students in the process of using the e-learning system during their studies. Consequently, an integrated model based on five constructs shows factors influencing students intend to use the system. Construct Facilitating Conditions resulted as the most significant from students' point of view. Our findings can help teachers with how to improve students' intention to use the system and to increase the overall learning potential, giving insight on what to pay attention to, accordingly.

Keywords: E-learning · IS usage · Students-perspective · UTAUT · Linear regression

1 Introduction

In the case of classroom learning, convergence allows learning materials of all kinds to be used by students, on demand, through a variety of platforms – desktop computers, laptops, cellular "smart" phones, and agile digital book readers and media players. Digitally transmitted content accessed by students for purposes of gathering different sorts of information and aptitudes, which we name e-learning, is getting to be an progressively common viewpoint of learning [1].

E-learning as a term implies to a variety of diverse forms of technology-supported learning, ordinarily characterized as the application of information, data and educational innovation to interface individuals to each other and/or with instructive assets, for the purpose of education [2].

Technologies are changing rapidly within the e-learning range and it is exceptionally important to adjust the change proficiently. In order to make progress to the total learning process, institutions of higher instruction ought to alter their conventional

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model of learning by digitalizing the learning environment. Although numerous universities over the world have incorporated learning frameworks based on the Internet, the success of their implementation requires a broad understanding of the end-user acceptance process [3].

It is vital to recognize that quality of a learning process is not only something that is conveyed to a learner by an e-learning supplier but rather constitutes a process of co-production between the learner and the learning environment [4], including other factors influencing this process. The accessibility of an e-learning system does not guarantee its use, let alone its adequacy as an instrument to progress students use behaviour.

In general, like every information system, client acknowledgment and utilization are critical essential measures of system success [5]. The user perspective is hence significant to look at within the usage of a Learning Management System (LMS) in order to evaluate its acceptance [6].

This paper seeks to develop a model consisted of factors that are important to the end-users of an e-learning system (i.e. students) when concerning their behavioral intention on system usage. Consequently, the proposed model will be statistically examined with the aim to find the foremost vital variables.

The paper is organized as follows: Sect. 2 presents a comprehensive background and a summary of the related work focused on the e-learning system acceptance and factors affecting the system usage, as well as the appropriate hypothesis development, according to the topic. In Sect. 3, which presents the methodology that directs the research, the research model of this study is illustrated along with the data collection method. Section 4 presents the statistical data analysis of the results. Discussion, research implications, limitations and further research are addressed in Sect. 5. Finally, the key findings and conclusion are presented in Sect. 6.

2 Background and Related Work

In modern education, an important place is taken by e-learning, for which the development is substantially defined by the evolution of technologies. E-learning includes the use of Information and Communication Technologies (ICT) to provide educating and learning. Modern e-learning switched from the application of distinct technologies (multimedia, videos, e-mail, etc.) to system decisions among which LMS and social networks dominate [7]. With the development of ICT and its influence both toward face-to-face education and also distance learning, e-learning systems are discussed in many occasions by many higher education institutions. The biggest percentage of researches among this topic is focused on the Information System (IS) success and quality [3, 8–10].

2.1 E-learning System Concept

E-learning has been one of the newest educational innovation at the beginning of this 21st century. It is believed that e-learning has the capability to address the development of skills needed by the workforce of modern age in any countries, i.e., good communication skills, ability to learn independently, social skills, teamwork skills, capacity to adapt to changing circumstances, thinking skills and knowledge navigation. In addition, if the system is appropriately targeted and skilfully designed, e-learning has high potential in empowering the learner [11]. Online education is getting to be a part of classical education where students are advertised by the adaptabilities of the educational process within the form of mixed learning, moreover picking up additional competences and abilities, quick and anywhere access to materials, and the possibility to understand and learn better [12]. When talking about changes in higher education, the introduction of modern ICT instruments into the teaching and learning processes needs to be effective within the eyes of all stakeholders – students, instructors and administration of the higher instruction institution. Based on adequate estimations, statistical analyses of the results of implementing an LMS need to be performed regularly and changes made in order to discover out whether the results are satisfactory or in case any additional measures are required [13].

2.2 E-learning System at Faculty of Technical Sciences, University of Novi Sad

The Department of Industrial Engineering and Management at Faculty of Technical Sciences, University of Novi Sad, established an e-learning system based on Moodle called “Moodle eLLab” in order to improve the complete learning process in conventional studies. Users of the e-learning system, depending on the course they approach, can be teachers, assistants, course managers, students, administrators or guests.

As Liao et al. [14] stated: “Moodle e-learning platform is easy to use and provides a good communication tool, discussion area, group space, workspace, and makes learning more interesting”. When comparing some open-source LMSs, Kareal and Klema [15] concluded that Moodle is one of the foremost versatile frameworks and highlighted this feature as a noteworthy component of an effective e-learning framework. They moreover stressed that Moodle is the leading user-friendly e-learning framework among the frameworks beneath comparison.

Users of the e-learning system Moodle eLLab at Faculty of Technical Sciences can use the system through eleven functionalities developed within the system: Forum, Messages, Learning materials, Lesson, Video materials, Quiz, Assignments, Marking of completed activity, Chat, Gradebook and Participants list.

2.3 Conceptual Model and Hypothesis Development

According to the findings, the Unified Theory of Acceptance and Use of Technology (UTAUT) model is found to be one of the most used models when investigating the way of the system usage and overall system acceptance. Research has shown [16] that two central factors of UTAUT and Technology Acceptance Model (TAM), i.e. perceived usefulness and perceived ease of use of a new technology, are exceptionally imperative for the clarification of the purposeful to use ICT and ICT competence. Hence, creators of this paper selected an approach that strongly depends on a few essential concepts of UTAUT.

Considering the views of Information Technology (IT) students, a model for measuring the key variables impacting the usage of the e-learning system during their studies has been given. Based on the previous research results [10, 17, 18], the initial conceptual model has been designed and it is presented on Fig. 1.

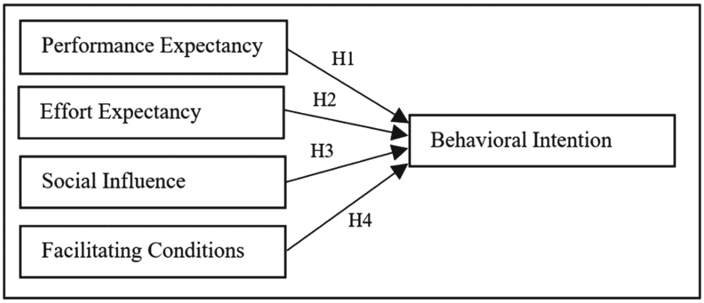

Fig. 1. Conceptual model.

The initial model has been balanced in order to see whether the anticipated preconditions of technical and organizational infrastructure that are expected for e-learning, including training, support, and infrastructure, influence behavioral intention, directly. This relationship has been implemented in UTAUT2 [19]. Each measure within the model is briefly explained underneath.

Behavioral Intention (BI) is characterized as the generally response of the individual to use the system [20]. All factors have been observed in the manner of their effect on Behavioral Intention and thus four hypotheses are proposed for examining key factors influencing students' intention to use the e-learning system.

Performance Expectancy (PE) is defined as a degree to which a person accepts that using an information system will offer assistance him or her to achieve benefits in work performance [20]. In the context of academic information systems, this shows that users of the system (i.e. students, lecturers, and employees) believe that they will not only find technology as useful, but also will complete their tasks timely and effectively. Previous researches has shown Performance Expectancy to be the strongest predictor of Behavioral Intentions [21, 22]. Wang et al. [23], in their research claim that factor Performance Expectancy has a positive influence on the factor Behavioral Intention. Having that in mind, authors of the paper test the following hypothesis:

– H1: Performance Expectancy has a positive influence on students' usage of the e-learning system (Behavioral Intention). Effort Expectancy (EE) is addressed as the level of ease which people associate with using the new system [20]. In this context, it relates to the perception of students ease of use of the academic information system and related features. Within the previous researchers results authors [23] state that factor Effort Expectancy has a positive effect on the factor Behavioral Intention and authors test the hypothesis accordingly:

– H2: Effort Expectancy has a positive influence on students' usage of the e-learning system (Behavioral Intention). Social Influence (SI), is characterized as the degree to which individuals perceive that significant others believe that they are supposed to use the new system [20]. In this context, it is related to the affect of important people such as friends, older colleagues and teachers on the tendency of students to embrace e-learning system. While the role of social influence has been appeared to weaken over time, it is still deemed be an influential factor in the early phases of technology adoption [24]. Previous researcher state that social influence has a positive influence on behavioral intention, so authors test the following hypothesis:
– H3: Social Influence has a positive influence on students' usage of the e-learning system (Behavioral Intention). Facilitating Conditions (FC) are defined as the extent to which a person believes that technical and organizational infrastructure supports the use of the system [20]. In that sense, this factor measures the degree to which students believe that their Faculty provides the necessary support for e-learning system. The factor also indicates whether students believe they have the necessary knowledge and resources to use the e-learning system. Previous researchers [25] found that facilitating conditions have a positive effect on Behavioral Intention. Thus, the following hypothesis is tested:
– H4: Facilitating Conditions have a positive influence on students' usage of the e-learning system (Behavioral Intention).

3 Methodology

The goal of this research is to investigate the factors influencing students' usage of an e-learning system in order to find possibilities for improving the system and its contribution to the entire learning process.

3.1 Measures

The indicators and builds of the conceptual model have been embraced from past studies who examined the success of ISs [20, 22].

3.2 Sample and Data Collection Procedure

Data collection lasted for one month and has taken place through an online questionnaire survey, which was carried out at the Department for Industrial Engineering and Management, Faculty of Technical Sciences, University of Novi Sad, Serbia. Web based questionnaire was distributed to 259 students form IT study programs. Demographic characteristics of the respondents in this study were divided into three groups gender, age and computer literacy. Detailed descriptive statistics relating to demographic characteristics are shown in Table 1.

Table 1. Demographic characteristics of the respondents (N = 248*).

Measure	Items	Frequency	%	Mean	St. Dev.
Gender	(1) Male	91	36.7	1.63	0.486
	(2) Female	157	63.3		
Age	(1) Younger than 21	112	45.2	1.60	0.589
	(2) Between 21 and 24	125	50.4		
	(3) Between 25 and 30	10	4.0		
	(4) Older than 30	1	0.4		
Computer literacy	(1) Professional user	65	26.2	1.81	0.553
	(2) Middle user	164	66.1		
	(3) Beginner	19	7.7		

*Note: 11 respondents were excluded from the research, as they had very low standard deviations (below 0.2), to minimize non-engage bias [26].

Observing the previous researches on IS success, the factors influencing student's usage of an e-learning system have been determined.

The measures that were used to analyze this influence have been adopted from similar studies [10, 18]. A survey instrument was created to test the hypothesis given in this research. For measuring the five constructs in the questionnaire, 23 items were included in the survey. Authors selected constructs from UTAUT model and used a five-point Likert scale for measuring all constructs. After ending with the collection process, data was analyzed with IBM SPSS tool.

4 Results

Linear regression was performed to estimate the set of factors for predicting the intention to use the e-learning system at the Faculty of Technical Sciences, by its end users – students. Based on the results of validation and reliability test taken 30% of the number of respondents, the data is valid and reliable ($\alpha > 0.60$). Based on the Cronbach Alpha value, the entire construct consisted of all examined elements is reliable to use as a measuring instrument, $\alpha = 0.855$. Reliable test for each construct is shown in Table 2, column α.

Table 2. Construct correlation, reliability and descriptive statistics (**p < 0.01).

Construct	PE	EE	SI	FC	BI	Mean	St. Dev.	α
PE	–	0.408**	0.423**	0.427**	0.344**	4.37	0.634	0.834
EE		–	0.230**	0.450**	0.388**	4.72	0.449	0.715
SI			–	0.328**	0.187**	3.55	0.789	0.706
FC				–	0.465**	4.42	0.528	0.662
BI					–	4.61	0.641	0.909
Entire construct								0.855

4.1 Hypothesis Testing

Hypothesis testing was done by linear regression analysis technique. To examine the relationship between each person hypothesized factor and its relationship to use the e-learning system, a correlation matrix was created. Both descriptive statistics and correlations are shown in Table 2.

Each construct correlated in the expected direction with the use of the e-learning system and was significantly correlated with other constructs. This has provided initial support for all hypotheses.

4.2 Model Testing

Preliminary analyses have been carried out to determine that there are no significant deviations from expected normality, linearity, multicollinearity. The set of predictors included the following factors: PE, EE, SI and FC who have been explained by a number of variables – questionnaire questions. The model resulted as statistically significant, $F (4, 233) = 21.44$, $p < 0.001$, with $R^2 = 0.269$. Regression analyses are presented in Table 3.

Table 3. Regression coefficients and significance.

Model	Unstandardized coefficients		Standardized coefficients		
	B	Std. error	Beta	t	Sig.
PE → BI	0.116	0.058	0.135	1.987	0.048
EE → BI	0.205	0.070	0.190	2.919	0.004
SI → BI	−0.018	0.052	−0.022	−0.345	0.730
FC → BI	0.278	0.056	0.329	4.939	0.000

Three predictors had a significant coefficient – PE ($\beta = 0.135$, $t = 1.987$, $p = 0.048$), EE ($\beta = 0.190$, $t = 2.919$, $p = 0.004$), FC ($\beta = 0.329$, $t = 4.939$, $p = 0.000$) and one, SI ($\beta = -0.022$, $t = -0.345$, $p = 0.730$) showed no effect on BI. This confirms hypothesis 1, 2 and 4, but undermines hypothesis 3. Construct Facilitating Conditions showed the strongest influence on students' intention to use the system. Table 4 summarizes hypothesis testing.

5 Discussion

The goal of this research was to examine appropriateness of the UTAUT model while testing the factors influencing students on their usage of the e-learning system. A measuring instrument was tested using linear regression method. During the analysis, mutual influence of four independent and one dependent variable from conceptual model was observed. Connections of independent factors PE, EE, SI and FC towards dependent factor BI were analysed.

The results showed fitting of the e-learning environment with the constructs of the original UTAUT model. Analysis of the data obtained within this research strongly supported three out of four hypotheses. The summary of our findings regarding tested hypothesis are shown in Table 4.

Table 4. Summary of hypothesis testing.

Hypothesis	Relationship	Result
H1	PE → BI	Supported
H2	EE → BI	Supported
H3	SI → BI	Not supported
H4	FC → BI	Supported

Factor PE significantly and positively influences construct BI, i.e. students' intention to use the e-learning system. This factor approves the presumption that students who are expecting that the system will benefit them in future learning, are more willing to use it.

EE has positive and significant influence on BI, which we can consider as if students believe that their effort in learning how to use the system will have good result in the end usage, their willingness to use the system increases.

Previous researchers [27] stated that perceived usefulness – as a key indicator of Performance Expectancy, together with perceived ease of use – as a key indicator of Effort Expectancy, significantly influence students' satisfaction in utilization of the system. Thus, we conclude that if they are satisfied with the system performance and its usage, they will be more willing to use the e-learning system.

As Decman stated "UTAUT includes a social component which is very important in learning environment. Even if e-learning is online and unphysical, the importance and the extension of use of social networks and online communication in todays' society shows the significance of a social component" [28]. The SI, as one of the UTAUT construct which differ from other models who are examining the acceptance of IS, resulted with no effect on the students intention to use the e-learning system in our research. We can address the rejection of the proposed hypothesis to a mandatory usage of Moodle e-learning system on Faculty of Technical Sciences, University of Novi Sad. Namely, since guidelines on how to complete seminar work and prepare for an exam are available there, it doesn't matter if people from students' environment influence them regarding the usage of the system. They will have to use it if they want to get the grade they want, anyway.

According to the previous research results [29] learners attitude, self-efficiency and subjective norm are of a greatest importance towards behavioral intention on system usage. Hence, if it is expected from students to have positive attitude on system usage, key stakeholders should pay additional attention to students' needs and benefits of utilization of the e-learning system.

Factor FC, which we examined in direct influence on factor BI, resulted as the most significant factor influencing students' intention to use the system ($\beta = 0.329$) and thus hypothesis H4 has been confirmed. As from the previous research results [30] both instructors influence and technology availability have impact on students satisfaction while using the e-learning system. Therefore, we can conclude that all facilities and technology in the form of computer classrooms, full support from teachers and technicians as well as user-guides are of a great importance on students' intention to use the e-learning system.

6 Conclusion

E-learning systems are progressing and making the learning process more productive and their usage is increasing. Researches among this topic are also increasing. Thus, this paper goal was to examine factors which are influencing usage of an e-learning system by its end users-students.

Outcomes of this paper are showing the factors that, within the use of the e-learning system by students, are of the most noteworthy significance. The model used in this paper was created with five factors from UTAUT model and has been tested with statistical data analysis.

On one hand, Constructs PE, EE and FI confirm their influence on BI; on the other hand, the social influence showed no effect on students' intention to use the e-learning system. The research indicated the biggest influence from facilitating conditions on behavioral intention, which guide us to the conclusion that it is imperative for students to have an e-learning environment well organized, back from teachers and associates in usage of the system and the guides depicting how to use the system. We advise all course administrators (professors and assistants on their courses) to prepare a good context and keep it easy to read. It is better to write simple language and organize context heading, points and headlight to make it clearer and easier to find information, yet they should be focused on improving the system by enriching the courses contents implementing virtual images and videos.

These conclusions opened new inquire about interests for authors, like actualizing game-based learning into e-learning environment with the point of both moving forward the e-learning concept and students' intention to use the system. Since gamification is gaining huge attention in the past couple of years, our future research and development of the learning environment will be based on it.

Likewise, social networks are online communities that "draw together" people of similar interest [31]. Since students mostly communicate using social networks, it might be a challenge to investigate them in a manner as a possible option to involve in the e-learning process with the aim of improving the e-learning environment.

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Professional Style of Employee Behaviour at the Novi Sad Fair

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Abstract. This paper points to the needs of assessing the professional style of employees' behavior in the company Novi Sad Fair with a goal to encourage greater performance in their work. The Novi Sad Fair is engaged in the service management and the main engine of the company is its employee workforce, which makes it very important to determine what type of behavior is dominant, which will signify the extent of their competence. The Professional Style Profile, used in this research, was developed and processed in 1984 when it was first used after extensive research, tested in specific areas and certified after testing 500 managers and experts. It is designed to determine the desired or dominant style of behaviour when distributing jobs. It is designed to determine the desired or dominant style of behaviour when distributing jobs. This research involved 100 employees in this company, whose professional behavior styles were measured using the "Professional Style Profile" questionnaire. The confirmed hypothesis of the study of the uniformity of the presence of a developmental and controlling behavioral style concludes that a space is created for the proper positioning of employees with certain style behavior dimensions in the required workplaces.

Keywords: Management · Professional style · Competence of employees

1 Introduction

The modern concept of human resources management contributes to improving the competitiveness of enterprises through continuous learning and improvement of employees' competences. The development of human capital provides the company with unique capabilities for constant changes in the environment. Since it has been understood that human capital is the main tool of competitive ability and advantages in the global market, people and their needs, motivation and satisfaction are increasingly becoming the focus of management in each organization/enterprise. Human behaviour research is done to fully understand the behaviour of employees in order to be able to predict, shape and control with more success. Employees are helped to adapt their behaviour to the needs and goals of the organization [1].

The concept of human resources management is not a question of imitation practices of economically developed countries. It is expected primarily to have a higher operating effect, increase productivity, and then more quickly adapt the organization to

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the requirements of the environment. Stable and constant growth of the organization, maximal use of employees and creative potentials of the employees is something that every company should aim to achieve. This can be realized through long-term consideration of human resources needs, efficient and effective decision making on human resources, increasing the level of motivation of employees for the work and development of the organization, and increasing the organization's flexibility in relation to the requirements of the environment.

Based on these expectations, it can be concluded that in the existing human resources management radical changes are necessary, and the fate of the organization depends to a large extent on the process [2].

Organizational adaptation, both to the requirements of the environment, and to its needs and capabilities, is done within the management process change. Business results of the organization depend on the way it is done and the dynamics of these changes.

Finally, it can be concluded that the performance management process implies the management of the company's performance and strategic development through employee behaviour management and assigned employee targets. The process contains both quantitative and qualitative performance measures. The basis for creating the basic elements of the system is the mission and vision of the company from which we set the values and strategic goals as key components for defining the behaviour standards (required competencies) and goals, i.e. indicators of key performance that are managed in the direction of realization of organizational vision [3].

2 Literature Review

The way employees behave inside an organization is influenced by many external and internal factors. Personal background and culture organization influence of both, managers and employees in the hospitality industry [4]. Especially in this industry, employees must perform assigned duties and responsibilities effectively, where it is of outmost importance for the company to define behavior of each employee that will result in fulfilling the customers' needs [5].

In the research "Changes in leadership styles in a transitional economy: A Serbian case study", from 2011 where 64 managers from 5 different businesses were included, leadership style was measured by a standardized questionnaires a survey instrument consisting of 24 real situations and their subjective perceptions in the process of leadership. The purpose of this work is to search for the optimum leadership in the system and its surroundings, by using or combining the appropriate leadership skills and styles. The basic premise was that, leadership style can be considered in two independent dimensions; autocratic and/or democratic leadership and commitment to people and/or tasks. The subject of this study was the way managers cope with people in the company taking into account three situational factors; the level of authority, job satisfaction and years spent in managerial positions in specific organizations. Leadership styles were monitored in firms, differentiated by their ownership structure, activities and business functions, where there are different hierarchical structures and where leadership roles are defined differently [6].

Miller et al. [7] states the new form of ROI, not return on investment but return on individuals, a supervisor succeed only to the degree that each person under you produces; you are judged on the performance, the productivity and efficiency of others. It is also worth to note that the attention given to leadership style is based on the assumption that subordinates are more likely to work effectively for managers who adopt a certain style of leadership than they will for managers who adopt alternative styles [8].

According to Luthans [9], leadership style can make a difference, both positively and negatively. For example, a survey found that senior executives view their companies' leadership styles as pragmatic rather than conceptual, and conservative rather than risk taking. These executives felt that to meet their current and future challenges, the styles should be the other way round. Work unit leadership theory suggests that leaders should analyze factors in their work unit and act accordingly. For example, to be effective, you should assess your followers' environments, abilities and behave in ways that complement them. Jamal [10], comments that a part of good leadership is to set a clear direction, find your employees' innate gifts and encourage them to use those gifts. By doing this, you encourage your employees to work to their potential.

Today's employees are demanding more from their work in terms of fulfilment and personal satisfaction. They use words such as 'empowerment' and 'self-development' in expressing demands [11]. As a consequence, the old hierarchies of manual work will be replaced by more open and negotiated networks [12]. According to Cooper and Starbuck [13], there is substantial evidence that fairness is an important dimension affecting employees' actions and reactions within organizations.

The indicators to measure employee outcomes comprised work performance; job satisfaction, organizational commitment and (low) job stress [14]. Employee wellbeing includes broader areas of focus, including psychological health, physical health, and behavioural outcomes. The component of psychological health is distinct from the other approaches in that it includes not only attitudinal outcomes, such as satisfaction, but also personal fulfilment, growth and stress reduction [15].

After careful consideration of relevant literature and previous research, we propose the following hypothesis:

- H1: All investigated types of behaviour among employees are distributed evenly. This hypothesis asserts the balanced relationship between different types of behaviours among the employees in the hospitality industry.

3 Research Methodology – The Distribution of Different Types of Professional Styles of Employee Behaviour

The Professional Style Profile, used in this research, was developed and processed in 1984 when it was first used after extensive research, tested in specific areas and certified after testing 500 managers and experts. Since the very beginning of its use, thousands of managers and executive directors have used it in: Great Britain, Ireland, Western Europe, America and Canada [3].

The Professional Style Profile was created by The Leadership Style Profile, designed for people in managerial positions and whose roles are to direct the activities of other employees. It is designed to determine the desired or dominant style of behaviour when distributing jobs.

The Professional Style Profile is therefore an ideal tool for people in managerial positions as well as at the operational level, from higher to lower positions [3]. With equally good results it can be used as an integral part of the assessment or development center, and for determining the workgroup, and hence their developmental needs. It can also be used to obtain additional feedback and further define managerial tools such as Blake's Grid, Reddin 3-D Scales, Porter's Strengths Deployment Inventory and Hersey Blanchard Situational Leadership Measures.

Rarely, some forms of behaviour can be determined with high precision. What psychometric tests offer is an analysis of the tendencies, tendencies and competencies of the respondents. Based on this, it is possible to determine the range of behaviour of an employee in a work environment that is in accordance with his/her competencies, and beyond the ambient the interviewer would probably be less productive.

The Professional Style Profile is designed to determine the desired shapes of people's behaviour in all six dimensions of the business style of behaviour. It is important to note that these psychometric data is not even limited. They essentially have the function of referring to certain steps in order to improve both the attitude towards employees and the attitude towards work.

The aim of the artwork is to show what type of behaviour is dominant with the employees in order to know how many employees are competent to do their job and how to direct managerial and organizational measures towards practical solutions in order to increase competence and expertise, and hence the business of the organization.

The Professional Style Profile is designed to determine the preferences of business and professional behaviour with 12 dimensions of behaviour. Dimensions of behaviour:

"Developmental behaviour type"

- A – Giving Inspiration/or Self-Confidence
- C – Active relationship with colleagues
- E – Encouraging acceptance of change, challenge, risk and excitement
- G – Ability to independence and personal choice
- I – Flexible, responsible and flexible behavior in every situation
- K – Tendency to team work

"Controlling the type of behaviour"

- B – Guidance and control
- D – Independent, persistent behavior
- F – Careful behavior, in order to provide stability and certainty
- H – Pledge for clearly defined positions and a disciplined approach to business
- J – Behavior that reflects consistency and consistency in quality performance
- L – Preference for individual work and personal freedom, privacy and non-engagement in work

The responses ‘A’, ‘C’, ‘E’, ‘G’, ‘I’, and ‘K’ represent a more open type of behaviour that is flexible in relation to others. In essence, these are developmental behaviours that leave room for:

Conversation and controversy Agreed changes, compromise and changes in contrast.

The answers are ‘B’, ‘D’, ‘F’, ‘H’, ‘J’ and ‘L’ that are primarily authoritative and in which there is a clear difference between good and bad behaviour. Condemnation, criticism and approval/disagreement are often the basis of the aforementioned form of behaviour. They are usually considered ‘closed’ forms of behaviour in psychology versus A, C, … which are considered open forms of behaviour.

This division of behaviour is not “good” and “bad”, nor can it be concluded from the name of “open” and “closed” type of behaviour: they are only contradictions. Constitutions, both types are necessary for cooperation with colleagues. The key question is how, when, where and with whom to apply them to get the best effect and results [3].

The research was done using the The Professional Style Profile questionnaire with 60 questions. The questionnaire was filled out by 100 respondents/employees at the Novi Sad Fair in five consecutive days.

The data was processed and analysed in the SPSS statistical program version 17, using descriptive analysis methods.

4 Results

The result achieved in this research shows that in both types of behaviour (development and controlling) we have positively highlighted significant dimensions of employees’ behaviour at the Novi Sad Fair and a confirmation of the even distribution of business behaviour styles (Table 1).

Table 1. Average values of behavior dimensions.

Dimensions of behavior (type)	Min.	Max.	Mean value
A – incentive/development type Encouraging/reassuring score	4	10	7.58
B – the type that controls Directive/organization score	0	5	2.09
C – responsible type/including Involving/responsive score	1	10	6.36
D – the type who thinks about the results Single-minded/assertiveness score	0	9	3.64
E – the type that prefers risk and challenge Need for change and risk score	0	8	2.95
F – the type that strives for safety and stability Need for certainty and stability score	2	10	7.04
G – the type who likes freedom of work Preference for freedom and experimentation score	1	8	4.28

(*continued*)

Table 1. (*continued*)

Dimensions of behavior (type)	Min.	Max.	Mean value
H – the type that prefers organization, discipline and order Preference for structure, order and discipline score	2	9	5.72
I – the type that prefers versatility and flexibility Flexibility and variability score	0	9	3.29
J – the type that is consistent and does not like the change of Consistency and invariability score	1	10	6.71
K – the type that tends to fit into a group Group affiliation score	2	10	6.68
L – the type that is analytical and relies on itself self reliance score	0	8	3.32

Minimum, maximum and average values are displayed for each observed scale.

4.1 Descriptive Analysis the Professional Style Profile - Business Style of Behaviour

The report of the research points to the exceptional potential for development and the improvement of both types of business styles of behaviour in order to get as efficient and effective employees as possible in the group, as well as individually. The next step would be the correct positioning/selection of employees depending on the style and the working position, in order to show the full effect of the working performance of employees.

The concrete results obtained by this research show that the following behavioural dimensions are positively highlighted in the development type of behaviour:

- A – INCENTIVE/DEVELOPMENT TYPE
- C – INCLUDING/RESPONSIBLE TYPE
- K – THE TYPE THAT STRIVES TO FIT INTO THE GROUP

We will also highlight positive behavioural dimensions in a controlling type of behaviour:

- F – A TYPE THAT STRIVES FOR SAFETY AND STABILITY
- H – TYPE THAT PREFERS ORGANIZATION, DISCIPLINE AND ORDER
- J – A GUY WHO IS CONSISTENT AND DOES NOT LIKE CHANGE

In a developmental type of behaviour, we can also consider the lowest value that relates to the dimension type that prefers risk and challenge, as well as the highest value that relates to incentive/developmental type of behaviour. These results point to the above mentioned adequately framing and analysis of the competences of the employees, so as not to have an opportunity to annihilate the potential effect of the capacity i.e. the potential of a certain capacity of workers (Fig. 1).

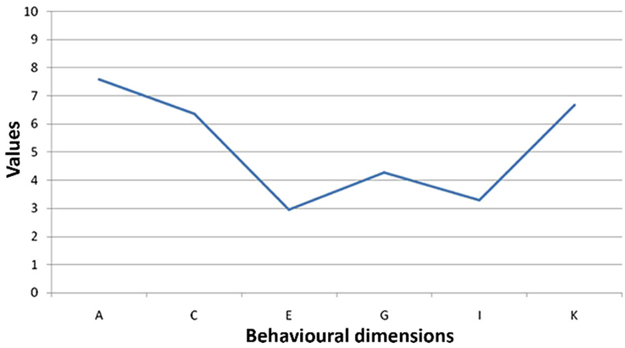

Fig. 1. Controlling the type of behaviour.

When we observe the lowest and highest values in a controlling type of behaviour, a controlling type, and a type that strives for security and stability, we also see the need for these dimensions of behaviour that can stimulate the developmental behaviour type, and thus, in the first place, focus it in the best direction for future functioning companies. 'F', 'H' and 'J as particularly high results indicate that a person will be alert, attentive and conservative (Fig. 2).

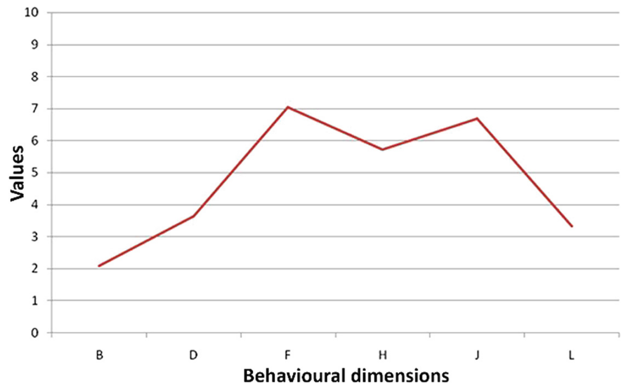

Fig. 2. Controlling the type of behaviour.

The Figs. 1 and 2 also show a uniform phenomenon of both categories of behaviour, which makes it an advantage for a company that has the capacity to clearly direct its needs and possibilities towards the execution of its vision.

5 Conclusion

The conclusion is that both behavioural categories have a "passing score" in relation to the overall score, and there is a potential for improvements in both types of behaviour in order to get as efficient and effective employees as possible in the group and individually.

There is no doubt that there is a need for both categories, and the essential strength lies in the correct setting, i.e. selection of employees to adequate work positions, in order to feel the full effect of the opportunities that employees have.

The results of this research indicate the potential for the application of the formal procedure and more detailed analysis in order to determine the model for the development of employees' competencies.

The results of the research have shown that it is necessary to determine the assessment of the performance of employees at all organizational levels in order to find a method for determining training needs, especially individual training needs, as it is usually the manager who identifies the need for training.

The survey shows that human resource professionals need to work closely with line managers and top managers in order to make joint efforts, each in their own domain, in order to improve and develop competencies of employees, in order to achieve organizational goals and improve competitiveness.

The research indicates that it is necessary to harmonize the process of training and development of competencies of employees with the strategy of the company, which is one of the fundamental preconditions for the success of the company and the return on the investment in the training of employees.

The study focused on the general Professional Style Profile of the employees and further studies should be carried out on how gender relates to both behavioural categories and its influence on employee job performance.

Finally, it should be stated that this research has limited results, since it has observed employees from only one organization. Further research should compile data from different companies in the hospitality industry, and also from different types of this industry.

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Understanding Millennial Perception of Website Characteristics

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Abstract. Improving effectiveness of communication with customers is one of the key elements for strengthening organizational competitiveness. One of the basic channels of communication with customers is digital communication via website. Millennials are considered as the second largest generational group after the baby boomers. Due to their size and consumerism mentality this generation is attractive target for many industries, especially for creative industry and digital products. The purpose of this paper is analysis of Millennial perception of various website characteristics: General perception of website, Perception of aesthetic appeal, Perception of navigation convenience, and Perception of content. Research was conducted on a sample of 234 respondents from Southern California. Statistically significant differences in respondents' perception of website characteristics according to age, gender, and education level were determined. Research findings contribute to the digital marketing and customer behavior literature, as do findings related to differences between various Millennial sub groups. Better understanding of the Millennial perception of website characteristics should benefit businesses globally.

Keywords: Millennials · Website perception · Digital marketing

1 Introduction

Millennials are defined as a generation whose birth years range from 1980 to 2000 [1]. This generation is also known as Generation Y, Generation Next, the Net generation, the Digital natives, the dot.com generation, or Echo Boomers [2]. Millennial generation is larger than Baby boomer generation [3], with high level of spending power, that has been estimated to reach 50% of global consumption in 2017 [4, 5]. Some researchers suggest that members of millennial generation have different values, characteristics, and behavior compared to previous generations [1, 6]. Considering their spending power it is obvious why it is important to study this generation [7]. Members of millennial generation are considered to have shorter attention span and need for instant gratification, and they tend to act immediately on their ideas and execute them promptly [8].

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Millennials have become more detached from most of institutions such as political parties, religion, marriage and military. They are on track to becoming the most educated generation in the history of USA, especially women. The rate at which they are earning undergraduate degrees has surpassed all previous generations. Besides being academically well educated, members of Millennial generation lead in adoption and expertise in the use of technology which distinguishes them significantly from the generations that preceded them [5]. They are often associated with technology, and considered the first digital natives, having grown up with the Internet, cell phones, and social media. Members of this generation use technology to enhance their communication with their families, friends and business associates.

Millennials are moving away from the traditional media and opting for contemporary interactive digital media. In general, they approach new media channels looking for functional and entertainment value [5].

Millennial generation, given its size, purchasing power, and online presence, is an essential element in the development of e-commerce. Its role will continue to grow along with the rise in its discretionary income. Even though Millennials tend to spend more, they have less loyalty to the brands than previous generations. They look for products and brands that match their personality, lifestyle, and social values. Brands are important to Millennials only if they communicate their values [5]. Research suggests that Millennials do not like pop-up ads, but it seems that graphics are very effective in capturing their attention [7].

Technology is much more integrated into daily lives of this generation whose members use their mobile devices and traditional internet means to connect to retailers or brands [9]. Some minor online retailers have reaped huge benefits from this important segment of consumers because of their purchasing power and technological capability.

In order to attract this market segment, immune to traditional advertising, brands and companies must develop strategies designed for such audience. Most of Millennials consider smartphone as an essential tool in everyday life. That is forcing most industries into a fully digital direction, with mobile-friendly content.

2 Objectives

Humanity is facing perhaps the biggest challenge in its existence. Information technology, telecommunications and production have been integrated, and the means of production are becoming more complex. The proposed strategy in "INDUSTRY 4.0" occupies the space where the physical world overlaps with the virtual one. Companies, factories and production processes are rapidly changing. Scientists from all over the world, from all scientific areas, are called upon to respond to many challenges of "INDUSTRY 4.0". One subject of research in the scientific publications is an analysis of the changes that have occurred in the segment of Millennials, young users of services and products offered by knowledge organizations operating within "INDUSTRY 4.0". The literature also examines views and beliefs of the Millennials and what implications that has on contemporary economy. There are many papers examining this topic [10–12].

The research in this paper reflects one segment of the above-mentioned open question, it refers to Millennials as participants in "INDUSTRY 4.0", and examines issues pertaining to their perception of various website characteristics. In this paper we analyze perception of website of Millennials from a developed economy (knowledge based economy). In the paper [13], views of Millennials from a country in transition from the industrial economy to the knowledge economy were studied in regards to perception of different characteristics of website. The results of the research in these two papers can serve as comparative analysis of attitudes towards website of Millennials from transition and knowledge economies.

There are many papers that examine attitudes towards the website [14, 15].

In the following section, we define constructs in relation to which the views of internet users belonging to Millennial generation are analyzed, and we give review of the literature from which the constructs have been adopted.

2.1 Attitude Toward the Website – General Perception

The scale used to measure attitude toward website is composed of three, seven-point Likert-type statements used to measure person's overall evaluation of a website: I1 - I liked the website I saw; I2 - I think it is a good website; I3 - I think it is a nice web-site.

This scale originally appeared in the study by Stevenson, Bruner, and Kumar [16]. However, they indicated that the items were adapted from a measure of attitude toward the website by Chattopadhyay and Basu [17]. No examination of the scale's validity was reported in these studies. However, another study was conducted with that as one of its purposes [14]. Using a procedure called similarity analysis, the evidence indicated that the scale showed greater evidence of validity than two other competing measures of the same construct.

2.2 Attitude Toward the Website – Aesthetic Appeal

Four, seven-point Likert-type items measure how much a person likes a website because of the way it looks. Kwon and Lennon [18] stated that the scale was an adaptation of a scale they had used previously. The scale is composed of four, seven-point Likert-type statements which measure person's evaluation of aesthetic appeal of a website: I4 - I like the feel of this website; I5 - I like pictures/images used in this website; I6 - I like the opening page of this website; I7 - This website makes the games look very appealing.

Kwon and Lennon [18] used the scale in two main experiments, Experiment 1 with 630 respondents, and Experiment 2 with 650 respondents, each composed of college females.

2.3 Attitude Toward the Website – Navigation Convenience

The ease with which a person reports being able to get around a website and find what is being looked for is measured using four, seven-point Likert-type items. Kwon and Lennon [18] stated that the scale was an adaptation of a scale they had used previously. The scale is composed of four, seven-point Likert-type statements used to measure person's evaluation of ease of navigation of a website: I8 - It looks easy to find what you are looking for in this website: I9 - It is easy to locate tabs and links in this website; I10 - It is easy to navigate around this website; I11 - This website is well organized.

2.4 Attitude Toward the Website – Content

This scale uses four, seven-point Likert-type items to measure how informative and useful the site is, especially with respect to merchandising the products. Kwon and Lennon [18] stated that the scale was an adaptation of a scale they had used previously. The scale is composed of four, seven-point Likert-type statements used to measure a person's evaluation of informativeness and usefulness of a website: I12 - This website is informative; I13 - This website reflects the brand's merchandise well; I14 - This website seems to use advanced technologies; I15 - There seem to be a lot of merchandise options you can choose from.

In accordance with the research objectives, research hypotheses have been defined as:

- H1: There are differences between Millennial respondents of different gender regarding their perception of the website characteristics.
- H2: There are differences between Millennial respondents of different age regarding their perception of the website characteristics.
- H3: There are differences between Millennial respondents of different level of education regarding their perception of the website characteristics.

3 Research Methods and Instruments

Within this paper, views of Millennials from Southern California were studied in regards to perception of different characteristics of website: General Perception of website, perception of Aesthetic Appeal, perception of Navigation Convenience, and perception of Content. Research hypotheses were tested by analyzing data collected from a sample of 234 Millennial respondents from Southern California. We analyzed statistically significant differences in respondents' perception of website characteristics according to age, gender, and education level. Better understanding of the Millennials' perception of characteristics of website should benefit businesses not only in Southern California, but also globally.

A structured questionnaire has been developed in order to collect data on the views of internet users. All constructs and related items used in the questionnaire were adopted from published studies and linguistically adapted. The questionnaire was structured in the following way: in the first part of the questionnaire, general demographic data (gender, age and level of education) were requested, and in the second part of the questionnaire were questions that included attitudes regarding the perception of the characteristics of the website. The second part of the questionnaire contained 15 items that measured 4 constructs in relation to the perception of a website: Attitude toward the Website - General (3 items), Attitude toward the Website - Aesthetic Appeal (4 items), Attitude toward the Website - Navigation Convenience (4 items), Attitude toward the Website - Content (4 items). All questions indicating attitudes of the respondents were evaluated on the seven point Likert scale, ranging from 1 - strongly disagree to 7 - strongly agree. This reduced the possibility of forced choice of respondent, enabling a more accurate determination of attitude of the respondents toward the individual claims. All the above items were positively formulated.

The questionnaire was distributed online, and a call for participation in the research was sent through the Mail Chimp mass mailing platform to the database of 1000 randomly selected former and current students of the College of Business Administration, California State University, San Marcos. To evaluate respondents' different perceptions towards web pages we used the following website: http://eipix.com/. The respondents were asked to simply browse the site and then express their attitude towards the website characteristics defined in the questionnaire. During the autumn of 2016 and during the spring of 2017, a total of 234 valid responses to the questionnaire were collected. Out of the total number of respondents, 184 (78.6%) of them were under the age of 26, 29 of them (12.4%) were between 26 and 30 years old, and 16 of them (6.9%) were between 31 and 40 years old, and 5 of them (2.1%) were older than 40.

When it comes to respondents' gender, 113 (48.3%) of respondents were male and 121 (51.7%) of respondents were female.

In relation to the highest level of education, 44 (18.8%) completed secondary education (high school), 156 (66.7%) had Associate degree, and 34 (14.5%) obtained Bachelor, Master or PhD degree.

Statistical analysis was done with inferential (t-test for independent groups) and descriptive statistics.

All the theoretical concepts used in this study were taken from previous studies published in scientific literature and they provided the theoretical framework for this research.

Due to the fact that the items for measuring perception of the characteristics of the website were not taken from just one source, we first performed the analysis of the main components for the confirmation of the theoretical constructs. The KMO (Kai-ser-Mayer-Olkin) test and the Bartlett test were used to analyze the justification of the application of factor analysis. The measure of sample representativeness evaluated by means of the KMO measure of sample adequacy is 0,932, and according to the Kaiser's interpretation it is categorized as high. Bartlett's test for sphericity has reached statistical significance ($\chi 2 = 3685.483$; $p = 0.000 < 0{,}05$), and in this way the conditions that justify the application of factor analysis were fulfilled. To assess the underlying structure for the 15 items of the Perception of Website Characteristics questionnaire, Principal Components Factor Analysis with Varimax rotation and Kaiser Normalization was performed. The analysis confirmed existence of 4 factors as presented in Table 1. The total variance explained by the factor analysis was 84.841%. Since all items have the significant factor loadings (Table 1), the construct validity of individual subscales is considered appropriate. Items are grouped into factors (constructs) that constitute the characteristics of a website, in the same way as described in the literature.

Table 1. Principal components analysis results.

Constructs/items	F 1	F 2	F 3	F 4	% of exp. variance	Cronbach's alpha
Factor 4 - General Perception					5.068%	0.942
I1 - I like the website I saw				,788		
I2 - I think it is a good website				,771		
I3 - I think it is a nice website				,767		
Factor 2 - Aesthetic Appeal					9.907%	0.936
I4 - I like the feel of this website		,840				
I5 - I like pictures/images used in this website		,830				
I6 - I like the opening page of this website		,794				
I7 - This website makes the games look very appealing		,772				
Factor 1 - Navigation Convenience					62.590%	0.957
I8 - It looks easy to find what you are looking for in this website	,861					
I9 - It is easy to locate tabs and links in this website	,859					
I10 - It is easy to navigate around this website	,837					
I11 - This website is well organized	,799					
Factor 3 - Content					7.277%	0.882
I12 - This website is informative			,850			
I13 - This website reflects the brand's merchandise well			,759			
I14 - This website seems to use advanced technologies			,679			
I15 - There seem to be a lot of merchandise options you can choose from			,674			

Extraction method: principal component analysis; rotation method: varimax; rotation converged in 6 iterations.

Factor 1: Navigation convenience. The amount of explained variance of the most influential factor is 62.590%. The item with the highest factor loadings is: I8 - It looks easy to find what you are looking for in this website.

Reliability of the scale evaluated by means of the Cronbach's alpha in this research is 0.957 (Table 1). Cronbach's alphas of 0.964, and 0.989 were reported for the sub-scale *Navigation Convenience* in the study by Kwon and Lennon [18].

Factor 2: Aesthetic Appeal. The amount of explained variance of the second influential factor is 9.907%. The item with the highest factor loadings is: I4 - I like the feel of this website.

The reliability of the scale evaluated by means of the Cronbach's alpha in this research is 0.936 (Table 1). Cronbach's alphas of 0.880 and 0.912 were reported for the subscale *Aesthetic Appeal* in the study by Kwon and Lennon [18], with two main experiments, Experiment 1 with 630 respondents, and Experiment 2 with 650 respondents, respectively.

Factor 3: Content. The amount of explained variance is 7.277%. The item with the highest factor loadings is: I12 - This website is informative.

Reliability of the scale evaluated by means of the Cronbach's alpha in this research is 0.882 (Table 1). Cronbach's alphas of 0.904, and 0.947 were reported for the subscale *Content* in the study by Kwon and Lennon [18] with two main experiments, Experiment 1 with 630 respondents, and Experiment 2 with 650 respondents, respectively.

Factor 4: General Perception. The amount of explained variance is 5.068%. The item with the highest factor loadings is: I1 - I like the website I saw.

Reliability of the scale evaluated by means of the Cronbach's alpha in this research is 0.942 (Table 1). Cronbach's alphas of 0.97, 0.93, and 0.95 were reported for the subscale *General Perception* in studies by Bruner and Kumar [19], Stevenson, Bruner, and Kumar [16], and Johnson, Bruner, and Kumar [15], respectively.

4 Results and Discussion

In order to test the proposed hypothesis H1 that there are differences between Millennials of different gender regarding their perception of the website characteristics, the next part of this study represents the analysis of given scores with Levene's test for testing equality of variances, and t-test.

By using t-test for independent samples we did not find significant gender differences in the average scores calculated for any dimension of their perception of the website (Table 2), and hypothesis H1 was not supported. On all dimensions of attitudes toward the website male respondents achieved higher average score than female respondents, but those differences were not statistically significant.

Table 2. Independent samples t-tests for gender comparisons for Generation Y's respondents.

	Levene's test		t-test for equality of means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. er. difference
General perception	,276	,600	,870	232	,385	,11387286	,13088887
Aesthetic appeal	,202	,654	,682	232	,496	,08937825	,13097082
Navigation convenience	1,321	,252	,335	232	,738	,04393984	,13107046
Content	,433	,511	,496	232	,620	,06500528	,13103272

To test the proposed hypothesis H2 that there are differences between Generation Y's respondents of different age (younger than 26 years vs. 26 and older) regarding their perception of the website characteristics, given scores were analyzed with Levene's test for testing equality of variances, and t-test, which confirmed those differences (Table 3). By using t-test for independent samples we found significant age related differences in the average scores calculated for all dimensions of perception of the website (Table 3), and hypothesis H2 was supported. On all dimensions of attitude toward the website older Millennials had significantly higher average scores.

Table 3. Independent samples t-tests for age comparisons for Generation Y's respondents.

	levene's test		t-test for equality of means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. er. difference
General perception	1,325	,251	−2,972	230	,003	−,46517	,15654
Aesthetic appeal	1,945	,164	−2,215	230	,028	−,34986	,15795
Navigation convenience	,161	,688	−1,946	230	,050	−,30558	,15707
Content	,680	,411	−2,030	230	,044	−,31952	,15742

In order to test the proposed hypothesis H3 that there are differences between Generation Y's respondents of different levels of education regarding their perception of the website characteristics, given scores were analyzed with Levene's test for testing equality of variances, as well as with the t-test, which confirmed these differences (Table 4). By using t-test for independent samples we found significant differences between Millennials with high school degree and Millennials with college (associate) degree in the average scores calculated for two dimensions of their perception of the website (Table 4), and hypothesis H3 was supported.

Table 4. Independent samples t-tests for education level comparisons for Generation Y's respondents with high school degree and those with college (associate) degree.

	Levene's test		t-test for equality of means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. er. difference
General perception	,055	,815	−2,503	198	,013	−,39532	,15791
Aesthetic appeal	,082	,775	−2,710	198	,007	−,42604	,15719
Navigation convenience	1,130	,289	,336	198	,737	,05425	,16149
Content	,676	,412	−,308	198	,758	−,04954	,16066

The statistically significant differences in the average scores between respondents with high school degree and those with college degree were determined for the following dimensions of the perceptions of the website: General perception of the website ($t = -2{,}503$, $df = 198$, $p < .05$), Aesthetic appeal ($t = -2{,}710$, $df = 198$, $p < .01$ (Table 4). These results support the hypothesis H3.

We further tested hypothesis H3 that there were differences between Generation Y's respondents of different levels of education regarding their perception of the website characteristics, by analyzing given scores with Levene's test for testing equality of variances, as well as with the t- test, on Millennials with college (associate) degree and Millennials with bachelor, master or PhD degrees (Table 5). By using t-test for independent samples we found statistically significant differences between these two groups in the average scores calculated for two dimensions of their perception of the website (Table 5), and hypothesis H3 was supported.

Table 5. Independent samples t-tests for education level comparisons for Generation Y's respondents with college (associate) degree and those with bachelor's, master's or PhD degree.

	Levene's test		t-test for equality of means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. er. difference
General perception	6,273	,013	1,846	40,721	,072	,43009	,23297
Aesthetic appeal	5,666	,018	2,698	40,996	,010	,60851	,22558
Navigation convenience	2,659	,105	2,396	188	,018	,46021	,19207
Content	5,231	,023	1,254	40,962	,217	,29386	,23425

There are statistically significant differences between respondents with college degree and those with bachelor's, master's or PhD degree in the average scores calculated for the following dimensions of their perception of the website: Aesthetic appeal ($t = 2{,}698$, $df = 40{,}996$, $p < .05$), Navigation convenience ($t = 2{,}396$, $df = 188$, $p < .05$) (Table 5). These results support the hypothesis H3.

5 Conclusion

Every paradigm shift brings with it a crisis in which standard approaches do not produce good results and the question of the correctness of the currently accepted concepts arises. Thus, the transition from the old concept (industrial economy) to the new concept (knowledge economy), and the announcement of "INDUSTRY 4.0" bring new trends, and they bring threats and opportunities with them.

Developing economies could use this singularity as a chance. By having better understanding of the new dimensions of economic reality, of the behavior of users belonging to generation Y, and digital strategies, they could make faster progress and gain competitive advantage.

User opinions were analyzed in this paper in relation to the four constructs: General perception, Aesthetic appeal, Navigation convenience, and Content. It has been established that there are not statistically significant differences between Generation Y respondents in terms of gender. A statistically significant differences in the attitudes of respondents belonging to the Generation Y in terms of age, and level of education were determined. In further research, it would be useful to analyze more precisely the identified differences for better understanding of this segment.

A better understanding of attitudes relating to the perception of the characteristics of the website of Millennial users from Southern California could benefit business public globally, having in mind the characteristics of “INDUSTRY 4.0”.

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Relations Between Key Elements of Quality Management: A Dematel Method Approach

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Abstract. This study investigates the nature of relationships between key factors of quality management. The study is based on a questionnaire. The research sample was consisted of respondents, from different management levels, within the public organisation, "Parking service", from, Novi Sad, Serbia. The questionnaire was constructed based on theoretical assumptions and results of previous studies in the field, where key elements of quality management were considered, concerning their mutual relations. These key elements were brought together by the DEMATEL method, in order to identify intensity and interdependency between relevant connections [1]. Taking into account the study results, we argue that the basis for the successful establishment and implementation of an efficient and effective quality management system is strongly influenced by the competence of employees and their knowledge. Also, continuous involvement of employees enables continuous advancement and knowledge sharing and continuous acquisition of new skills, which, eventually, leads to the achievement of quality management goals.

Keywords: Dematel · Quality management · TQM · Influence · Employee involvement

1 Introduction

Total quality management (TQM) has become an unstoppable, globally intermittent strategic force in today's industrial economy. Moreover, since TQM requires companies to coordinate a wide range of behaviors, tangible, intangible resources, its dissemination also stands as a support and as a challenge for a new emphasis on specific resources in the research of strategic management [2]. The subject of this research is precisely observation of the quality management system in organizations by looking at the knowledge of employees with its basic elements and their mutual influences. The role of employees in quality management is to be empowered to make decisions, build relationships and take the necessary steps in order to improve quality within the system designed by the management. Additional training and education opportunities provide the necessary skills for this role.

Quality is a key parameter that distinguishes the organisation from the competition. Quality management also ensures an increase in revenue and higher productivity of the organisation, as well as close coordination between employees in the organisation [3].

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Decision-making trial and evaluation laboratory (DEMATEL) is considered as an effective method for the identification of cause-effect chain components of a complex system. It deals with evaluating interdependent relationships among factors and finding the critical ones through a visual structural model. Using the DEMATEL method, connecting the key elements of quality management, brings us one step closer to discovering the one key element with the greatest impact on all the other key elements and the progress of the whole organisation. The DEMATEL questionnaire was filled out by fourteen experts from the public organisation "Parking service" from Novi Sad.

2 Quality Management and Quality of Work

There is no argue in the fact that quality programs such as ISO 9001 improve management practices and production processes and that these improvements lead to increased sales and employment (unless productivity gains outperform sales growth) [4]. Later use is enhanced if users interpret the adoption of ISO 9001 or other quality programs as a signal for high-quality products or services, meaning that additional skills and training of employees are needed, as development and implementation of procedures, all in order to achieve improvement. The theory of human capital suggests that the earnings of employees also need to grow. Finally, ISO 9001 can also improve employee safety through the identification and elimination of potentially dangerous activities, the development of a formal process of corrective action, and the institutionalization of routine audit and management reviews. Some critics suggest that such formalization and documentation of work practices can negatively affect employees, in the form of reduced skills requirements or an increase in cumulative traumatic disorders [5]. Several major studies have examined the relationship between quality management practices and employee injuries. Lean manufacturing practices such as faster working pace and shortened cycle times are positively related to worker stress and quality circles and job rotation [6].

Quality is analysed from an integral and cross-functional perspective. Progressive implementation in companies of ideas and techniques for the concept of quality management is perhaps the best indicator of change and innovation in organizations in recent years. The importance of quality management is clearly expressed by experts, both on a practical and theoretical level. In general, there is an increasing interest in this topic, which reflects the importance of quality management in managing the company and its results [7].

A very large part of managing organisational change is managing individual change readiness. It is people who make up organisations and it is they who are the real source of change [8]. The phenomenon of readiness is defined as the ability to recognize changes, and then, after computing advantages and disadvantages, willingness to plan changes. Needless to say, the head of the organisation being an active supporter is necessary for major change [9]. In order to follow innovative strategies, individual readiness to change can lead to organizational changes, and a practical outcome can be achieved, as it is shown in Fig. 1. Haffar et al. [10] believed that individual readiness for change was strongly linked to TQM and to serve each other as an add-on in terms of improvement.

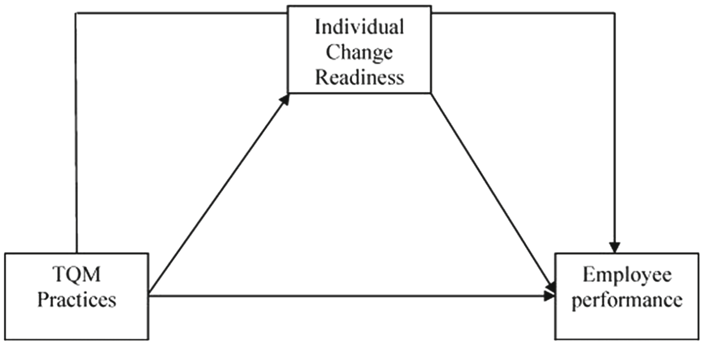

Fig. 1. TQM practice [2].

3 Methods and Objectives

For this research work, psychometric methods, and methods for determining the intensity of the interdependent effects of the identified variables were used (matrix questionnaire). The research was conducted based on two types of questionnaires and answers, i.e. subjective attitudes of the respondents. The research sample consisted of respondents who were employed at workplaces of different levels in JKP “Parking service” Novi Sad. The questionnaires were constructed based on theoretical assumptions and results of previous research in the field of quality, where key elements of quality were considered. These elements were statistically and by the method of determining the intensity of the interdependent effects of the identified variables brought into the link and analyzed the statistical significance and intensity of these connections.

The subject research includes the following phases:

1. Development of instruments (questionnaires) for research based on theoretical backgrounds of the results of previous research in the field - identification of variables and formation of the questionnaire under analyzed substrates and formed research model;
2. Preparation of the questionnaire - assessment of the reliability and validity of the contents of the questionnaire and methodological validity from the aspect of the stakeholders - organizations and experts in the content validity on the smaller sample of the respondents;
3. Sampling - defining a representative sample of stratification;
4. Data collection - calling respondents from the sample into research (telephone, written, electronic, personal);
5. Data analysis - input of collected data; data processing; the method of determining the intensity of the interdependent effects of the identified variables (DEMATEL);
6. Discussion of the results obtained and
7. Conclusion.

The need for research and analysis of the quality elements results from the awareness of the high importance of employee involvement and their familiarity with the quality management system for improving the quality of enterprises. The subject of this research is the observation of quality management in the organisation through the consideration of the employees' knowledge of its essential elements and their interactions with each other.

3.1 Dematel

Decision Making and Trial Evaluation Laboratory (DEMATEL) was developed by the Battelle Memorial Institute in Geneva between 1972 and 1976 developed in the belief that the appropriate use of scientific research methods could improve understanding of the specific problem, was used to research and solve complex and intertwined problem groups [11, 12]. DEMATEL has been developed in the hope that the pioneering use of scientific methods could improve understanding of specific issues, a set of intertwined problems and contribute to the identification of functional solutions through a hierarchical structure. The DEMATEL method builds upon graph theory, enabling us to plan and solve problems visually so that we can divide the relevant factors into groups of causes and consequences in order to better understand causal relationships [13]. The methodology can confirm interdependence among variables and help develop a directed chart to reflect interactions between variables.

The most important feature of the DEMATEL method used in the field of multi-criteria decision making (MCDM), that is the construction of mutual relationships between the criteria [11]. After establishing the relationship between the criteria, the results derived from the DEMATEL method can be used for non-expressive integrals for measuring the superadditive efficiency value or for the multi-criteria decision-making method (ANP) for measuring the dependence and relationship of feedback between specific criteria. The steps of this method are shown in Fig. 2.

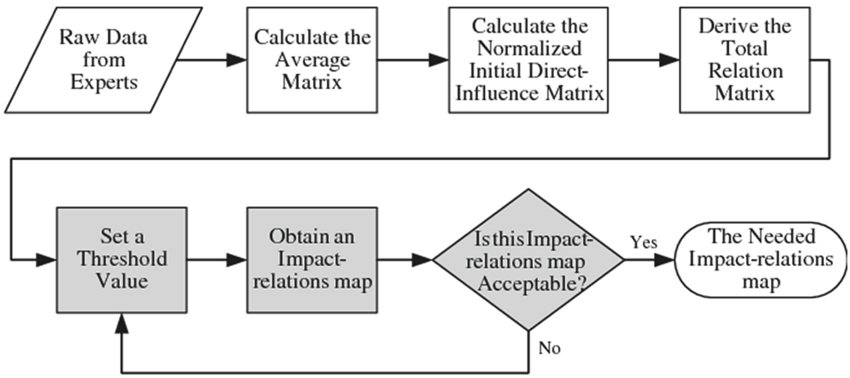

Fig. 2. The steps of the DEMATEL method [13].

Based on the theoretical aspects of the application of the DEMATEL method, the intensity of the interdependent effects of the following factors in Table 1 was determined.

Table 1. Key factors of quality management [14].

Key factors	Description
Leadership (L)	Providing a favorable climate for implementation and development of quality management
Quality planning (PK)	Planning the development and improvement of quality management
Employee management (MZ)	Establishing a system for monitoring, measuring, evaluating and rewarding employees
Procurement management (MN)	Possession of clearly defined procurement specifications
User orientation (OK)	Analysing the thinking and expectations of the user
Process management (MP)	Regular implementation of preventive, corrective measures and internal checks
Continuous improvements (KU)	Identifying areas suitable for improving quality management
Learning (U)	Regular implementation of necessary training, the success of knowledge exchange and experiences between employees
Customer satisfaction (ZK)	Meeting the requirements, expectations, and needs of the users regarding products/services
Innovation (I)	Development of new products/services and processes
Customers/users/consumers (KKP)	Collecting and processing user requests
Suppliers/procurement (DN)	Developing partnerships with suppliers
Market (T)	Data processing to identify market trends, supporting the achievement of market advantages
Products/services (PU)	Ensuring the integrity of information about products/services
Organisation efficiency (EO)	Effectiveness of sector coordination, meetings management, and decision-making processes, strategic planning, and communication between sectors

The matrix formed questionnaire was given to the experts, with these key factors horizontally and vertically aligned. Answers (0 to 4) are given horizontally, filling in row by row. In this way, we gained insight into their thinking about the intensity of different factors affecting each other.

According to the summed up opinions of fourteen experts who filled out the questionnaires, certain factors with the lowest mean values have been removed (Fig. 3a and b):

– Suppliers/Procurement (D/N)
– Market (T)
– Products/Services (PU)

	L	PK	MZ	MN	OK	MP	KO
L	0	0.6223278	0.55332999	0.55274759	0.54513675	0.55978085	0.56705301
PK	0.50407916	0.51085227	0	0.51318082	0.50873419	0.50610115	0.52766972
MZ	0.55613627	0.6019461	0	0.53055459	0.5239729	0.55375313	0.56285183
MN	0	0	0	0	0	0	0
OK	0.5363007	0.60143937	0.52280981	0.53070392	0	0.51855293	0.53818034
MP	0.56187626	0.63166077	0.56123955	0.55210742	0.5514748	0	0.58179011
KO	0.58300533	0.64323372	0.57135197	0.56242298	0.56379705	0.57576453	0.51851924
U	0.60948172	0.67614339	0.59959735	0.58381966	0.58971439	0.59565717	0.61683103
ZK	0	0.55654072	0	0	0	0	0
I	0.51908018	0.5730838	0	0	0.50432444	0.50867387	0.52360026
KKP	0	0.52976072	0	0	0	0	0
D/N	0	0	0	0	0	0	0
T	0	0.51552599	0	0	0	0	0
P/U	0	0.5046785	0	0	0	0	0
EO	0.56691233	0.61549359	0.54531369	0.53134595	0.52663498	0.5473808	0.56512435

(a)

	U	ZK	I	KKP	D/N	T	P/U	EO
L	0	0.56734858	0.58337708	0.54359786	0.54737052	0	0.57672163	0.58337496
PK	0	0.54395059	0.53959931	0.52584184	0	0	0.54132587	0.53627534
MZ	0	0.56052577	0.56813109	0.54142472	0.51857621	0	0.56764545	0.59391416
MN	0	0	0	0	0	0	0	0
OK	0	0.56417774	0.56404128	0.54959319	0.52298594	0	0.57459525	0.55172121
MP	0.51052682	0.58272314	0.59228137	0.56312099	0.55067084	0	0.59409462	0.59388534
KO	0.51965611	0.59327559	0.60525615	0.57543448	0.56293302	0	0.60261795	0.60237637
U	0	0.60956974	0.62822977	0.59759102	0.5687602	0.50780907	0.62339365	0.62765529
ZK	0	0	0.51935687	0	0	0	0.52103946	0.51200313
I	0	0.52609835	0	0.50790718	0	0	0.52985847	0.51905673
KKP	0	0	0	0	0	0	0	0
D/N	0	0	0	0	0	0	0	0
T	0	0	0	0	0	0	0	0
P/U	0	0	0	0	0	0	0	0
EO	0	0.55687942	0.57081927	0.54411298	0.52766918	0	0.58308169	0.50533999

(b)

Fig. 3. (a) Average values of expert ratings (matrix A – first part). (b) Average values of expert ratings (matrix A - second part).

This was also reflected in the application of the DEMATEL method, on the data collected by this research instrument. The data, which is related to the specified factors, has been removed and is not taken into account during processing.

Based on the completed questionnaires, the matrices were formed. Each employee evaluated the influence of the identified factors (variables) on other factors in the above constructs, which is represented by grades 0–4, where the ratings have the following meanings:

- 0 – no influence,
- 1 – extremely weak influence,
- 2 – weak influence,
- 3 – strong influence,
- 4 – extremely strong influence.

After the matrix estimates were formed, the calculation of the matrices of the average values of the estimates was performed. A filtered matrix of the total effects of the observed factors was formed, which presents the interdependent effects of the factors.

The following Diagram of interdependent factors influence, based on the Importance and contribution of factors (Fig. 4a and b), enables a graphical representation of data in order to easily identify and understand the relationship of factors in the observed system.

Importance	6	2	7	12	9	4
+	17.702823	17.9406609	17.6439024	15.4097423	17.2410095	17.865613
	L	PK	MZ	MN	OK	MP
-	0.60399831	-1.18844049	0.74015277	-1.74437988	0.15232439	0.7412964
Contribution	cause	reciever	cause	reciever	cause	cause

(a)

Importance	1	5	10	8	11	3
+	18.1710867	17.7575634	16.7734169	17.2684444	16.2875173	17.9001617
	KU	U	ZK	I	KKP	EO
-	0.85863592	2.30897692	-0.93960302	-0.63011816	-0.81510554	-0.08773761
Contribution	cause	cause	receiver	receiver	receiver	receiver

(b)

Fig. 4. (a) Importance and contribution of factors – first part. (b) Importance and contribution of factors – second part.

4 Results

In the analysis of the DEMATEL results, one factor is significantly different from the others – Learning (U) (Fig. 5). This factor has an impact on all other factors, while no other factor has any influence on it. What this factor entails is the existence of basic knowledge about product development/service development processes, the existence of an adequate "climate" necessary for the development of skills, the continuous implementation of necessary training, continuous leadership participation in specialist training and the success of the exchange of knowledge and experience between employees. Possession of appropriate knowledge and skills is necessary for the inclusion of employees, and above all the need in daily work, and the organisation is obliged to provide precisely these skills and knowledge through training and knowledge exchange among employees. It is also important to emphasize that active involvement of managers in such training improves the knowledge exchange within the organisation and reduces the gap, if any, between employees and their superiors.

If necessary, employees are trained to use specialized methods and techniques (tools) of quality. In addition to Learning, the most significant and most influential are also shown to be:

– Management of employees,
– Process management and
– Continuous improvement.

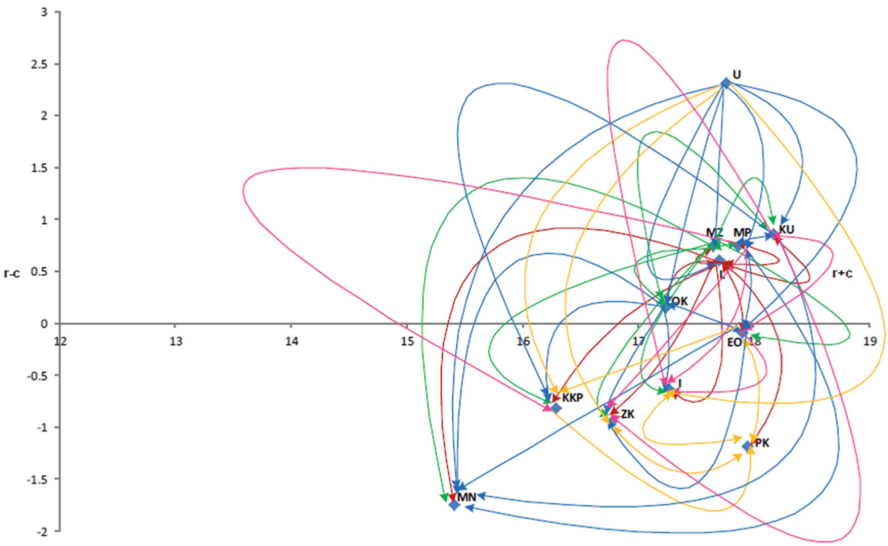

Fig. 5. Diagram of interdependent factors influence.

5 Conclusion

If employees are committed to quality, this should facilitate its improvement. Therefore, they should be trained for it. Through training, employees should learn how to use knowledge and skills, identify and solve problems, and improve working methods. Hence, it brings contribution to the development of new knowledge. Taking into account the overall picture of the results obtained by the DEMATEL method, the authors conclude that the basis of the successful establishment and implementation of efficient and effective quality management is the competence of the employees. Besides, knowledge acquired through the necessary training in order to manage the processes with a minimal disagreement or entirely without any discrepancy will also contribute to the goal as mentioned above. Employees should, by all means, be encouraged to actively seek opportunities to enhance their competence, knowledge, and experience [15].

Managing employees and involving them in the processes and their activities enables continuous advancement and knowledge sharing, and continuous acquisition of new skills, moving toward achieving the goal and achieving the mission and vision of the organisation. Process management activities focus on mapping processes and incremental improvements, whereas continuous improvement supports a planned systematic approach of improvements. Newer versions of ISO 9001 standard place more importance on customer focus, process approach, and the continuous improvement principles [15].

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Contribution to the Development of an Instrument for Exploring Combined Impact of Quality Management and Knowledge Management on Innovation Performances

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Abstract. In a rapidly changing business environment, innovation becomes one of the most relevant factor for the development of a company, as well as the key element for market competitiveness. Organisations strive to improve their innovation performances, by improving the quality of their processes, and with knowledge management. Some studies claim that knowledge management and quality management produce positive impact on organisational innovation, others point to the, shortcomings of quality management. Such contradictions still draws attention of academic community. The purpose of this study is to evidence on the nature of relationship between quality management, knowledge management and innovation performance. The aim of this paper is to present methodology and basic concepts of making an instrument (questionnaire) for examining observed impacts.

Keywords: Quality management · Knowledge management · Innovation · Innovation performance

1 Introduction

Responding to changing environments is proved to be simple for firms with greater innovativeness. That also goes for developing new capabilities that allow them to achieve better performance [1]. This research, from a quality management perspective, provides a reassessment of the need for implementing quality management in organisations. Knowledge management is an essential strategy which can improve organisation competitiveness and innovation performance. The implementation of knowledge gives the organisation the advantages of being adaptive, innovative, intelligent, and sustainable. The positive impact of knowledge management and quality management on organisational innovation is claimed by a number of studies, while at the same time, there are those that point to the shortcomings of quality management. What this study examines is the impact of quality management and knowledge management on innovation performances. Further from that, the authors present the methodology for the

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development of an instrument (questionnaire) for examining the coupled effect of quality management and knowledge management on organisational innovation performance.

2 Methods and Materials

For developing a questionnaire according to Saraph et al. [2], the beginning of the research is an overview of the literature and governing attitudes of the academic community, in the fields of quality management, knowledge management and innovation performance of an organisation.

To synthesize results of the narrative approach in the literature review, a CIMO framework was utilised. Thus, every paper was reviewed and assessed, in accordance with key CIMO elements. These are [3]:

Context:

- Clearly defined research boundaries and research space;
- Identification of key aspects, factors, entities or elements;
- Identification of key characteristics of those elements.

Interventions:

- Which, of the aforementioned key elements, has a mediating or moderating role?;
- What is the intervention of interest?

Mechanisms:

- How can interventions occur, concerning given mechanisms?;
- What are the mechanisms of interest?

Outcomes:

- What are the outcomes of such mechanisms?

During the reading of each paper, the focus is placed on the answers to these questions. Hence, the application of CIMO framework has resulted in the synthesized form of key factors of this research, as well as their mutual relations (Interventions), between them. These elements are thoroughly explained in the following paragraphs.

2.1 Innovation Performance Indicators

In this paper, the concept of innovation performance is considered in the context of an organisation. Thus, innovation performance is defined as product and process innovation. Moreover, innovation performance can be incremental, as well as radical. In detail, incremental innovation consists of the refinement and reinforcement of current products, processes, technologies, methods, and organisational structure in the organisation, while radical innovation is related to the innovation that produces fundamental changes towards products, processes, technologies, methods or organisational structure [4].

Based on an extensive literature review (from 1980 to 2015), Marisa Dziallas et al. [5], concluded that innovation performance, as a construct, can be measured and expressed through certain items. Such findings are also supported by other scholars. These items are:

- Straightforwardness (how easily can the customer learn the correct use of the innovation?) [6];
- Count of new product announcements [7];
- Number of new products [8];
- Product advantage, differentiated, unique benefits, superior value for the customer [9];
- Degree of innovativeness [10];
- Number of improvements in existing products [11];
- Success rate of new products and rate of survival on market [12];
- Shared ideas submitted and successful ideas [13];
- Time taken in turning an idea into a product or market launch [11, 14];
- Rate of suggestions implemented [8];
- Total cost of all commercially successful projects divided by the number of commercially successful projects [15];
- Number of improved processes [13];
- Time from identification of a customer product need until commercial sales [15].

2.2 Impact of Quality Management on Innovation Performance

Total quality management (TQM) and quality management systems which satisfy requirements of ISO 9001 standard can help the organisation to identify and achieve quality goals through process improvements [16, 17].

Based on a comprehensive literature review, [2, 18–23], singled out the key factors of quality management. That is, they tried to answer the question which, by its nature, key factors could make up the structure of quality management. These elements are defined by combining different models of excellence in quality management (eg National Quality Award - Malcolm Baldrige, European Quality Award - EFQM, Deming Award and Kanji Business Excellence Model, etc.) [22, 23].

These key factors are: leadership, quality planning, employee management, supplier management, customer focus, process management, continual improvement and learning.

Leadership - Leadership drives the organisation toward the realization of its vision. It involves creating a trustful environment which will lead to the feeling of appreciation of employees and, thus, to their contributions [22].

Quality planning - Quality planning consists of establishing quality goals and, at the same time, the best way of their realisation through all the processes of an organisation [24].

Employee management - Employees, as the essence of the organisation, should be involved. Management in the means of involvement leads to empowering the abilities of human resources [22].

Supplier management - Establishing a teamwork relationship with suppliers, aiming to enhance the value creation ability of both the organisation and its suppliers [22, 24].

Customer focus - Creating services and products following the needs of customers, including the changes in their needs over time. Proactive approach in this field makes it possible to create radical innovations [22].

Process management - Handling activities and resources as processes which leads to systematization of processes that make up the organisation, and their interactions [22].

Continual improvement - Continual improvement of knowledge, application, and alignment with business objectives is needed for an organisation to achieve a competitive advantage [22, 24].

Learning - Learning of, as well as obtaining, sorting through, synthesizing, and understanding all the data and information that could productively be used is an ongoing process, where the learning comes by doing [24].

Several studies have empirically demonstrated that quality management practices have a positive impact on innovation [22, 25–29]. Empirical studies have suggested that quality management can do a good job of training and encouraging employees to research and develop, thereby creating opportunities to apply quality management principles and techniques in innovative activities. Thus, it helps the organisation to improve according to customer needs, to minimize non-value-creating activities and reduce the time and cost of new product development [30].

However, several authors have pointed out that there is no link between quality management and innovation, even mentioning that quality management can be an obstacle for innovation [30–32].

The following will highlight the researchers' interpretations regarding the impact of individual quality management elements on the process of innovation performance.

Empowerment leads to a feeling of a certain degree of autonomy and thus, makes the employees reach a new level of innovativeness. It creates two-way communication where employees share knowledge, experience, and their problems, and the organisation helps them with solving these problems [22]. All of this facilitating radical and incremental product innovation. Cross-functional teamwork is one of the most effective channels of communication, and communication is recognised as the primary determinant in organisational innovation. Usually, employees are involved to deal with only a small scope of the management system improvement.

Research shows that customer focus encourages organisations to be innovative because they have to seek a better way to meet and exceed customers' requirements needs. Connecting innovation with customers' needs provides a clear focus for innovation. What this also promotes is an understanding of customers' needs and expectation, facilitating product innovation and radical innovations [22]. Nevertheless, customer focus could lead organisations to be reactive in responding to customers' needs, but may prevent organisations from exploring unserved needs and markets and hindering radical innovation because on this way companies are reactive in the short term [33]. Around that, customer focus may be an obstacle for developing radical new products in organisations, because of its inherent risk-avoidance philosophy, and it could not help organisations to cope with turbulence and discontinuity of the market.

Continuous improvement encourages new forms of thinking in means of how work is organised and conducted, promotes an analytical, structural, planned approach, facilitating incremental innovation, but delaying radical innovation due to higher levels of risk aversion [22, 34]. On the other side, some research shows that continuous improvement is promoted employee training that facilitating incremental and radical innovation, but some that continuous improvement only supports single-loop learning and not double-loop learning. Single-loop learning rather than double-loop learning and its concentration on cost efficiency would confine the capability and opportunity for innovation in organisations [34].

2.3 Impact of Knowledge Management on Innovation Performance

In a literature review about the relationship between knowledge management and innovation, performance was examine the relationship between knowledge management, innovation performance is shown. Analysed studies are from different countries and different areas, but show the same effect. A number of academic studies have identified a knowledge management has a positive effect on different types of innovation, and it would be a motivation for employees and managers to use knowledge management in their organisations. In this way, they will be more innovative and achieve competitive advantages [35–37].

Furthermore, Johnston and Paladino [38] found that a significant association between the use of knowledge management techniques and involvement in innovations existed. Knowledge management expands the creativity in organisation and improves the innovation performance through quicker access and trend of new knowledge and the development of new products [39].

Consequently, in many papers knowledge management is presented as an important antecedent of innovation [38, 40, 41]. By empirical research [37, 42], have confirmed that a company with knowledge management capability is likely to be more innovative.

2.4 Impact of Quality Management on Knowledge Management

In the field of quality management and knowledge management, researchers state that quality management can be considered as a precursor of knowledge management [36, 43].

By implementing quality management, organisations are encouraged to improve relationships with suppliers and customers. In order to respond to the needs and expectations of users in a timely manner, they need to modify their existing knowledge and apply new knowledge. The goal is to find and solve problems, to improve organisational processes by creating teams, fostering employee collaboration and staff training. All these actions involve the acquisition, sharing and application of knowledge [44].

3 Results

This paper discusses the relationship between the implementation of quality management, knowledge management and innovation performance. The results of literature review is primarily based on the considerable controversy concerning this relationship, due to the different sorts of results – some of them show that the impact of quality management on innovation performance is positive and some of them show that the impact is negative, and the same case is with knowledge managament. With the obtained results, authors established a research model (see Fig. 1) for further research, and present methodology for the development of an instrument (questionnaire) for examining the complementarities between quality management and knowledge management and their combined influence on innovation.

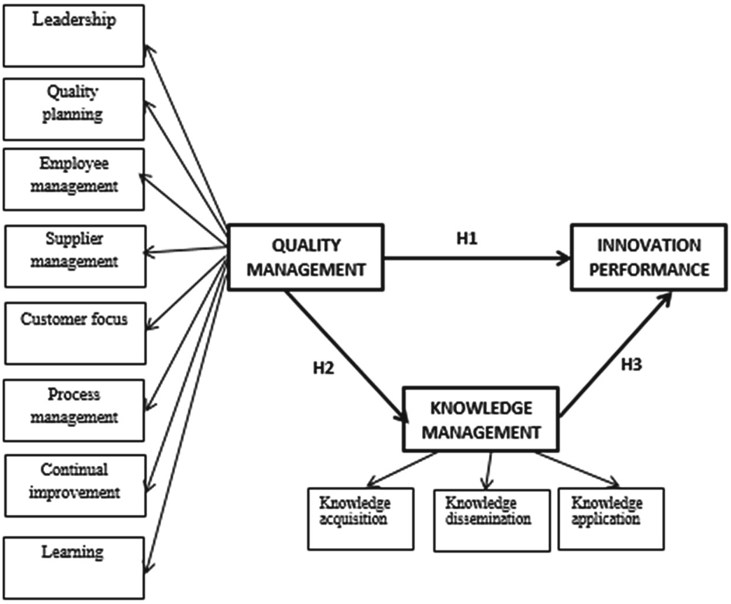

Fig. 1. The research model.

On the premises of the literature backbone provided for this study, the following hypotheses are assumed. These are:

– H1: Quality management has a positive impact on innovation performance
– H2: Quality management has a positive impact on knowledge management
– H3: Knowledge management has a positive impact on innovation performance

Objective assessment of parameters based on data from the processes is a common thing. In addition, their assessment can be based on subjective estimates of responders [45]. It is worth mentioning that methods of subjective assessment should be used only when objective data is not available.

For the subjective assessment of performance indicators by respondents, authors propose a bipolar Likert-type [46], because they can be viewed as a variable whose value can decrease, increase or stay unchanged.

For subjective assessment of a quality management, knowledge management and innovation performance elements by responders, authors suggest a unipolar Likert-type scale [46], because it is convenient for assessing the presence or absence (five-point scale) of a measured attributes.

In appendix is shown proposal of questionnaire constructs and items for the concepts quality management (Table 1), knowledge management (Table 2) and innovation performance (Table 3).

4 Conclusion

This paper includes the most important parameters used in within recent studies and represents conclusions relevant to academics and practitioners. In addition, research model proposed by authors is an original extension on the existing knowledge. Beside many studies that emphasize impact of quality management and knowledge management on innovation performance indicators, a few of them examine combined impact. In addition, it is important to point out that empirical research has not been carried out in Serbia, so in the next research it is planned to realize empirical research related to the given research model. The further studies should show how to use quality management, knowledge management in right way to increase capabilities for innovation in organisation.

Appendix

Table 1. Proposal of questionnaire constructs and items for the concept - quality management [2, 18–23].

Proposal of constructs	Proposal of items
Leadership	Management's commitment to quality; Involvement of employees by management; Autonomy in decision-making by employees; Motivation of employees by management
Quality planning	Quality planning according to customer requirements; Quality planning according capabilities of the organisation; Quality planning involves comparing the achieved with planned results; Communication of strategy and goals across the organisation
Employee management	Monitoring, measuring and evaluating employee performance; Encouraging employees in developing their own promotion tools; Rewarding employees for their success in contributing to the quality system; Representation of team work and division of work in the organisation; Measuring employee satisfaction
Supplier management	Establishing close and long-term cooperation with suppliers; Existence of specifications and requirements for procurement and suppliers; Providing technical assistance to suppliers; The quality supplier processes and their ranking based on this
Customer focus	The quality of the product/ service is based, among other things, on customer requirements; Analysing customer opinions and expectations; Conducting customer satisfaction measurement activities; Conducting activities to improve customer satisfaction; Analysing the loss of customers due to poor product/service quality
Process management	Preventive action; Corrective actions; Regularly conducting internal audits; Performance evaluation by employees
Continuous improvement	Encouraging continuous improvement; Identification of areas suitable for improvement; Reduction of unused time in processes; Reducing unnecessary costs in processes; Promoting quality and improvement through specific organisational structures
Learning	Existence of basic knowledge of product/ service development processes; Existence of a favorable and adequate "climate" required for skills development; Regularly performing necessary trainings; Regular participation of leadership in specialist training; Successful exchange of knowledge and experience between employees

Table 2. Proposal of questionnaire constructs and items for the concept - knowledge management [47, 48].

Proposal of constructs	Proposal of items
Knowledge acquisition	My organisation has processes for acquiring knowledge from inside and outside of the organisation; My organisation has processes for capturing knowledge of our competitors; My organisation has processes for capturing knowledge obtained from other industry sources such as industrial associations and clients; My organisation has processes for acquiring customer knowledge; My organisation has processes for acquiring knowledge on developing new products/services
Knowledge dissemination	My organisation has processes for distributing knowledge throughout the organisation; My organisation has processes for distributing knowledge among our business partners; My organisation designs processes to facilitate knowledge sharing across functional boundaries
Knowledge application	My organisation has processes for integrating different sources and types of knowledge; My organisation has processes for transferring organisational knowledge to employees; My organisation has processes for filtering knowledge; My organisation has processes for applying experiential knowledge; My organisation has processes for applying knowledge to solve new problems

Table 3. Proposal of questionnaire constructs and items for the construct - organisational innovation performance [5].

Proposal of constructs	Proposal of items
Innovation performance	Straightforwardness (how easily can the customer learn the correct use of the innovation?); Count of new product announcements; Number of new products; Product advantage, differentiated, unique benefits, superior value for the customer; Degree of innovativeness; Number of improvements in existing products; Success rate of new products and rate of survival on market; Shared ideas submitted and successful ideas; Time taken in turning an idea into a product or market launch; Rate of suggestions implemented; Total cost of all commercially successful projects divided by the number of commercially successful projects; Number of improved processes; Time from identification of a customer product need until commercial sales

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The Role of Management in Solving Organizational Conflict

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Abstract. This paper points the important role of management in managing organizational conflicts. Conflicts are the natural consequence of interaction among people in each organization, but they are also very complex and require the involvement of management in solving them. Conflicts affect all segments of the organization. Poor conflict management increases the level of stress, reduces the motivation of employees, negatively affects the work efficiency and productivity of the organization. On the other hand, management that adequately manages conflicts can transform conflicts into new chances and improve their business. In this paper we will examine the attitudes of employees from service companies in relation to conflicts, determine the impact of conflicts on work, examine the behavior of employees in conflict situations such as: interpersonal relations in the observed organizations and interpersonal relationships between members and service users.

Keywords: Management · Conflicts · Conflict resolution · Organization

1 Introduction

Trends such as constant changes, different types of employees, a large number of teams, lack of direct communication put the organizational conflicts in the first plan. One of the most important activities of management are knowledge and skills to maintain correct and uniform relationships among all participants in the organization. The organization represents a group of people organized into a set of smaller teams or individuals. Interpersonal relations represent the interaction between two or more participants, and the participant in the interaction is an individual and a group. Generally, organizational conflicts are each disagreement by individuals or groups within the organization. The presence of conflicts means that people care enough to defend their opinions and attitudes. Conflict is a social process that produced certain situations, or a course of events consisting of several episodes of different intensities and manifestations.

Conflict is a phenomenon that is present in all areas of human life and work and is the subject of numerous scientific disciplines, and especially psychology. Conflict is not bad in itself. It can have positive and negative consequences depending on the

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approach and viewpoint of the conflict. The traditional view is extremely negative for conflict, and the modern view sees conflict as a normal and inevitable phenomenon. The significance of the conflict is that it often carries many negative emotional reactions, numerous frustrations and dissatisfactions. Conflicts greatly affect interaction among people and interrupt their communication.

The existence of unsolved conflicts in the organization leads to an unhealthy working atmosphere, a decrease of employee satisfaction and loyalty. This creates the conditions for fluctuation, reducing organizational efficiency that directly affects the financial result of the organization. Organization can lose its position on the market in relation to its competitors and endanger its own survival. Conflicts are an integral part of modern life and have great significance and influence both on the individual and the entire organization, so it is necessary to know how to manage conflicts properly. Management should learn how they can use positive aspects of organizational conflicts while preserving good interpersonal relationships. The causes of conflicts in the organization are numerous and it is a great challenge for management to solve and guide them in proper way. This enables organizations to keep up with development and create solutions that will respond to new threats and opportunities.

2 Objectives

The aim of research is to determinate ways in which organizational conflicts are handled by the management in observed organizations as well as determining employees' attitudes towards conflict phenomena.

Practical goals:

- Investigate conflicts as causes of efficiency decline in an organization,
- Identify the existence of conflicts in observed organizations,
- Identify the causes of conflicts in the observed organizations,
- Identify ways of resolving conflicts in the observed organizations,
- Identify conflict management modes in the observed organization.

Scientific objectives:

- Describing the concept of organizational conflict,
- Defining and classifying attitudes of employees towards conflicts,
- Proposing measures for conflict management in organizations.

3 Methods

The research, in relation to the set goals, includes organizations, i.e. employees of organizations at different working positions, educational level, years of age and work experience. The number of respondents included in the survey was 54 employees from different organizations.

Research hypotheses are defined in accordance with the subject and objectives of the research. The research method we use is a survey technique. The survey included

40 questions that were answered by completing the most acceptable answer or stating the degree of agreement with the given statements. Data processing is done in the SPSS program.

By obtained data we got answers to the questions whether the hypotheses that were previously set are correct or not and the hypotheses are the following:

- H0: conflicts negatively affect the work of employees,
- H1: conflicts are the most common among employees at different hierarchical levels,
- H2: conflicts are always resolved in the observed organizations,
- H3: there is a connection between years of age and attitude towards conflicts.

4 Concept and Definition of Organizational Conflict

Conflicts are as old as humanity. They are a general phenomenon, which can be found at all levels of coexistence of human beings but they are also very complex [1]. In everyday life conflicts are often identified with quarrels, conflicts of interest, use of force. Conflicts are often perceived as a battle in which one must win and they represent any conflict of interests, goals, etc. between two or more individuals, while one side considers that another side has taken or intends to undertake an action that will have negative consequences for his interests [2]. The conflict occurs when one person negatively acts, or he can negatively affect the goals, which are important persons with whom he interacts. Within the conflict there is a special dynamic that makes difficult or even completely excludes the application of the agreed rules. Research on the behavior of people in conflict situations shows that most people are trying to represent their point of view and to achieve their goals by constantly insisting on confirming their own position, even when the first signs of failure are shown. This behavior is followed by limiting the horizon of the understanding of the overall situation or the action of the new elements on the situation, as well as the limited decision-making power. The better an employee is managing the stress, there will be more positive affect those around and the less other people's stress will have a negative effect.

Below are some of the definitions of the organizational conflict:

- The clash that occurs when the goal-directed behavior of one group blocks or thwarts the goals of another [3],
- Conflict is a disagreement about the allocation of insufficient resources or disagreements in relation to goals, values, etc., can occur at the interpersonal and organizational level [4],
- Most definitions of conflict are similar and relate to the existence of three essential elements [5]: at least two parties are needed for a conflict, the parties to the conflict may be individuals or groups, and the interests of the conflicting parties are opposed.

4.1 Nature of Organizational Conflict

Conflicts are normal in any organization, because people have different opinions, while some individuals cannot accept other people's different opinions [6]. Organizational conflicts are expressed through certain contradictions that exist between people during the work process.

The conflict includes contradictory or incompatible interests between individuals or groups, the perception of these conflicting interests, and the conviction of both parties that their opponent has undertaken or will soon take measures to prevent the realization of their important interests [7] as shown in Fig. 1.

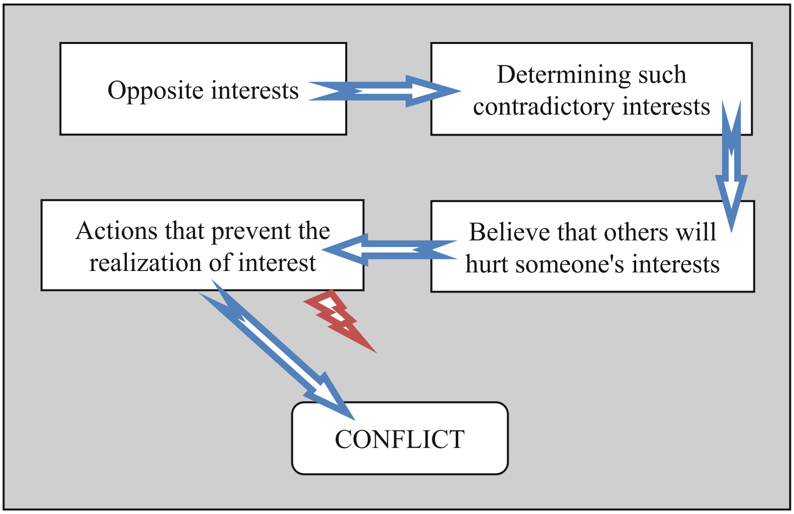

Fig. 1. The emergence of an organizational conflict.

As the causes of conflict at work, the following are most often recognized [8]:

– Poor work organization,
– Inadequate reward,
– Poor relationship between superiors and subordinates,
– Poor relationship between employees in general,
– Poor working conditions,
– Poor work protection.

Each of these causes requires a careful selection of approaches in conflict resolution.

4.2 Types of Conflicts

General conflicts are divided into [9]:

– Constructive or functional,
– Destructive or not functional.

A constructive conflict is one that has a positive impact on performance. Constructive conflicts contribute to the success of the organization and to the growth and development of both organization and personality of an individual. They show the rivalry of the conflicted sides, but at the same time they seek to find the best solution.

A positive conflict interprets conflict as a productive force, which stimulates members of the organization to increase their knowledge and skills. Organization foster constructive conflicts that will improve the organization's performance. Today, the key to success is creativity and the ability to adapt to changes in the environment. In any case, these conflicts, although giving a positive outcome, need to be controlled because they can turn into a destructive conflict. Sometimes conflicts are inevitable, so we need to learn how to use their positive aspects and preserve good interpersonal relationships.

Destructive conflicts pose a major problem for one organization because they prevent the growth and development of the organization and cause hostile charges. Participants in these conflicts are apathetic, aggressive and hostile toward each other, and their energy is concentrated on the conflict, which makes it difficult or even completely stop the execution of tasks, and therefore organizational efficiency decreases. The consequence of these conflicts is that the group does not find a solution to the problem or solutions are not good enough, the energy of the members of the group is related to the conflict, which leads to problems of reduced work performance.

4.3 Conflict Resolution

A discipline called "Conflict Resolution" includes two segments: [8]:

- Prevention of conflict,
- Conflict resolution.

The conflict cannot be resolved if you do not first understand the causes of conflict [10]. In order to assist managers in understanding conflict, a number of factors regarding individuals and organizations have been identified. Differences in individual characteristics have been shown to impact the development of conflict and its potential resolution [11].

Preventing conflicts creates a precondition for conflicts in the organization not to appear. This applies especially to destructive conflicts. It implies a series of measures and activities in the field of training communication, behavior, thinking, and also solving problems and negotiating. Of course it is not possible to determine a clear and unique way to resolve conflicts. One of the basic principles is that human beings do not behave mechanically and predictably in accordance with previously defined rules of conduct. The conflict solution must be adaptive, flexible, sensitive to small and frequent changes and is ready for unexpected.

Some of the precautionary procedures are:

- Creating an organizational culture,
- Creating an organizational climate,
- Fostering interpersonal relationships,
- Fostering interpersonal personal styles,
- Development of knowledge and awareness of an individual.

Resolving conflict cooperatively requires considerable intellectual, logical, emotional and interpersonal capabilities [12].

5 Results

The results below are obtained by the research performed for the needs of the final master's work.

H0: Conflicts negatively affect the work of employees. From the group of questions that are related to the H0 hypothesis we will point out question number 25. (How do You see the conflict?) as shown in the Table 1.

Table 1. How do You see conflict?

Degree of education	How do You see conflict?			Total
	Conflict is constructive and functional	Conflict is partly constructive	Conflict is destructive and not functional	
IV	1	6	10	17
VI		1	3	4
VII1	4	17	11	32
VII2		1		1
Total	5	25	24	54

Most of the of respondents, regardless of educational level, 46.3% of them answered that the conflict was partially constructive while a large number of respondents, 44.4% answered that the conflict was destructive and not functional.

On the basis of the obtained results it can be see that the views of the majority of the respondents are negative according to the occurrence of the conflict and that the conflicts negatively affect their work. Therefore, we can conclude that the hypothesis H0 is confirmed. This leads us to conclude that many organizations do not have an adequate approach to the emergence of conflict and as well as poor quality of conflict management. Employees in such organizations in conflict do not see any benefits that it can bring to the organization, but only damage and conflict as such creates negative emotions at workplace and adversely affects their work.

Therefore, it is necessary to develop an organizational culture that fosters the emergence of conflicts and sees conflicts as chances for their organization.

H1: Conflicts are the most common among employees at different hierarchical levels. From the group of questions which are related to the H1 hypothesis, we will point out question 27. (At which level conflicts are the most commonly occurring?). The answers are shown in the Table 2.

Table 2. At which level conflicts are the most commonly occurring?

At which level conflicts are the most commonly occurring?	Frequency	Percent	Valid percent	Cumulative percent
Between employees at the same hierarchical level	15	27,8	27,8	27,8
Between the employees and the superiors	6	11,1	11,1	38,9
Between employees in different sectors	27	50,0	50,0	88,9
I do not know	6	11,1	11,1	100,0
Total	54	100,0	100,0	

The largest number of respondents, 50% of them think that conflicts are the most frequent among employees in different sectors, followed by respondents, 27.8% who believe that conflicts are the most common among employees at the same hierarchical level. The smallest group of respondents, 11.1% of them, thinks that conflicts are the most common among employees and superiors.

Based on the results, we can conclude that the hypothesis H1 is not confirmed. In view of such a result in the observed organizations it is necessary to develop the cooperation of different sectors and find adequate techniques to resolve their conflicts.

H2: Conflicts are always solved in the observed organizations. From the group of questions which are related to the H2 hypothesis, we will point out question 29. (Do You solve conflicts in Your organization in reality?) Table 3 shows the results of question 29.

Table 3. Do You solve conflicts in Your organization in reality?

Do You solve conflicts in Your organization in reality?	Frequency	Percent	Valid percent	Cumulative percent
Yes, we always clarify the disagreements	24	44,4	44,4	44,4
We solve only those that are directly related to the productive	16	29,6	29,6	74,1
We do not have conflicts in the organization	11	20,4	20,4	94,4
We do not solve conflicts in org	3	5,6	5,6	100,0
Total	54	100,0	100,0	

In the observed organizations, most of respondents, 44.4% answered that they always resolve disagreements in the organization. Next were respondents, 29.6% who answered that they only deal with those conflicts that are directly related to productivity. They are followed by respondents who answered that they have no conflict in the organization, 20.4% of them.

On the basis of the obtained results we can conclude that the hypothesis H2 is confirmed. Taking into account this result, it is necessary to work on the equal treatment of conflicts that directly affecting the observed organizations and those that do not affect productivity. The conflict that remains unsolved will come sooner or later in relation to productivity.

H3: There is a connection between years of age and attitude towards conflicts. Employees aged up to 30 and ages 31 to 40 were the only ones in their group of respondents who consider that conflicts are constructive and functional as shown in the Table 4.

Table 4. Cross-tabulations: year * How do you see the conflict?

Age	How do you see the conflict?			Total
	Conflict is constructive and functional	Conflict is partly constructive	The conflict is destructive and not functional	
Under 30	3	13	12	28
From 31 to 40	2	9	6	17
From 41 to 50		2	4	6
From 51 to 60			2	2
Over 60		1		1
Total	5	25	24	54

Based on the results we can conclude that the hypothesis H3 is confirmed. However, the obtained result should be accepted with a certain caution because there is a possibility that this is the result because there is a significant increase in the number of respondents of these two age groups than those of the other age groups. On the other hand, younger workers may more readily accept the new concept of viewing conflict as constructive. Managers play a key role in presenting the positive effects of conflict to all employees, regardless of their age.

6 Conclusion

Because of the negative emotions they carry with them, conflicts should be an important part of the management of each organization and especially human resources management, which task is maintaining and promoting good interpersonal relations in the organization. There is no universal definition of conflicts, but most cite actual or observed differences in interests, needs, goals, ideas between at least two people as their essential character.

When conflict occurs, first of all, it is necessary to define its cause and to determine whether it is destructive or constructive according to the organization. Research has shown that managers at all levels must be part of the conflict. They should manage conflicts to minimize the negative effects on the organization and increase the positive ones. Destructive conflict should be resolved as soon as and in such a way that it brings the greatest benefit and satisfaction to the largest number of participants. For those whose conflict is negatively addressed, management should provide adequate assistance in overcoming the problems that carry negative emotions with them, such as aggression, frustration, apathy, etc. Several ways (discussions, threats and coercion, the introduction of a judge and compromise) are listed as ways to resolve the conflict in literature. We consider the compromise as the solution most acceptable, because in this way a solution is reached that all parties are somewhat satisfied with. The creative potential of conflict situations is large and should not be neglected but used. Constructive conflicts should be encouraged, employees should express their opinions and attitudes, as it is very certain that in this way, with good management, the quality of decisions, solutions and, ultimately, the entire business of the organization will be improved. A constructive conflict is desirable and brings many benefits to the organization, but there is always the danger that a constructive conflict will turn into a destructive conflict. Therefore, it is important that a constructive conflict is managed. Conflicts need to be controlled continuously and in no way should be ignored even when they appear to be harmless for the functioning of the organization.

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Triple Bottom Line Analysis in an Agribusiness Supply Chain

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Abstract. Nowadays, modern and competitive industries have been evolving towards integrated supply chains. Nevertheless, in today's competitive and globalized markets, production systems must also meet sustainability requirements considering social, economic and environmental dimensions. In this research project, we analyze such different dimensions of sustainability in a supply chain of the agribusiness. A survey of the supply chain of the swine industry in the western region of the State of Santa Catarina, Brazil, was made. The data was analyzed using Entropy and the technique for order of preference by similarity to ideal solution (TOPSIS). Results demonstrate that sustainability is related to the positioning of the company in the supply chain and its level of integration. The model developed in this research, focused on the level of sustainability maturity in supply chains, can be used as a tool of diagnosis and to compare different industries.

Keywords: Sustainability · Triple Bottom Line · Supply chain · Agribusiness · TOPSIS

1 Introduction

Integrated supply chains made it possible to finance the producers of raw materials, gave a commercialization scale to suppliers and buyers, as well as facilitates the transfer of technologies, among other benefits. In supply chains it is fundamental to measure the social, economic, environmental and institutional impacts of production activities in order to give support to better economic strategies that can rule the relationship among all the actors involved towards a better social inclusion, nature preservation, social responsibility, institutional interaction and economic outcomes [1, 2].

Sustainability can be understood as the "development that aims to meet the needs of the present without compromising the ability of future generations to meet their own needs." To fit the new global production profile, organizations need to modify their production processes or even restructure the entire business [3]. Therefore, sustainable development involves attitudes and actions by individuals and companies, aiming at preserving natural resources, maintaining the ecological balance of the planet, reducing pollution, encouraging recycling, eliminating waste, that is, generally reducing and

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eliminating impacts on the environment. Companies from the most diverse sectors are incorporating actions with less environmental impact, taking advantage of materials and waste from their production process, and other initiatives and strategies to be able to offer more sustainable products.

Typically, sustainability is presented as compounded by three interrelated aspects: economic, environmental and social, known as the "Triple Bottom Line". With this broader vision, the "Triple Bottom Line" (or tripod of sustainability) proposes the incorporation in the strategic planning of specific goals for a better balance of economic, environmental and social results [4].

2 The Agribusiness Supply Chain and the Triple Bottom Line

The beginning of the colonization of the western region of Santa Catarina comprises the period between 1900 and 1930, coinciding with the emergence of the swine sector, which was promoted the development of important agroindustrial plants that were formed and consolidated over the decades. They were the main responsible for organizing and promoting the development of the swine and other production chains in the meat sector that currently supply national and international markets [5].

But in the 1980s, with Brazil's indebtedness and the consequent reduction of credit to the agricultural sector, accompanied by the fall in the price of soybeans in the international market, the pig industry started a new management model based on an Integrated Production System [5].

The pig farmer is an important element in the swine production chain, being considered the primary link of this chain from two perspectives: with the companies that supply inputs (in the upstream) and with the agroindustry (in the downstream). It is noticed that these two transactions are essential to understand the processes of coordination of the swine sector. However, it is necessary to consider that the transactions in the downstream present particularities and depends on the production model adopted by the pig farmer (if integrated or cooperated model), since the transaction is assured by contract relations and carried out directly with the agroindustry. If it is an independent producer, the transaction will not have a purchase and sale agreement and will be carried out in the spot market; i.e., according to the law of supply and demand (day price) without the presence of contracts or futures market [6].

In the agribusiness market, leading companies have the peculiarity of forming a competitive oligopoly market. These strategies follow international trends, already adopted by other companies in the sector in the European Union and the United States [7].

While approaches may vary by company, sector, and geographic area, there is increasing investment in sustainable supply chains. Sustainability of the supply chain can be defined as managing environmental, social and economic impacts and encouraging good governance practices throughout the life cycle of goods and services [8].

The food industry supply chain has achieved outstanding success in the last decades, while it has been criticized for its adverse environmental and social impact. The comparative analysis of farm sustainability performance is relevant, since supply chains have their own characteristics, where attention to social, economic and environmental issues are different, because stakeholders may be also different [9].

Figure 1 presents the stages of the pig production process.

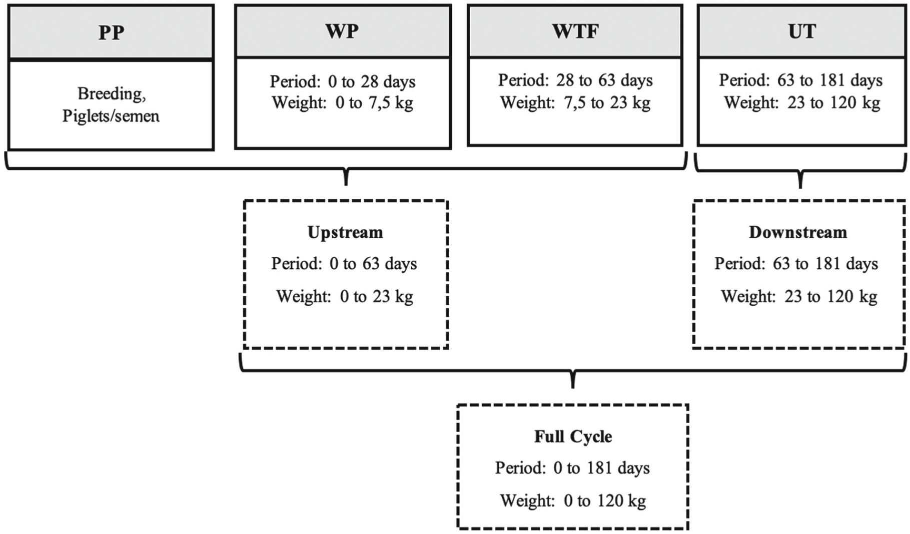

Fig. 1. Stages of the pig production process. Source: Adapted from [10].

The evaluation of the agribusiness supply chain from the perspective of the Triple Bottom Line, implies to consider the ability of farms to generate economic returns (economic performance), addressing the conservation of environmental resources and waste reduction (environmental performance), and people's ability to work together for a common purpose (social performance) in organizations and groups [11].

Although some studies have analyzed supply chains under the economic dimension [11–14], the social aspects [15, 16], and the environmental perspective [17, 18], under the lens of the three pillars of sustainability (TBL) together [9, 19, 20]. Food supply chains can promote rural development, increase producers' profits, benefit consumers with lower prices and higher quality food products by encouraging farmers to adopt environmentally sustainable practices [19].

Some benefits related to improved biodiversity, job creation, increased profitability and control over agricultural products are related to short supply chains [9]. In turn, short supply chains can reduce transport costs and improve environmental sustainability [20].

By improving environmental, social, and governance performance across the supply chain, companies can enhance processes, reduce costs, increase productivity, innovate, differentiate, and improve social outcomes [21].

3 Materials and Methods

This research project is focused on a supply chain of the swine industry in the western region of the State of Santa Catarina. This State is the largest producer and exporter of pork in Brazil and the fourth largest exporter in the world. In the swine industry, the supply chain is characterized by a well-defined set of activities or companies; including producers, abattoirs and meat processors, transporters, packers, wholesalers, retailers, and export/import distributors. A good supply chain management in agribusiness industries, as it is the case of the pork industry, maximizes product quality, efficiency and profitability.

In Brazil, pork production occurs independently (complete cycle) or associated with companies, either as cooperative or integration arrangements. The independent farms assure the whole process, starting with the production of piglets until the termination unit, and all costs of the activity (facilities, labor, food, technical assistance, among others) occur on their own. In this case, it will be able to market the products to the agroindustries that pay more for the product, being able to have greater gain in periods of less supply of pigs. When the supply of products is greater than demand, independent farms receive less value for the product, having some instability, which provides greater risk.

The largest concentration of pork production in Brazil occurs in farms that have partnership agreements with agroindustries or cooperatives. In these cases, the production process includes several actors within the production chain as shown in Fig. 1. The pig production unit (PP) produces breeding stock, breeding females and semen for artificial insemination, which are destined for Weanling Piglets (WP), remaining until the age of approximately 28 days. Afterwards, the pigs are taken to another farm: the Wean to Finish (WTF), where they remain until the approximate age of 63 days. Finally, they go to another farm that makes the final process, called Termination Units (TU), in which the pigs stay until they reach approximately 120 kg (181 days), followed for slaughter in the agroindustries. Some farms assure both the WP and WTF processes.

In the cooperative production model or integration, farms make all investment in facilities, maintenance, labor, electric power. Farms are also responsible for the disposal of waste generated in the activity, as they can pollute the environment. Agribusinesses deliver the pigs on the various farms in the form of lending. They are responsible for technical assistance and food, including logistics used in transportation between the various farms and the agroindustry. Producers receive a remuneration per animal. In this case, farms are less risky because most of the costs are borne by agroindustries, and producers are paid for the labor. Each actor in the production chain receives a remuneration from the agroindustry that dominates the entire chain (i.e., the focal company).

To perform the comparative analysis, the supply chain was split in terms of upstream (PP, WP and WTF) and downstream (TU). The triple baseline analysis was made comparing the integrated production system with independent companies. A questionnaire containing 30 questions was used to measure the different levels of sustainability in the political-spatial (PD), social (SD), economic (EcD) and environmental (EnD) dimensions.

In addition, 17 questions were used to capture categorical information about the farms, seeking to cross-data and position each company in the supply chain.

A total of 422 valid questionnaires were returned. The data were analyzed using Entropy and the technique for order of preference by similarity to ideal solution (TOPSIS). Sustainability analysis was performed using the difference between means and variances.

Table 1 presents the structure of the questionnaire based on the abovementioned four dimensions in terms of weights, number of measures used and average weight of each measure by dimension.

Table 1. Weights, indicators and average weight by dimension.

Sustainability dimensions	Number of measures	Weight of the dimension	Average weight of each measure
Political-spatial (PD)	5	0,22	0,0444
Social (SD)	6	0,10	0,0166
Economic (EcD)	7	0,29	0,0433
Environmental (EnD)	12	0,39	0,0333

4 Results

Table 2 presents the overall results per sustainability dimension and per type of company in the supply chain and production system.

Table 2. Global results.

Sustainability dimensions	N.	EcD	EnD	PD	SD	Overall
Means test (T-Student)						
Upstream	160	1,319335	2,479885	1,585053	0,394896*	5,779169
Downstream	262	1,349151	2,454825	1,612829	0,246305	5,663110
Variance test (Teste F)						
Upstream	160	0,204116*	0,256478	0,341174	0,052272*	1,619805
Downstream	262	0,280893	0,244010	0,317120	0,029261	1,552407
Means test (T-Student)						
Integrated	356	1,350477	2,505596*	1,649889*	0,306340	5,812302*
Independent	66	1,269722	2,241720	1,345592	0,282702	5,139736
Variance test (Teste F)						
Integrated	356	0,248195	0,24197	0,297236*	0,04064*	1,504034
Independent	66	0,267438	0,226965	0,406418	0,056667	1,614583

*Significance level of 5%

With regard to the production system, 84% of producers are in the integrated system, where a focal company controls all the value chain being responsible for the logistics and the coordination of operations, technical assistance to producers and transportation. The producer has the responsibility of supplying all the physical structure and the correct disposal of the wastes occasioned by the pig production, including the labor, which can be outsourced.

Regarding the levels of sustainability, it was verified that in the PD dimension, the most sustainable farms were PP, while the less sustainable were FC and WP. In the EnD, the most sustainable production units were PP and the least sustainable were FC and WTF, and, in overall, this dimension was the most sustainable. In the EcD dimension, TU farms were the most efficient, while the FC units presented the lowest performance. In SD, the most sustainable farms were WTF, while the least sustainable were TU producing units, with 92% of these units classified as "unsustainable".

Table 3 indicates the level of sustainability of the Upstream (PP, WP e WTF) of the supply chain for Integrated Production Systems versus Independent companies.

Table 3. Sustainability at the upstream of the supply chain for the integrated production system versus independent companies.

Sustainability dimensions	N.	PD	EnD	EcD	SD	Overall
Means test (T-Student)						
Integrated	123	1,345607	2,551448*	1,671710*	0,417152*	5,985918*
Independent	37	1,232000	2,241988	1,296976	0,320908	5,091872
Variance test (Teste F)						
Integrated	123	0,184181**	0,246063	0,279795*	0,048728	1,408640
Independent	37	0,267143	0,223234	0,447707	0,058413	1,748869

*Significance level of 5%; **Significance level of 10%.

The results indicate that the farms in the initial cycle of the supply chain within the integrated production system are more sustainable in the economic, environmental and social dimensions, as well as in terms of global sustainability.

These findings suggest that the requirements imposed by the focal company (agribusiness) to integrated companies (farms that work under the integrated production system) provides greater sustainability for the entire supply chain. The extensive monitoring of the focal company under the integrated companies results in greater sustainable returns compared to farms that are independent.

In addition, the focal company has a greater investment capacity and have quick access to innovations in the market, which allows the farms in this integration system to have easier access to the factors of innovation that contribute to higher levels of sustainability. Table 4 indicates the sustainability of the Downstream (UT) of the supply chain for Integrated Production System versus Independent.

Table 4. Sustainability at the downstream of the supply chain for the integrated production system versus independent companies.

Sustainability dimensions	N.	PD	EnD	EcD	SD	Overall
Means test (T-Student)						
Integrated	233	1,353047	2,481391*	1,638370*	0,247842	5,720650*
Independent	29	1,317851	2,241379	1,407619	0,233956	5,200805
Variance test (Teste F)						
Integrated	233	0,282908	0,239158	0,307303	0,026615*	1,536263
Independent	29	0,273089	0,239868	0,360740	0,052057	1,492702

*Significance level of 5%; **Significance level of 10%.

The results indicate that the downstream farms of the supply chain have high present economic, environmental and global sustainability in the integrated production system, main method of production independent. In general, these results suggest that farms with integration tend to guarantee greater economic potential and also greater investments in reducing environmental impacts. These results reflect the efforts of the focal company with the economic and environmental satisfaction of the pig supply chain, mainly with farms (integrated company).

Table 5 indicates the sustainability in the integrated production system for the upstream versus downstream of the supply chain.

Table 5. Sustainability at the upstream and the downstream of the supply chain for the integrated production system.

Sustainability dimensions	N.	PD	EnD	EcD	SD	Overall
Means test (T-Student)						
Upstream	123	1,345607	2,551448	1,671710	0,417152*	5,985918*
Downstream	233	1,353047	2,481391	1,638370	0,247842	5,720650
Variance test (Teste F)						
Upstream	123	0,18418*	0,246063	0,279795	0,04873*	1,40864
Downstream	233	0,282908	0,239158	0,307303	0,026615	1,53626

*Significance level of 5%; **Significance level of 10%.

It can be seen in Table 4 that the farms in the integrated production system present social and global sustainability in the initial cycle of the supply chain. In general, it is suggested that the initial cycle of the supply chain is more sustainable because of the greater care that the farms must have with the losses of pigs that are in the process of growth. At this stage of the supply chain cycle, technology and innovation bring efficiency gains that minimize losses with pig mortality and increase the sustainability of the farm.

Table 6 indicates the levels of sustainability in the independent production system for the upstream versus downstream of the supply chain.

Table 6. Sustainability at the upstream and the downstream of the supply chain in the independent production system.

Sustainability dimensions	N.	PD	EnD	EcD	SD	Overall
Means test (T-Student)						
Upstream	37	1,232000	2,241988	1,296976	0,320908	5,091872
Downstream	29	1,317851	2,241379	1,407619	0,233956	5,200805
Variance test (Teste F)						
Upstream	37	0,267143	0,223234	0,447707	0,058413	1,748869
Downstream	29	0,273089	0,239868	0,36074	0,052057	1,492702

*Significance level of 5%; **Significance level of 10%.

The results suggest that the sustainability of the farms of the independent production system do not differ in the upstream and downstream of the supply chain. These results reveal that farms in the independent production system have similar levels of sustainability in the different production cycles of the supply chain.

Another relevant aspect is the lack of technical advice and management in the farms of the independent production system. In the integration system the farms are well advised by focal companies. These findings become even more evident in the beginning of the supply chain, considering that these stages of production require greater care and considerable investment in innovations to maintain competitive levels of productivity.

5 Conclusion

The model developed in this research, focused on the level of sustainability maturity in supply chains, can be used as a tool of diagnosis and to compare different industries. The search for sustainable development is a constant challenge asking for a great engagement of all organizations involved in the supply chain. The evidence of patterns and trends is important to support a better design and application of public policies and company strategies towards the social, economic and environmental sustainability of integrated production chains in this and other industries.

Regarding the sustainability levels, it was realized that in the PD dimension, the farms with greater sustainability work in the PP stage, while the less sustainable ones were the FC and WP. In EnD, the most sustainable production units were PP and the least sustainable FC and WTF. In overall terms, this dimension (EnD) was the one that shown the highest levels of sustainability. In the EcD dimension, the TU farms were the most sustainable, while the CF units showed less sustainability. In the SD perspective, the most sustainable farms were WTF, while the less sustainable ones were TU producing units, with 92% of these units classified as “unsustainable”.

The results indicate that the production of pigs independently, without partnership with other actors in the production chain, has not been a sustainable option. It is therefore necessary to establish lasting partnerships through the integrated production system to obtain benefits that contribute to higher levels of sustainability, such as technical advice and access to innovation.

This finding is supported by the results found in the integrated production system, in which it has proved to be more sustainable in several aspects and in all stages of the supply chain, either in the upstream or the downstream. This study contributes to the literature by demonstrating that integration is not an evil aspect, as some farm managers consider. Indeed, it is the opposite, it provides incentives for the farms to change and implement innovations, achieve production in scale, reach higher levels of sustainability, all these essential to keep people and families in rural areas.

It is concluded that the farms have to meet the environmental legislation requirements imposed by the focal companies in the industry, demanding constant investments to reduce the environmental impact caused by their activities. In turn, the focal companies need to provide social conditions to benefit farm workers namely, offering training and suggestions to improve work conditions. Finally, in the economic aspect, the focal companies provide greater stability in the purchase and in the price paid by the pigs, unlike in the system of independent production that coexists with the economic uncertainty.

The environmental sustainability presented better indicators in farms integrated in supply chains managed by the big companies in the industry (i.e., focal companies). This is because large corporations are very scrutinised by customers concerned with the environment. Thus, these pressures in addition to complying with current legislation, require adjustments throughout the entire supply chain.

In general, economic, environmental, and global sustainability has performed better in the integrated production system, especially in the upstream of the supply chain. Thus, it is perceived that the monitoring actions developed by the focal company under the integrated farms have provoked beneficial effects in economic, social and environmental terms. In addition, the requirements in terms of investments in innovation have provoked satisfactory effects in the sustainability of the integrated farms.

These findings corroborate previous studies, [9] for example, showing that farms integrated in supply chains managed by large corporations can reach higher performance than companies working independently.

The understanding of the different factors that contribute to sustainable supply chains is important to recognize what must be improved in the short and long term, always in the direction of reaching the highest level of sustainability desired by the companies and the society. As suggestions for future research, a larger number of farms could be surveyed and the model can be applied in other regions and particularly industries characterized by a high impact in the sustainability of the communities and societies where they are inserted.

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Main KPI's of Successful Sales in an Online Environment

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Abstract. Doing business of today is characterized by quick changes, which require swift responses by all retailers who run their businesses on a marketplace such as Amazon. In that sense, many factors have to be taken into account in order to gain and maintain top performance in the ever-growing market. For this reason, the product's listing positioning, or products' ranking plays a significant role when it comes to achieving positive results in a certain market niche. By gradually gaining higher page position, retailers will be more likely to have their products performing better in terms of sales volume. Otherwise, sales velocity will come at a slow pace and these listings could induce negative effects on retailers' product portfolio. The purpose of this paper is to show what effects does products' positioning has on its performance in terms of sales as well as to give a brief insight into other fundamental elements which have to be attained in order to enhance doing business in an online environment.

Keywords: Head title · E-commerce · Amazon · Ranking index · KPI

1 Introduction

Under the influence of the rapid development of the Internet and information and telecommunication technologies, many goods have become more available. Millions of people, daily, make a transaction over the Internet to acquire wanted merchandise. On this occasion, when both fast moving consumer goods and everyday necessities, such as tools, sports equipment, furniture, etc. are concerned, many online shoppers first seek for these on marketplaces such as Amazon, since research has shown that such platforms provide customers with a better understanding than traditional shopping platforms [1]. Since this way of goods acquirement has gained a lot of popularity in last years, it is essential to be able to understand these distribution channels both from business and users perspectives [2], since online business environment is expected to attract even more customers in the near future. Amazon Annual Report from 2017 [3], there were roughly around 2 million Amazon Sellers. Amazon alone, not including books, media, wine, and services sells around 12 million products, but when Amazon marketplace sellers are included, that number is significantly larger and comes up to 353 million products [4]. Solely in the first quarter of 2016 there were 310 million Amazon users worldwide [5]. These numbers indicate how important online sellers it is to rank their products on the first couple of pages, when certain terms are searched via

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Amazon's search engine, for them to come on top and gain more conversions, than other competitors on the marketplace.

The purpose of this paper is to give a brief insight into e-commerce significance with a special review on the importance of good ranking establishment in an online environment on the example of Amazon marketplace for sellers to reach the best performances in terms of sales of their products. Since listing ranking depends on multiple criteria, which are consistent within Amazon A9 algorithm, speculations regarding its functioning will be used as a methodological approach within this paper. The paper itself is structured of five main points. The first point of the paper is related to a short statistical overview, which depicts Amazon's current state, regarding its size, number of sellers, customers, etc. The rest of the paper will be focused on providing necessary terms related to Amazon sellers, methodology, results, and conclusion.

2 Significance of Ranking on Amazon Pages

Every product on Amazon has its ranking, which can be described as product positioning on the selling portal when a certain keyword is searched on Amazon's search engine. To achieve wanted sales volume and sales velocity, Amazon sellers strive towards positioning their product listings on top of Amazon sales pages. Multiple pieces of research and studies that have dealt with this topic in the past but also in the present have shown, that product positioning stands for one of the most essential elements when it comes to achieving top sales performance in the marketplace. In that sense certain findings [6], indicate that only 30% of all Amazon shoppers will look beyond the first page, which clearly points to a fact that chances of making a sale after the first page will significantly drop, where most of the buyers will rarely click through page four.

Amazon sales rank, also known as Amazon Best Seller Rank is a score assigned to the product by Amazon following its historical sales data and it fluctuates on an hourly basis [7]. Besides other information related to products' listing, Amazon bestseller rank can also be seen both for wider categorization and its narrower searches in exact category. A product ranked number #1 indicates that it has recently gained more in sales than any other product listed in the same category. It has sales which perform better than the rest of the products in that category and because of that get a higher ranking score than the other competitors.

On all online marketplaces including Amazon, listings are represented by its titles, images, bullet points, brands, and products' descriptions. With this being said, creating appealing products' listing stands for the starting point when it comes to products' positioning. According to survey results [8], which involved 2000 online shoppers, it showed that 30% of them used Amazon as the first source for product research before they eventually decided to purchase them, while at the same time Google attracted only 13% of them. Another finding [9] which included 572 online shoppers overtook past research and showed that 57% of online shoppers surveyed picked Amazon as their first source for product browsing. In addition to this, another research [10] indicates that when keywords or key phrases which customers search via the search engine on Amazon are not indexed for products' listing, it is not likely that they will show up to customers search for those terms. Further on it illustrates that missed sales opportunities will translate to lower sales velocity. In this case, lower sales velocity will result in lower listings' ranking, depends on multiple factors, but sales volume represents one of the key elements when gaining ranking is concerned [11]. It is still unclear how does, Amazon rank product, and what other metrics besides sales it uses to grant sellers with better market positioning [12]. Besides this, there are many unfamiliar information regarding Amazon's A9 Algorithm, which will in this paper be deployed as a methodological approach to better understanding listings positioning on Amazon SERP's, since there are many speculations in the wider public regarding its functioning.

3 Methodology

The popularity which e-commerce sites have gained in the past period has reshaped users' shopping habits and as a result, users' preferences have shifted towards spending more time shopping online [13]. Most of the e-commerce organizations use certain recommendation systems to be able to suggest products to their customers. These recommendations are based on multiple criteria such as the top sellers on a site, demographics of the customer, analysis of the prior purchasing behavior, etc. These systems generate different recommendations to suit different users' needs, thus providing a customized web interface to them. At the moment most of the e-commerce organizations have adopted their systems at the back end, offering suitable web recommendations to their customers. In this sense, a recommendation system is deployed as a type of decision support system created to explore user preferences, and to analyze them so it can predict their needs and preferences. They provide information to customers by their taste within a given product category [14]. This amount of data also referred as to "big data" implies to flood of digital information from various sources, including sensors, digitizers, scanners, numerical modeling, mobile phones, Internet, videos, e-mails, and social networks. It includes texts, geometries, images, videos, sounds and combinations of each [15].

Amazon as one of the leading e-commerce platforms uses intelligent searches and recommendation algorithms to reach potential customers and enhance its business even more. Since Google's and Amazon's search algorithms differ significantly, Amazon sellers have to understand the working principles of its functioning to be able to increase their visibility on Amazon search pages. A9 algorithm predicts how relevant are the customers, analyses their buying behavior and shows them competitive prices of other products together with other buying opportunities. Some of the other elements considered by A9 functioning that helps with visibility increasement of brands also take into account sales ranking of similar listings (as mentioned above, increased sales volume in a particular category will result in ranking), sellers past sales record, customer reviews, clarity in image and information of the products, completeness of product information etc. [16]. Although it is not completely accurate whether these elements can be concerned as the most crucial ones when wanted ranking establishment is concerned, we will use them as the starting point in order to gain better understanding of algorithms' working principles. In the following section these KPI's will be discussed since they are considered as the most relevant factors for products' successful listing positioning on Amazon's SERP and can be described as the main elements taken into account by A9 Algorithm, which will therefore be used as a methodological approach deployed within this research.

4 Results

So far, both business professionals and academics were not able to completely understand, what are the main elements required for gaining and maintaining wanted listing positioning at the SERP. Regardless, based on existing papers and Internet posts by researchers and business professionals, we were able to map certain elements most frequently mentioned, which can be taken into consideration for analyzing listing positioning on online market places with special emphasis on Amazon.

4.1 Main Factors for Products' Positioning on Amazon's Top Pages

Multiple elements in accordance to Amazon's A9 algorithm have to be taken into consideration when products' positioning has to be analyzed. These elements are related to the following indicators:

- Products' sales. With an 8% increase in competition on Amazon in comparison to the previous year, it is possible to conclude that more online sellers are changing their products' prices more often, seeking and scouting for new products niches, optimizing their marketing strategies in order to reach their business goals, and automating their business processes and systems in order to focus on increasing profitability [17]. As previously mentioned, high sales indicate products' higher ranking on Amazon. A9 algorithm takes into account the volume of sales, the sales velocity and the conversion rate of the products in their respective categories [18].
- Products' prices. The rapid development of e-commerce has enabled an application for algorithmic pricing approaches, which is frequently referred to as a dynamic pricing algorithm or Revenue/Yield Management. This pricing strategy is not possible to implement in traditional retail surroundings since the data such as competitors' prices are scarce and also due to physical boundaries such as manual relabeling prices on products. Unlike traditional retail organizations, e-commerce has no constraints by physical limitations, and real-time data collection regarding customers and competitors [19]. Dynamic pricing strategy has widely been adopted in revenue management literature, with the deployment of applications mainly in travel and fashion industries [20]. Amazon's experience with dynamic pricing, whether it intended to engage in this behavior or not, suggests that customers negatively reacted to paying different prices for the same products [21]. In that sense, repricing is the most frequently used strategy by Amazon sellers so they can match up to the other marketplace competitors [22]. They deploy these strategies both manually and automatically through the usage of AI-based tools. Average prices of the top 75 items for a certain keyword and when sales prices were compared it was noticeable that top 3 ranked items had their prices 20% lower than the rest of the observed items [23].

– Title length. According to some of the recent research [24], although Amazon allows sellers to create titles as long as 200 characters, optimum title size should be in the range between 74 – 100 characters, so all the key terms can be visible on various devices used for products browsing. Another research [16], suggests that the title should contain the following elements.

$$Brand\,Name + Series\,Name + Model\,Name + Form\,Factor + Unique\,Identifier$$
$$(color,\ capacity,\ pack\,size,\ etc.)$$

Based on analysis on the top 100,000 keywords [25], 65% of the queries on Amazon were short, two- to three – word queries, while searches on engines like Google tend to run longer and are constantly changing:

– Web content. A9 algorithm also examines products' descriptions to rank the product and gives extra weight to the bullet points. Bullet points play a significant role in converting customers, especially ones on desktop, where they can be seen at the top of the product page [26].
– Products' images. A famous study from 2014 presented by Google, the eye-tracking study found that most users looked at pages in an elongated "F" shape, with almost all users starting at the left and looking across and then down. This large study demanded from participants conduct various searches using Google on a desktop [27]. In this sense, Amazon users should focus on making the first impression on sales pages as appealing as possible to potential customers to attract more clicks which can eventually result in higher conversion rates.
– Customer reviews. Product reviews ate the way for business managers and customers to interact with other customers [28]. Research showed that 80% of online shoppers read other customers reviews before eventually making a purchase decision [29]. Often, reviews for almost all e-commerce marketplaces are sorted based time when the product was reviewed. Amazon introduced a new way of sorting mechanism for customer reviews referred to as its top reviews. At the top, further filtration of the reviews can be done based on categories such as all positive reviews, all negative reviews, or reviews with star ratings [30].
– Sponsored posts. Sponsored products appear directly in the regular or "organic" search results on Amazon. Online shoppers that visit Amazon to purchase some products can see suitable advertisements for their keyword during the search and acquirement process [12]. Average ACoS (Advertising Cost of Sales) for 2018 was 30.1%.

$$\mathrm{ACo}S = Total\,Ad\,Spend \,/\, Total\,Sales$$

4.2 Amazon in Europe

E-commerce in Europe is supposed to reach €621 billion, which would represent an increase of 13.6%. The average spending of European online shoppers was 1346€ in 2018, whereas it is forecasted to grow this year and reach 1464€ in 2019 [31]. The conditions for e-commerce differ across Europe, and the countries of Europe are not on the same stages of their e-commerce acceptance. European countries also differ in terms of population size, which affects the size of their e-commerce market [32]. E-commerce sales in Europe reached 534 billion euros in 2017. Most of this turnover was generated in Western Europe, which represents 68% of total European online retail turnover. Southern Europe, Northern Europe, and Eastern Europe have much lower participation in European e-commerce with 12%, 8% and 6% [33]. E-commerce continues to grow throughout Europe and today as many as 270 million people say that they shop online. The German economy is one of the greatest economies in the world with a total share of 4.54% of the global economy. Therefore, Germany takes the biggest share of the e-commerce industry in Europe. Amazon is the most popular online marketplace in Germany, with a net revenue of €8,816,700,000 [34]. In addition to this, the EU, Germany's market alone grew almost 25% annually, making over $14 billion and accounting for 10.4% of Amazon's entire company revenue – qualifying it as the second largest Amazon marketplace in the world [35]. Today, Amazon's top five EU marketplaces (the UK, France, Italy, Spain, and Germany) attract around 85 million visitors monthly, compared to the 100 million visitors who visit Amazon.com each month.

5 Conclusion

Due to a high level of market saturation, it is very important for Amazon sellers to rank their offers as good as they possibly can to reach and maintain good wanted sales volume. Because of ferocious competition, listings optimization in terms of prices, images, head titles and web content, sponsored posts, images, etc. has to be extraordinary if sellers want to draw attention to their offers on Amazon. This can be achieved by constantly following the newest trends and technological changes by Amazon such as the A9 algorithm. Constant competition monitoring and offers updates stand for the most important elements when product positioning is regarded. By permanently seeking for new market opportunities to attract more customers, retailers who base their business on online marketplaces such as Amazon will be able to gain more revenue and further develop their product portfolio. This paper gave a brief insight into key factors that have to be polymerized into one single element, which will make a certain listing to always be competitive among numerous other offers in the marketplace. This paper will contribute to the ever-growing literature concerning functional aspects as well as key success indicators which will help future companies which will base their business operations solely on online marketplaces such as Amazon. In that sense, the most important findings of our study were exactly the elements which contribute to gaining as well as maintaining competitive advantages amongst other online sellers with special emphasis on ranking establishment as one of the main KPI's which is the result of carefully drawn strategic decisions and market analysis of online sellers, which has a potential of providing online businesses with better understanding of the way key performance indicators affect listings' performance.

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Digital Transformation Project Portfolio Selection/Prioritization: Literature Review and Future Directions

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Abstract. Due to the necessity in using digital transformation for agility and performance optimization, companies seek to involve it in their project's portfolio. However, the biggest difficulty for companies nowadays is to prioritize their projects, so that the portfolio contains projects of greater value and better cost benefit to the company. This difficulty exists because of the various conflicting criteria that need to be taken into account when prioritizing. Since Multi-Criteria Decision-Making (MCDM) methods have the purpose of finding the best alternative, in cases involving multiple criteria, the objective of this article is to carry out a literature review and verify which methods are used to projects portfolio selection or prioritization, encompassing digital transformation projects.

Keywords: Project portfolio selection · Project portfolio prioritization · Multi-criteria decision-making · Digital transformation projects

1 Introduction

Nowadays, companies are using digital transformation in order to improve agility and optimize business performance. A digital transformation project involves the implementation of digital resources to aid the transformation of business models [1].

Project Portfolio Selection (PPS) is considered a decision of high importance to achieve the objectives of an organization [2]. However, PPS is considered complex because of his various selection factors and criteria that need to be considered [3].

Multi Criteria Decision Making (MCDM) is a process that has the purpose of finding the best alternative among all the alternatives that are considered adequate [4]. The MCDM methods are decision making support techniques that have a finite number of alternatives, as well as a set of objectives and criteria by which the alternatives must be evaluated, and a method of classifying alternatives, based on the level of objectives and criteria satisfaction [5].

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The objective of this article is to study MCDM methods for the project's portfolio selection or prioritization that currently exist in the literature, in particular, portfolios of digital transformation projects.

2 Background

In this section of the paper, the background is presented, which is divided into the following four topics: Project Portfolio Management; Digital Transformation Projects; Projects Selection and Prioritization; and Multi-Criteria Decision-Making Methods.

2.1 Project Portfolio Management

According to PMI [6], project consists of a temporary effort to create a unique product, service or result, that is, projects have an established beginning and end. Still, PMI makes it clear that temporary projects can be considered short or long term and that most projects are carried out with the aim of creating a longstanding result. With regard to portfolio, PMI defines it as a collection of projects or programs that are grouped in order to facilitate its effective management, so that projects can be aligned with the strategic objectives of the company. According to Archer and Ghasemzadeh [7], project portfolio can be defined as a group of individual projects, which run simultaneously and compete for scarce resources.

Project Portfolio Management (PPM) encompasses the coordination and control of multiple projects that have the same strategic business objectives and also compete for the same resources. In this way, managers need to prioritize projects in order to achieve greater strategic benefits [8]. PPM can be considered a central way for companies to manage the development of their products efficiently and effectively [9]. According to [10], a good PPM is becoming a fundamental competency for companies that work with several projects at the same time. Cooper et al. [11] states that current literature stresses the importance of project portfolio management in evaluating, prioritizing and selecting projects according to business strategy.

2.2 Digital Transformation Projects

Recently, industries are facing technological changes and getting the need to respond quickly to demands due to market instability. In order to improve agility and optimize business performance, organizations are using digital transformation [1]. According to [12], digital transformation consists of a business model management through changes related to the application of digital technology. It becomes possible to automate processes, increase operational efficiency and gain productivity through opportunities related to the technologies advancement, such as intelligent systems for capturing, managing and analysing data and information [13]. According to [1], a digital transformation project consists in the implementation of digital resources to assist the transformation of business models.

2.3 Projects Selection and Prioritization

Project portfolio selection is the periodic activity involved in selecting a portfolio based on available and ongoing project proposals that meets the stated objectives of the organization in a desirable manner, without exceeding available resources or violating other constraints [7]. Still according to [7], the portfolios selection involves the simultaneous comparison of several projects in specific dimensions, in order to obtain a desirable sequential classification of projects.

2.4 Multi-criteria Decision-Making Methods

According to [14], problems related to multi-criteria decision making (MCDM) can be classified into multi-objective decision making (MODM) or multi-attribute decision making (MADM). Still according to the authors, a criterion is the basis for a decision, and it can be measured and evaluated. Multi-attribute decision making methods are data-driven. An attribute is considered a concrete descriptive value, a measurable characteristic of an entity. Multi-attribute techniques are called discrete methods, since the number of alternatives is explicit [15]. The multi-objective methods are oriented to mathematical programming models, where the alternatives, identified by the resolution of a multi-objective mathematical programming problem, must be generated [16]. According to [17], MCDM are complex because it involves technical, institutional, standards, social and economic factors, as well as stakeholders. The author still claims that MCDM is controversial, once the objectives can lead to different solutions, depending on time and on priorities established by the decision makers.

3 Methods

In order to carry out a more profound and well-structured literature review, selecting relevant articles to the bibliographic portfolio composition, the Knowledge Development Process – Constructivist (ProKnow-C) method was used. This method consists of a recognized scientific process for the modeling of a theme that allows to meet the specific objectives of the researcher [18]. The ProKnow-C method consists of four steps, however, for this paper, only the bibliographic portfolio selection was required. For the development of this stage, several steps must be taken to direct the researcher to the selection of the main and most relevant articles on the approached subject. Firstly, the research axes of the article were defined: Project Portfolio Selection/Prioritization; Multi-criteria Decision-Making Methods; and Digital Transformation Projects. These axes are in line with the objective of this article, which is the search and the study of multi-criteria decision-making methods used for the selection or prioritization of project portfolios that currently exist in the literature, with a greater focus on digital transformation projects. In second place, the keywords and, consequently, their combinations were defined in order to form the research strings. For this paper, the following strings were used:

– ((“Project selection” OR “Project prioritization”) W/10 “Portfolio” AND (“Multi-criteria decision making” OR “MCDM” OR “Multi-attribute decision making” OR “MADM” OR “Multi-objective decision making” OR “MODM” OR “Multi-criteria decision aid” OR “Multi-criteria decision analysis” OR “MCDA”));
– ((“Project portfolio selection” OR “Project portfolio prioritization”) AND (“Multi-criteria decision making” OR “MCDM” OR “Multi-attribute decision making” OR “MADM” OR “Multi-objective decision making” OR “MODM” OR “Multi-criteria decision aid” OR “Multi-criteria decision analysis” OR “MCDA”)).

The third step consists of selecting the databases for the research. After a brief study, six different databases were chosen for this article: Scopus, Science Direct, Web of Science, Emerald, Taylor & Francis and Wiley. In the sequence, the database research process was started through the use of the selected strings. As a result of the researches, using filters to search for articles only in English and with publication date between 2010 and 2019, a total of 781 articles were obtained. Through the use of the tools EndNote and Microsoft Excel, duplicate articles were identified and eliminated, reducing the total amount to 556 articles. Afterwards, the titles of these 556 articles were analyzed, in order to verify the alignment with the objective of the present work. In this screening, 299 articles were eliminated, leaving 257 articles with titles aligned to the theme. In the next step, the number of citations of each article was surveyed through Google Scholar, in order to separate them in different repositories. Articles with 12 citations or more were considered articles with confirmed scientific acknowledgment and were added to the K repository. Articles with less than 12 citations were considered articles with scientific acknowledgment not confirmed and were added to the P repository. Afterwards, the summary lecture of the 106 articles in the K repository was realized and only summaries that were aligned with the theme were added to the A repository. The articles from the P repository were classified by the publication date and the papers with less than two years were analyzed based on the alignment of the abstract with the theme, forming the B repository. Articles with more than two years were analyzed based on their authors, that is, only the articles in which the authors were the same from the A repository articles followed to the next step and then, were analyzed by the alignment of the abstract with the theme. The papers which had relation with the theme were also scaled to the B repository. In the sequence, the A and B repositories were unified, molding the C repository, which obtained a total of 96 articles, however only 83 articles were in full disposal. Therefore, these articles were fully read and, finally, 10 articles were selected to compose the bibliographic portfolio of this paper, seeing that only these articles possess relation with digital transformation projects. In Fig. 1 down below, is represented the research process carried out using the ProKnow-C method.

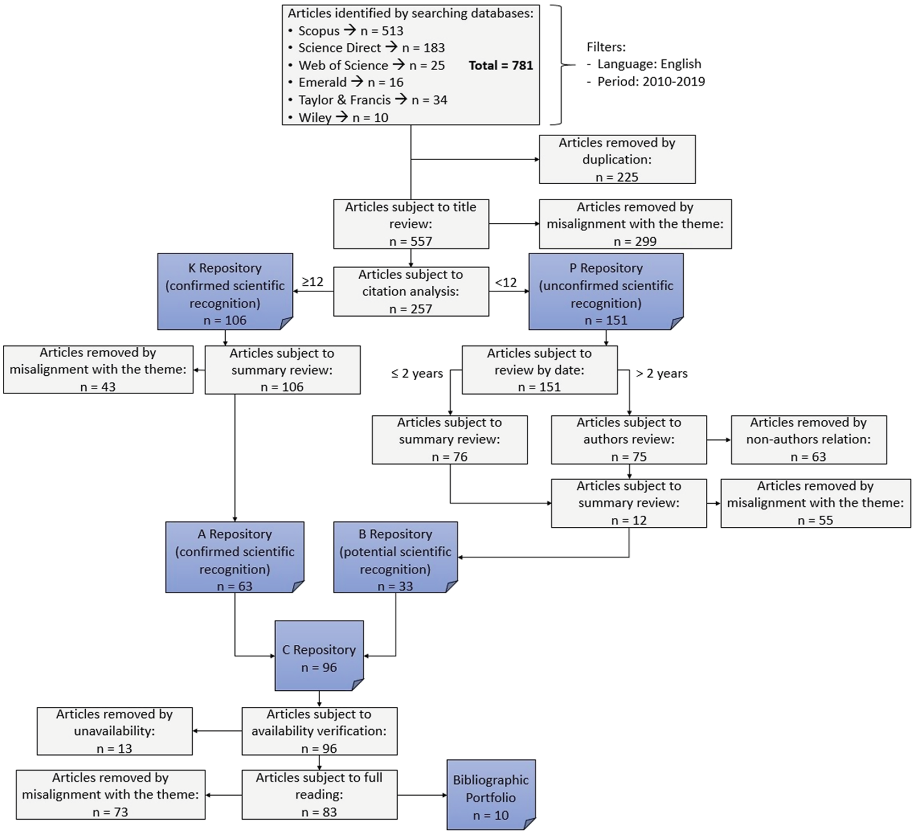

Fig. 1. Research process using the ProKnow-C method.

4 Results

After using the ProKnow-C method, with the intention of creating a bibliographic portfolio of articles that are aligned with the paper theme and that possess any type of relation with digital transformation projects, a total of 10 articles were obtained. Basic informations from these articles, as name, authors and publication year, can be observed in Table 1.

Table 1. Articles that compose the bibliographic portfolio of this research.

Item	Article name	Authors	Year
1	A methodology for selecting portfolios of projects with interactions and under uncertainty	Ghapanchi, A.H.; Tavana, M.; Khakbaz, M.H.; Low, G.	2012
2	A fuzzy group data envelopment analysis model for high-technology project selection: a case study at NASA	Tavana, M.; Khalili-Damghani, K.; Sadi-Nezhad, S.	2013

(*continued*)

Table 1. (*continued*)

Item	Article name	Authors	Year
3	A hybrid fuzzy group decision support framework for advanced-technology prioritization at NASA	Tavana, M.; Khalili-Damghani, K.; Abtahi, A.-R.	2013
4	A multi-attribute group decision support system for information technology project selection	Zandi, F.; Tavana, M.	2010
5	A fuzzy multi-criteria decision analysis model for advanced technology assessment at Kennedy Space Center	Tavana, M.; Sodenkamp, M.A.	2010
6	Fuzzy multicriteria decision support for information systems project selection	Yeh, C.H.; Deng, H.; Wibowo, S.; Xu, Y.	2010
7	Implementation of new hybrid AHP-TOPSIS-2N method in sorting and prioritizing of an IT CAPEX project portfolio	De Souza, L.P.; Gomes, C.F. S.; De Barros, A.P.	2018
8	The WINGS method with multiple networks and its application to innovation projects selection	Michnik, J.	2018
9	A mathematical modeling approach for high and new technology-project portfolio selection under uncertain environments	Mohagheghi, V.; Mousavi, S. M.; Vahdani, B.; Siadat, A.	2017
10	Intuitionistic fuzzy multicriteria group decision for evaluating and selecting information systems projects	Ma, B.; Tan, C.; Jiang, Z.-Z.; Deng, H.	2013

The article “A methodology for selecting portfolios of projects with interactions and under uncertainty” has the objective of selecting the best project portfolio of information systems and technologies (IS/IT), taking into account the uncertainties and interactions of the projects, simultaneously. To achieve the article objective, the authors used a mathematical programming model called Fuzzy DEA (FDEA). They affirmed that the DEA model is widely used to compare the inputs and outputs of a set of homogeneous Decision-Making Units (DMUs). According to the authors of the paper, “the DEA generalizes the usual efficiency measurement from a single-input single-output ratio to a multiple-input multiple-output ratio by using a ratio of the weighted sum of outputs to the weighted sum of inputs”. The method proposed by the authors incorporates 4 steps: problem modeling; projects evaluation and selection using the FDEA model; generation and determination of the best portfolios; and evaluation of the best portfolios using the FDEA model. The article was capable of selecting the most efficient project portfolio among all the options, according to established criteria [19].

The second article from the bibliographic portfolio, called “A fuzzy group data envelopment analysis model for high-technology project selection: A case study at NASA” aims to propose a data envelopment analysis (DEA) model with ambiguity and imprecision, with the intent to analyze and select projects involving high technology. The authors demonstrated the applicability of the proposed model and the effectiveness of the procedures through a case study involving the selection of high technology projects at NASA. According to the authors, the process of evaluating high technology projects at NASA involves considerations of budget, schedule, security, reliability, feasibility, and reuse. They claim that the evaluation and selection of high technology projects is usually a difficult process of decision making due to multiple and conflicting objectives. According to the authors, their approach helped decision-makers to think systematically about complex problems and improve the quality of their decisions [20].

The article “A hybrid fuzzy group decision support framework for advanced-technology prioritization at NASA” has an objective very similar to the previous paper, which is the proposal of a hybrid fuzzy group decision support framework for technology evaluation at NASA. However, the model proposed in this article is divided into two modules. In the first one, is performed a representation and analysis of the criteria and alternatives of prioritization through the Analytic Network Process (ANP). In the second module, advanced technology projects are classified using the Fuzzy Technique for Order or Preference by Similarity to Ideal Solution (TOPSIS) model. According to the authors, the proposed model is very well defined and structured, as well as simple and transparent, with a direct calculation process. Furthermore, the authors evaluate this method as realistic and practical, as it has the capacity to deal with imprecision in the problems of technology evaluation in the real world and can be applied to other prioritization problems that involve multiple criteria [21].

The fourth article of the bibliographic portfolio, called “A multi-attribute group decision support system for information technology project selection” aims to propose an embracing multi-attribute decision-making (MADM) approach, targeting the selection of information technology (IT) projects. According to the authors, the selection of IT projects that extend business objectives has become a complex task, as IT and global complexity have grown rapidly, with a higher number of conflicting and multiple alternatives and attributes. According to the authors, the proposed approach considers quantitative and qualitative attributes, as well as the interdependencies between projects, through the TOPSIS model, with multi objective decision making (MODM). MADM is used to classify IT projects according to several attributes. According to the authors, the case study showed that the proposed hybrid model can generate valuable information that can help decision makers to consider conflicting objectives and evaluate competing alternatives [22].

The article “A fuzzy multi-criteria decision analysis model for advanced technology assessment at Kennedy Space Center” aims to propose a decision-making model for the selection of advanced technology projects. The authors proposed the use of the Fuzzy Euclid model, which uses AHP, subjective probabilities, defuzzification, entropy and displaced ideal theory to reduce the complexities of decision making, decomposing the project evaluation process into manageable steps. This decomposition, according to the authors, encourages decision-makers to carefully consider the elements of uncertainty, improving the quality of their decisions [23].

The sixth article of the bibliographic portfolio, called “Fuzzy multicriteria decision support for information systems project selection” has the purpose of presenting an efficient multicriteria decision-making approach to the problem of selection of information systems (IS) projects. According to the authors, the evaluation and selection of IS projects is a complex process, since it involves different decision makers and multiple evaluation criteria. The authors formulated an effective algorithm, which is simple and applicable to the general problem of evaluation and selection, involving several criteria [24].

The article "Implementation of new hybrid AHP-TOPSIS-2N method in sorting and prioritizing of an IT CAPEX project portfolio" aims to propose a hybrid multi-criteria decision-making model for the prioritization of the portfolio of IT CAPEX projects. According to the authors, the implementation of the proposed model contributed with greater clarity and structure of the decision-making process and the model application obtained more consistent and aligned results with the strategic objectives of the organization. The AHP method made it possible to define decision-making criteria in a practical and robust way, while the TOPSIS-2N method allowed the ranking obtention in a harmonious, consistent and conciliatory way. The authors stated that the proposed model allowed the project prioritization problem to be handled efficiently, with optimal resources allocation and a high degree of alignment between the company's strategic objectives [25].

The eighth article of the bibliographic portfolio, called "The WINGS method with multiple networks and its application to innovation projects selection" aims to propose a weighted influence nonlinear gauge system (WINGS) method for the selection of innovation projects. According to the author, the WINGS method is implemented in five phases. First, there is a preliminary selection of innovation projects. In the sequence, the important objectives are identified. Third, four WINGS networks are developed. In the next step, using the project classification given by the complete model, the user is able to make a rational decision. Finally, the results of the model aided by robustness analysis are discussed. According to the author, this method is complete and can serve as the standard model for real-life applications [26].

The article "A mathematical modeling approach for high and new technology-project portfolio selection under uncertain environments" proposes a portfolio selection approach of high technology projects, whose application takes place in two parts. First, a multicriteria risk reduction model is used, which avoids the loss of information capable of reviewing and classifying projects. The second part consists of a project portfolio selection model, based on interval type-2 fuzzy sets (IT2FSs), which considers investment requirements and human resource necessities simultaneously, allowing the choice of the best portfolio of high technology projects. According to the authors, the use of the uncertainty modeling tool gives a practical advantage over the existing classical models [27].

Lastly, the tenth article in the bibliographic portfolio, called "Intuitionistic fuzzy multicriteria group decision for evaluating and selecting information systems projects" aims to present an intuitionist approach to multicriteria decision-making in order to adequately model the subjectivity and imprecision of the decision-making process. According to the authors, the proposed method uses TOPSIS based on Choquet, which is able to determine the overall performance of information systems projects, leading to more effective decision making [28].

Therefore, in Table 2, it is possible to observe the MCDM methods founded in each article of the literature, as well as their applications.

Table 2. MCDM methods founded in the literature and their applications.

Item	MCDM methods	Application in the article
1	Fuzzy DEA	Selection of the best project portfolio of information systems and technologies (IS/IT)
2	Fuzzy DEA	Analysis and selection of projects involving high technology, through a model that considers ambiguity and imprecision
3	ANP and fuzzy TOPSIS	Evaluation and prioritization of advanced technology projects
4	TOPSIS and MADM approach	Classification and selection of information technology (IT) projects
5	Fuzzy Euclid	Selection of advanced technology projects, taking into consideration elements of uncertainty
6	Algorithm formulation	Evaluation and selection of information systems (IS) projects
7	AHP and TOPSIS-2N	Prioritization of IT CAPEX projects portfolio
8	WINGS	Selection of innovation projects, through a robustness analysis
9	Multi-criteria risk reduction model and IT2FSs	Portfolio selection approach of high and new technology projects under uncertain environments
10	TOPSIS based on Choquet	Determination of the overall performance of IS projects to an adequate evaluation and selection process

5 Conclusion

The objective of the present paper was to develop a literature review, in order to verify which multicriteria methods are used to select or prioritize projects portfolio, specifically, projects involving digital transformation. In order to reach the objective of this paper, the ProKnow-C method was used to search for articles, with the intention to carry out a more profound and well-structured literature review. After completing the ProKnow-C method, a total of 10 articles was reached, which compose the bibliographic portfolio.

A similarity found among the searched articles is the authors affirmation about the current difficulty in selecting or prioritizing a project portfolio. Tavana et al. [20] state that the evaluation and selection of high technology projects is a difficult decision-making process due to multiple and conflicting objectives. Zandi and Tavana [22] affirm that the selection of IT projects has become a complex task due to the rapid growth of IT and global complexity. In addition, Yeh et al. [24] claim that the evaluation and selection of IS projects is a complex process, due to the different decision makers and the multiple assessment criteria. The articles found have often dealt with fuzzy methods, such as 7 of the 10 articles that compose the bibliographic portfolio. Still, 3 of the 10 articles used hybrid methods for the complete selection of project portfolio.

As directions for future works, it is recommended to perform a more profound analysis of digital transformation projects, by surveying their specific attributes, in order to verify which multicriteria decision-making method best suits these types of projects. Studies that deal with the accomplishment of case studies to verify the effectiveness of multicriteria methods are also suggested, seen that through the development of this paper, only 10 articles that have some type of involvement with portfolio selection of digital transformation projects were founded in the literature.

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Enterprise Architecture Requirements for Digital Transformation Projects in an Automotive Industry

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Abstract. The adoption of Industry 4.0 technologies and it's concepts are helping develop more collaborative, connected, and intelligent production systems. In particular, IT projects have used a digital transformation approach to deploy such technologies in different types of companies, including the automotive sector. The digital transformation literature has extensively focused on the required technical knowledge for the implementation of new technologies and associated concepts. However, the literature does not present an approach that focuses on the integration of these technologies and concepts with other business elements such as strategy and processes, leading to a more interoperable organizational environment. By definition, this is the realm of enterprise architecture (EA), whose main concern is to align IT strategies with business strategies, considering the resources and processes necessary to implement those strategies, and allowing the required integration of the elements that can act together in a dynamic business environment. This paper helps bridge the gap between the alignment of technology and business in digital transformation projects by proposing an extended list of EA requirements or attributes based on existing frameworks. A content analysis of the literature for the extraction of the main characteristics of digital transformation projects was performed, considering aspects of Industry 4.0 and EA frameworks as background. As a result, the characteristics that best fit within the EA frameworks are grouped, deriving an extended list of EA attributes oriented for digital transformation projects.

Keywords: Enterprise architecture · Digital transformation · Industry 4.0

1 Introduction

The concepts and technologies associated with Industry 4.0 are experiencing exponential growth in the application to the development of more collaborative, connected and intelligent production systems. Although digital transformation has been much discussed in both literature and industry, the theme encompasses several new concepts tied to new technologies, which require technical knowledge for implementation.

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According [1], conceptually I4.0 is a view of a fully interoperable system where highly automated and connected machines communicate with each other and with all sorts of components they process, pre-produce and provision through the supply chain. In the Industry 4.0 era, manufacturing systems are able to monitor physical processes, create a so-called "digital twin" (or "cyber twin") of the physical world, and make smart decisions through real-time communication and cooperation with humans, machines, sensors, and so forth [2]. Industry 4.0 combines embedded production system technologies with intelligent production processes to pave the way for a new technological age that will fundamentally transform industry value chains, production value chains, and business models [3]. Many organizations find it difficult to understand the concepts of Industry 4.0 and how to relate them to their organizational architecture, leading to failure in identifying possible new projects. One of the main goals of building an enterprise architecture is to align the business perspective with enterprise IT [4].

The objective of this work is to identify an extended list of enterprise architecture (EA) qualifying attributes oriented for digital transformation projects. More specifically, this paper aims to: (i) provide a background, literature and theoretical review, gathering main concepts, models, and frameworks; (ii) define the attributes based on the literature and in a knowledge extraction process.

The identification of the preliminary attributes occurs with a quantitative and qualitative approach. Initially a literature review of the subject was carried out, addressing elements of Industry 4.0, Digital Transformation and Enterprise Architecture. The papers were then analysed, and a list of extended EA attributes were extracted based on existing frameworks.

In the next section, we review background knowledge about digital transformation and enterprise architecture. In Sect. 3, the methodology of this study is introduced. Section 4 lists the EA attributes extracted and grouped into the four EA domains. Section 5 concludes the paper.

2 Background

2.1 Digital Transformation

Digital transformation is defined as "the use of technology to radically improve performance or reach of enterprises" [5]. Another well-known definition of the term is that it "is achieved when the digital usages which have been developed enable innovation and creativity and stimulate significant change within the professional or knowledge domain" [6].

The term Industry 4.0 (I4.0), also known as smart manufacturing, was first mentioned at the Hannover fair in 2011. [7] summarizes industry 4.0 as an integrated, adapted, optimized, service-oriented, and interoperable manufacturing process which is correlate with algorithms, big data, and high technologies. It facilitates inter-connection and computerization into the traditional industry. According to [8] the modelling and virtualization/visualization technologies have been the two most frequent enabling technologies applied to support the realization of Industry 4.0. The goals of Industry 4.0 are to provide IT-enabled customization of manufactured products; to make automatic and flexible adaptation of the production chain; to track parts and products; to facilitate communication among parts, products, and machines; to apply human-machine interaction (HMI) paradigms; to achieve IoT-enabled production optimization in smart factories; and to provide new types of services and business models of interaction in the value chain. Regarding the features, Industry 4.0 can provide more flexibility, reduce lead times, customize with small batch sizes, and reduce costs [9].

Although organizations realize the opportunities they can derive from the digital transformation, they are finding it difficult to put it into practice and succeed it [10]. They face the complex realities of implementation ranging from introducing new CPS and smart factories technologies and applications to adapting or replacing core enterprise architectures (EA), ICT infrastructures and processes. As the digital wave is hitting, adopting a standardized approach to frame and execute digital transformation initiatives is important to be fruitful. Companies need to establish frameworks, methods and management practices to govern the IS evolution. The horizontal, vertical and end-to-end integration in industry 4.0 [11] requires changes in enterprise architecture, ICT integration and processes [12].

Since 2013, many consultancies specialized in the theme have disclosed Industry 4.0 frameworks. In the present paper we will use the Acatech Maturity Index which has been widely applied to implement digital transformation in organizations. This Maturity Index helps companies to determine which stage they are currently at in their transformation into a learning, agile company. It assesses them from a technological, organisational and cultural perspective, focusing on the business processes of manufacturing companies. The road towards Industry 4.0 will be different for every company. It is therefore necessary to begin by analysing each company's current situation and goals. Questions concerning the company's current situation include what its strategic objectives are for the next few years, what technologies and systems are already implemented and how they operate within the company. The answers to these questions can be used to determine which capabilities the company still needs to acquire in order to successfully introduce Industry 4.0 [13].

This method results in the formulation of a digital roadmap for all the relevant areas with a step-by-step approach to achieving the benefits that reduces the investment and implementation risks for the company. The roadmap helps companies to understand the importance of developing a common digital strategy for the whole business. The maturity index is divided into organisational areas and functional areas. These organisational areas outline the key organisational capabilities required by an agile company in Industry 4.0. The framework also illustrates potential development goals for current corporate functions in the form of visions [13]. The Acatech Industry 4.0 Maturity Index has been used to help many organizations master the digital transformation across all the involved relevant business units. For that matter, a study regarding this framework was conducted. The main characteristics were analysed, and a list of digital transformation attributes was extracted.

2.2 Enterprise Architecture

An enterprise architecture (EA) presents the structure of an enterprise and consists of the main enterprise components such as a company's goals, organisational structures, information infrastructure and business process. It helps the organization determining how it can effectively achieve its current and future goals. The performance of an enterprise, such as innovations generated within the company, the re-engineering of business processes, and the quality and timeliness of information flow, can be improved if the EA system faithfully represents the characteristics and the nature of the organisation [14]. Enterprise architecture is the organizing logic for business processes and IT infrastructure reflecting the integration and standardization requirements of the company's operating model. Moreover, it is the backbone for enterprise and IS evolution [15]. According to [16], EA has been suggested as a discipline to ensure coherent structure, to make visible the underlying organizational system, and to facilitate change.

TOGAF is a comprehensive open EA standard which contains several components, amongst which, the Architecture Development Method (ADM) stands at its core. The ADM describes an iterative process for developing EA with the help of several phases (Preliminary phase, Architecture Vision, Business, Information systems, Technology, Opportunities and solutions, Migration planning, Implementation governance, Architecture change management, Requirements management).

Four architecture domains are covered by TOGAF:

- Business architecture,
- Data architecture,
- Application architecture and
- Technology architecture.

These are commonly accepted as subsets of an overall enterprise architecture. Business architecture focuses on the business strategy, governance, organization, and key business processes. While Data architecture approaches the structure of an organization's logical and physical data assets and data management resources. Application architecture creates a blueprint for the individual application systems to be deployed, their interactions, and their relationships to the core business processes of the organization. The Technology architecture works with software and hardware capabilities that are required to support the deployment of business, data, and application services. This includes IT infrastructure, middleware, networks, communications, processing, and standards [17].

The TOGAF framework, a standard of The Open Group, is a proven Enterprise Architecture methodology and framework used by the world's leading organizations to improve business efficiency [18]. Including the automotive industry where this study was conducted. For that reason, the framework was closely analysed and requirements regarding enterprise architecture were extracted.

3 Research Design

To establish the attributes orienting digital transformation projects, first a literature review of the subject was carried out, addressing elements of Industry 4.0, Digital Transformation and Enterprise Architecture. With the data obtained, a preliminary list of attributes was extracted. These were submitted for a relational analysis, resulting in a final list of enterprise architecture requirements oriented for digital transformation projects. The three stages of the research approach are represented by an IDEF0 in Fig. 1.

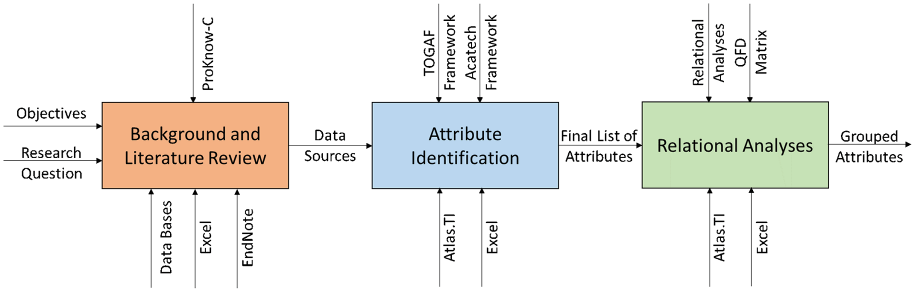

Fig. 1. IDEF0 of the research methodology (2019).

3.1 Systematic Literature Review (ProKnow-C Method)

This study follows the ProKnow-C method to conduct an efficient and well-structured systematic literature review [19]. The method was applied to investigate Enterprise Architecture requirements in the context of Digital Transformation. It consists of three main phases: (i) Initial investigation, (ii) Scientific Recognition of the Articles and (iii) Bibliometric Analysis. In this work, two research axes were selected, the first axe was represented by the keywords “Enterprise Architecture”, “TOGAF” or “Zachman” and the second axe contained the following keywords: “Digital Transformation”, “Industry 4.0”, “Industrie 4.0”, “Smart Factory” or “Fourth Industrial Revolution”.

In the first phase, these keywords were used to search within the published papers titles, keywords, and abstracts, collected from Scopus, Web of Science and Science Direct data bases, the search returned 260 results. After removing the duplicated articles, 199 results remained. All the titles were analysed, and all the unrelated papers were dropped, remaining 51 articles. For the second phase, composed of the scientific recognition of the articles analysis, a search on Google Scholar was conducted, and based on the results, the representativity of each article in the set of 51 papers was calculated. It was defined, as a threshold for the article to remain in the current portfolio, a representativity of at least 95%, which resulted in an amount of 19 articles.

These 19 articles were submitted to an abstract analysis, 13 of them presented a closer connection to the topic and raised a list of established authors, these were designated as “Group A”. In addition, 32 articles with less than 5 citations, were submitted to reanalysis for the period of the publications and by the relevance of the authors. Among the 32 articles under 5 citations, 27 articles of recent publication (2017 and later) were considered suitable for reading their abstracts. In addition, the authors of the 5 articles published prior to 2017 were correlated with established authors present in "Group A". From this last analysis, 2 articles were separated for abstract analyses. A total of 15 papers were selected to composed "Group B". These 15 articles together with the 13 articles included in "Group A", formed "Group C", which, after reading the full text, checking availability and alignment with the theme of the research, 28 papers were kept, becoming part of the bibliographic portfolio.

3.2 Attribute Identification and Relational Analysis

The preliminary list of attributes were derivatives of the three main data sources considered. Various requirements were identified from both frameworks, as well as from the systematic literature review. Among the 28 articles, four were identified as more adherent to the theme of this research. These four articles approached characteristics, requirements, capabilities and attributes for enterprise architecture frameworks for digital transformation [15, 16, 20, 21]. To extract the attributes from these four articles, the ATLAS-TI software was used. The papers were imported in the software and codes were created to categorize and identify the main requirements, characteristics, capabilities and attributes. As a preliminary result, 53 attributes were identified from the three data sources. All the attributes were analysed, and the requirements that had similar approaches were grouped together, resulting in a final list of 21 attributes. Lastly, a relational analysis between the attributes was carried out.

4 Results

The change from a closed-world modelling world to a more flexible open-world composition and evolution of enterprise architectures defines the moving context for adaptable and high distributed systems, which are essential to enable the digital transformation [22]. This work identified 21 EA attributes oriented for digital transformation projects. To organize the twenty-one attributes within the four EA domains, a relational matrix inspired in the QFD tool was constructed. The QFD (Quality Function Deployment) matrix was used to define the correlation between the attributes and the four EA domains. This tool was first used successfully by Japanese manufacturers of consumer electronics, home appliances, clothing, integrated circuits, synthetic rubber, construction equipment and agricultural engines, before American and European manufacturers started to use it within product development projects [23]. However, in practice, the QFD becomes widely applicable, since this matrix makes explicit the relations between the elements analysed [24]. The degree of correlation between attributes (attributes vs. EA domains) was evaluated by means of weights (1, 3, 6 and 9) assigned to each attribute, 1 being considered the correlation weak and 9 very strong. Then, the attributes with the highest weights in the considered aspect were allocated in each domain. The relational analyses between the 21 attributes and the four EA domains is represented in Table 1.

Table 1. Relational Matrix between the list of attributes and EA domains.

Attributes	Business architecture	Data architecture	Technology architecture	Application architecture
Application integration	1	3	6	9
End-to-end process integration and automation	3	6	6	9
Structured communication	3	6	6	9
Business modeling innovation	9	3	1	1
Flexible, robust and responsive services	9	6	6	6
Flexible communities	9	1	3	1
Stakeholder management	9	3	1	1
Agile management	9	3	3	3
Business principles, goals, drivers, and Key Performance Indicators (KPIs) validation	9	1	1	1
Organizational governance	9	1	1	1
Data integration	1	9	3	6
Architecture repository	6	9	1	1
Dynamic collaboration in value networks	3	9	1	1
Data migration	1	9	1	3
Data governance	1	9	1	3
Real-time data processing	1	9	6	6
Data-driven sensing and decision making	6	9	1	1
IT security	1	6	9	6
Digital capability	1	6	9	3
Hardware, software, and communications technology	1	3	9	3
Technology integration	1	6	9	6

With a total of seven attributes each, the Business architecture and Data architecture domains have the most attributes. The Business architecture domain is composed of the following attributes: “Business Modelling Innovation”, “Flexible, robust and responsive services”, “Flexible communities”, “Stakeholder Management”, “Agile Management”, “Business principles goals, drivers, and Key Performance Indicators (KPIs) validation” and “Organizational Governance”. The requirements “Data integration”, “Architecture repository”, “Dynamic collaboration in value networks”, “Data Migration”, “Data Governance”, “Real-time data processing” and “Data-Driven Sensing and Decision Making” were grouped in the Data Architecture domain.

The Technology Architecture is composed of the following four attributes: “IT Security”, “Digital capability”, “Hardware, software, and communications technology” and “Technology Integration”. Finally, the three attributes “Application Integration”, “End-to-end process integration and automation” and “Structured communication” were grouped into in the Application Architecture domain.

5 Conclusion

In conclusion, twenty-one enterprise architecture characteristics oriented for digital transformation projects were acquired. By performing a relational analysis inspired on the QFD tool, the main requirements each enterprise architecture domain is responsible for while implementing digital transformation projects were identified.

The research work in the next stage will focus on envisioning a framework that will assist enterprise architecture to approach digital transformation projects. To do so, the next step is to use the extended list of attributes to conduct a maturity assessment using multicriteria decision making methods (MCDM), under enterprise interoperability framework that will be carried out in the automotive company.

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Analysis of Possibilities for Improving Relationship Between Beer Producers and Distributors–Case of Serbia

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Abstract. The analysis of the satisfaction of beer customers has become a necessity since there is a very strong competition among about thirty beer producers on the Serbian market. Through the process of privatization of the domestic brewing industry in the first decade of the 21st century, a couple of the global beer brand producers have taken a share of the Serbian beer market, striving to increase market share through the supply of the high-quality products and the improvement of CRM in order to increase customers' satisfaction. In this paper has been researched the satisfaction of large beer buyers and distributors with the products of the three largest beer producers with the total share of 83% of the Serbian beer market. The research was carried out using a structured quantitative questionnaire, consisted of series of 5-point scales, which were used for evaluation of each indicator within 6 performance areas, plus one open-ended question per performance area with suggestions for improvement in the particular performance area. The questionnaire was delivered to the 100 large buyers and distributors and 43 of them or 43% of respondents completed the questionnaire. The analysis showed that distributors are mostly satisfied in terms of cooperation with these three beer producers and have not given any significant advantage to any of them. By analyzing the results of the survey it can be seen that 79% of the respondents stated that they will continue to cooperate with Company 1, 70% of the respondents stated the same for Company 2, while only 57% of the respondents pleaded for a certain continuation of cooperation with the Company 3.

Keywords: Beer producer · Distributors · Satisfaction

1 Introduction

In the last decade beer production and consumption on the beer's largest markets such as The USA, Germany, France and UK stagnated or even fell [1, 2]. China, The USA, Brazil, Mexico and Germany currently represent the top 5 producers of beer across the world. Per capita consumption by Germans, who are some of the world's biggest consumers of beer, has been falling consistently since 1990 [3]. There are a lot of factors influencing this trend of decreasing beer consumption worldwide such as demographic changes, the emergence of alternative beverage categories like wine, cider and health-promoting drinks, changing consumers' preferences, tighter regulatory and

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taxation measures, etc. [4]. At the same time emerging beer markets records growth rates which attract global beer producers to invest in these markets in order to increase production and market share. Emerging markets such as China, India, MENA (Middle East and Africa), Latin America and Europe currently represent the key drivers of the global beer market [5].

Although there is about 30 beer producers offering 40 beer brands on the Serbian beer market, it should be noticed that this market is highly concentrated having in mind that three main beer producers have total market share of 83%, while eight main beer producers have total market share of 95%. According to the Association of Breweries of Serbia total beer production in Serbia is about 5 million hectoliters yearly and 20% of production has been exported. After a couple of crisis years in the Serbian beer industry have been emerged dozens of small craft beer breweries and microbreweries that have promoted domestic beer industry.

Beer producers usually organize self-distribution when they sell products on a relatively small market or geographical area or have limited funds. Increasing popularity of brand and increasing demand as well as competition with other beer brands outside local beer market, stimulate beer producer to choose a distributor and establish a distribution agreement. Each of three analyzed beer producers on Serbian market have contracts with a third-party wholesalers or distributors.

Supply chain includes movement of products from suppliers to manufacturers to distributors, and information, funds, and products in both directions. Typical supply chain stages are customers, retailers, distributors, manufacturers, suppliers, although all stages may not be present in every supply chain [6]. In modern global business conditions supply chains should be dynamic and flexible to the changes in demand which requires continuous improvement of all stages of supply chain [7]. Focus in this paper is set on the producers and distributors as supply chain elements and research of possibilities for improvement of their relationship.

The objective of this research is to identify overall importance and performance of the three main beer producers that have total share of 83% of the Serbian beer market through evaluating business areas important for improvement of relationship between beer producers and distributors. Areas such as Brand & Marketing Communication; Sales representatives; Logistics; Advertising; Business Cooperation and Customer Service are identified as a key business activities and functions that significantly contribute to the distributors' satisfaction and interest to continue cooperation with certain beer producer.

The rest of the paper is structured as follows: methods, results and discussion of each evaluated area, conclusion and references.

2 Methods

In this research has been used structured quantitative questionnaire, consisted of series of 5-point scales, which were used for evaluation of each indicator within 6 performance areas, plus one open-ended question per performance area with suggestions for changes that would lead to improvement in the particular performance area. The largest three beer producers with the total share of 83% of the Serbian beer market are marked as Company 1, Company 2 and Company 3. The questionnaire has been delivered to 100 respondents – big buyers and distributors, but 43 respondents has successfully completed the whole questionnaire, which indicates response rate of 43%. Methods of analysis and synthesis as well as comparison of the obtained answers and their significance have been used in this research. Total responses were scored with 100 and on this basis, each scale was scored with a % participation in responses.

3 Results and Discussion

The analysis of the results will be carried out by evaluated areas and the most important issues. Evaluated areas are Brand & Marketing Communication; Sales representatives; Logistics; Advertising; Business Cooperation; Customer Service.

3.1 Brand and Marketing Communication

By analyzing responses relating to the general brand satisfaction, it can be seen that regardless of the advantages of particular beer producer in terms of certain aspects of the brand and marketing communication (brand strength, brand assortment, innovation, brand marketing efficiency, etc.), each of the three observed companies is similarly evaluated by respondents in relation to competitors (Fig. 1).

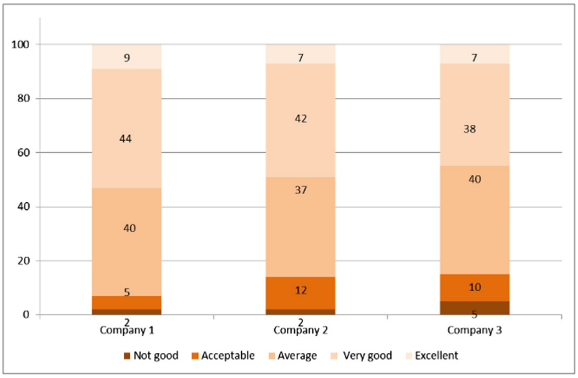

Fig. 1. General distributors' satisfaction with brand and marketing communication.

Analysis of the answers regarding distributors' satisfaction with brand strength in the assortment indicates that the respondents were similarly evaluated each of three beer producers. It can be noted that 30% of respondents rated the Company 2 as *Excellent*, compared to 16% and 17% of respondents who evaluated the other two companies with *Excellent* (Fig. 2).

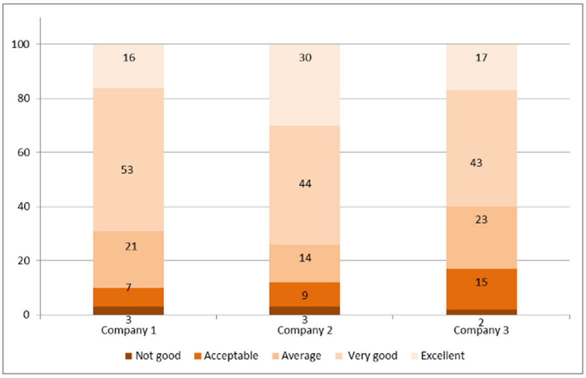

Fig. 2. Distributors' satisfaction with brand strength.

3.2 Sales Representatives

The next question concerned the brand assortment of all three companies and respondents rated similarly as the strength of the brand.

Respondents rated companies the worst in terms of introducing new products or new packaging. A large number of respondents complained related to the packaging and return of empty handling having in mind necessity of its standardization. Company 1 got the highest rates by 42% of respondents, Company 2 by 38% of respondents and Company 3 by 35% of respondents (Fig. 3). The management of analyzed companies have received significant feedback regarding direction of innovation, primarily related to product innovation and packaging.

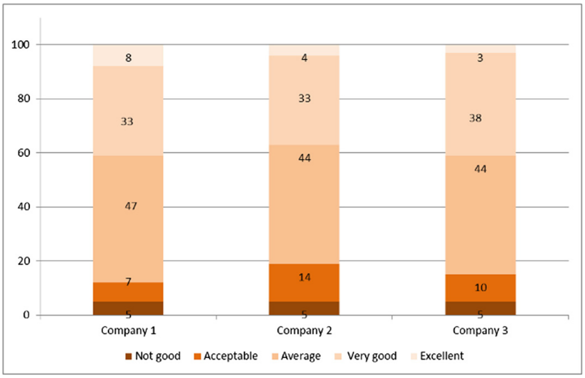

Fig. 3. General distributors' satisfaction with innovations provided by companies.

Analyzes of responses regarding brand marketing efficiency resulted in similar results and more than 55% of respondents evaluated all three companies with the highest rates. Company 2 has been evaluated with the highest rate by 65% of respondents, Company 3 by 58% of respondents and Company 1 by 56% of the respondents. Some respondents have also evaluated brand marketing efficiency of analyzed companies with *"Not good"* and management of these three beer producers should additionally analyze reasons of distributors' dissatisfaction regarding this aspect of business cooperation in order to find ways to improve relationship with distributors (Fig. 4).

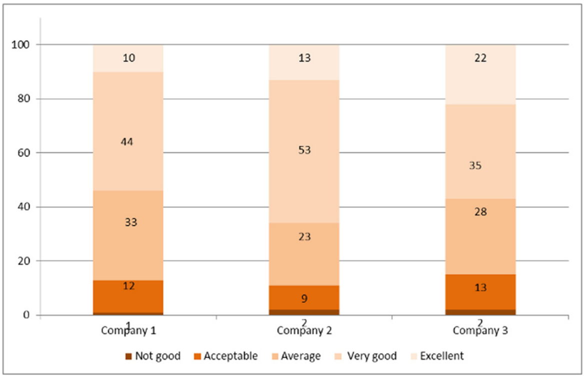

Fig. 4. Distributors' satisfaction with brand marketing efficiency.

The next researched area is related to sales and distributors rated sales representatives of the Company 1 as the best (Fig. 5). Distributors has particularly emphasized frequency of visits and contacts with sales representatives of the Company 1, while advantage of the Company 1 in the other two analyzed aspects (quality of contacts and decision-making authority) is not significant.

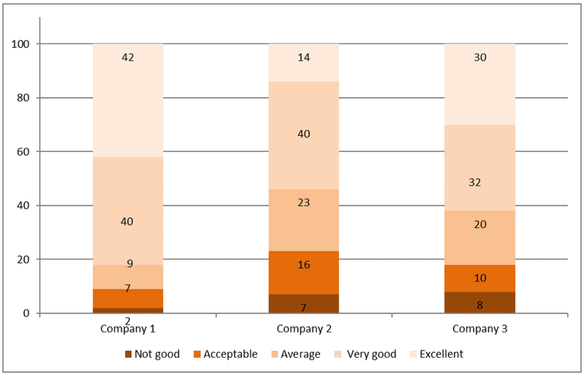

Fig. 5. Distributors' satisfaction with frequency of visits and contacts with sales representatives.

The next researched issue has been quality of distributors' contacts with sales representatives. Based on this analysis it can be seen that the results are similar to the results of previous question, which means that the Company 1 was the best rated. Company 1 has been rated with *Very good* and *Excellent* by 79% of respondents while Companies 2 and 3 have been rated with Very good and *Excellent* by 54% and 60% of the total number of respondents who answered this question (Fig. 6).

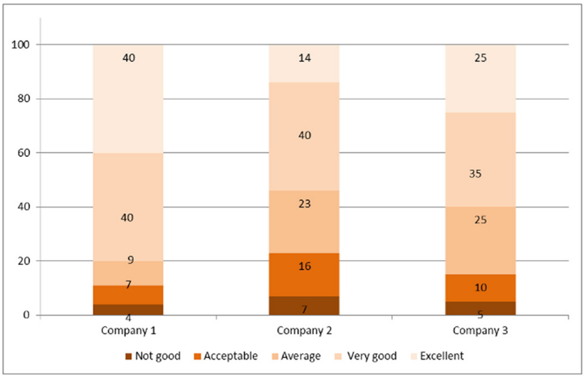

Fig. 6. Distributors' satisfaction with relationship with sales representatives.

3.3 Logistics

This area included evaluation of logistics aspects of relationship with distributors. Company 1 is rated as significantly better in terms of cooperation with transporters (communication, cooperation, problem solving), while in the other two aspects related to logistics it is estimated (but not significantly) better than the competition.

The next researched issues that have significant impact on the distributors' satisfaction are the delivery of the complete order in time, quality of transporters (communication, quality of cooperation, problem solving) as well as delivery of products of the appropriate production date. Company 1 was rated the best in terms of the complete order in time in comparison to Companies 2 and 3 (Fig. 7).

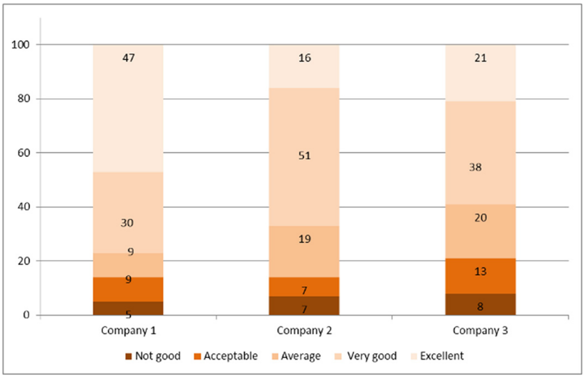

Fig. 7. Distributors' satisfaction with delivery of the complete order in time.

By analyzing answers of respondents, it can be seen that all three companies received satisfactory ratings, but at the same time each of three companies also received negative responses. Company 3 has been negatively assessed by 23% of respondents regarding the quality of goods transportation (Fig. 8). This Company outsources distribution activities.

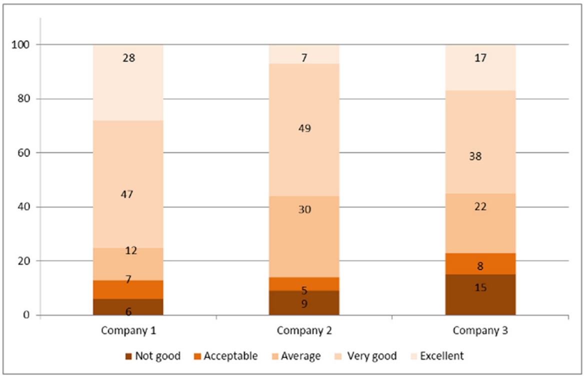

Fig. 8. Distributors' satisfaction with quality of transporters.

Having in mind importance of beer production date and expiry date special attention must be paid to this issue. Important issue is also satisfaction of the distributors regarding the delivery of products of the appropriate production date. Considering that numerous distributors do not have adequate storage capacities and need a lot of time to deliver products to consumers they are very careful in terms of production and expiry date (Fig. 9).

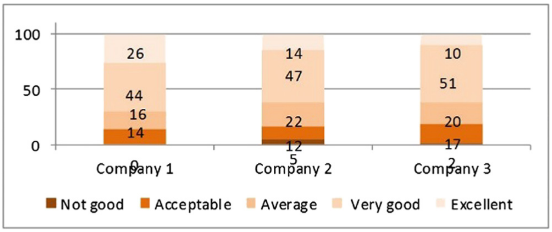

Fig. 9. Distributors' satisfaction with delivery of products of the appropriate production date.

3.4 Advertising

Advertising research field was covered by three questions and two of them were ranked by scale from 1 to 5. The third question was related to the most effective advertising material from distributors' point of view. By analyzing the obtained results, we can see that the distributors did not emphasized any type of advertising material as the most effective because 20 respondents out of 43 did not give any answer, while the remaining 23 respondents suggested different types of advertising material. The other two issues that were covered in this segment were level of distributors' satisfaction with the beer producers in terms of marketing and promotional activities as well as distributors' satisfaction with the sales representatives regarding the effectiveness of visual advertising material at the point of sale. Respondents believe that all three companies are not considered significantly different in terms of advertising.

3.5 Business Cooperation

This research segment included 5 questions rated by scale 1 to 5 and one issue where distributors suggested changes that would lead to the improvement of business cooperation with each of the companies. In this segment was analyzed distributors' satisfaction regarding: commercial terms of business, revenue realized by selling products of the three analyzed companies; available resources needed for running everyday business (human resources, promotional materials, etc.), the range of products offered by the beer producer, the way of handling empties. Respondents perceived all three companies as quite similar in terms of business cooperation in all aspects, except in terms of handling empties where Company 1 is considered better than other two competitors.

Respondents rated all three analyzed companies similarly regarding distributors' satisfaction with commercial terms of business, but rates were lower which indicates that beer producers should improve those terms in relationships with distributors (Fig. 10). Similar ratings were also obtained by analyzing the responses regarding distributor's satisfaction with the revenue realized by selling products of three analyzed companies (Fig. 11).

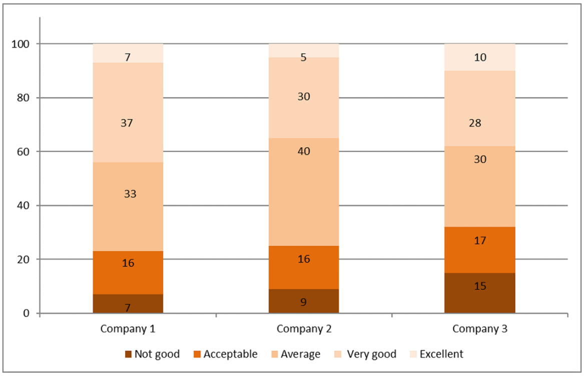

Fig. 10. Distributors' satisfaction with commercial terms of business.

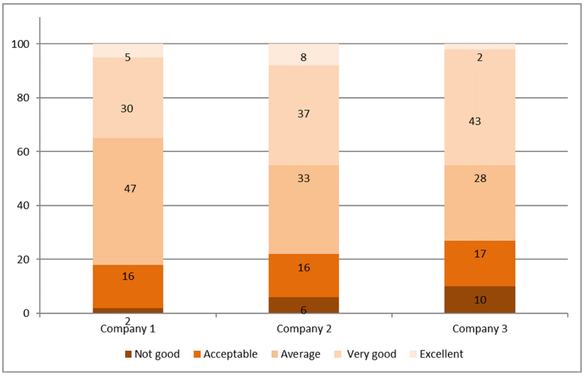

Fig. 11. Distributors' satisfaction with revenues realized by selling products of three beer producers.

A significant difference was noticed related to the distributors' satisfaction with the empties handling. In the previous part of the paper, we mentioned the problem of the empties handling that distributors are mostly faced with which emphasizes the significance of this issue.

Respondents (56%) rated Company 1 as the best regarding empties handling, while 35% of respondents rated Company 2 and 38% of respondents rated Company 3 with *Very good* and *Excellent* (Fig. 12). Additional attention should be paid to considerable participation of lower rates regarding this issue especially for Company 3. Three analyzed beer producers emphasized problems of empties handling as the most important, having in mind that consumers in Serbia still mostly buy beer in return bottles. In recent years, there has been a noticeable increase in the sale of beer in non-returnable packaging. The great contribution to this has also been reduced usage of beer cag collars in favor of non-returnable PVC packaging that meets the same quality standards as beer cag collars.

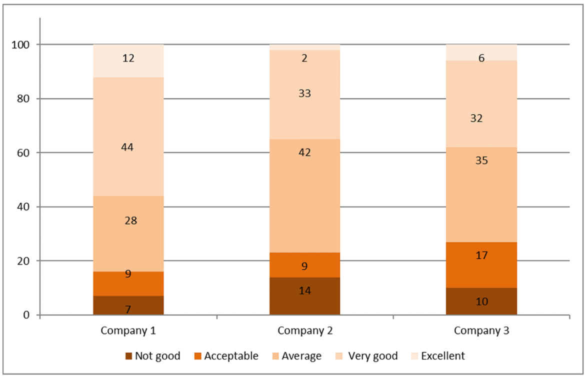

Fig. 12. Distributors' satisfaction with empties handling.

3.6 Customer Service

The research results regarding the relationships with distributors have given the greatest contribution to the objective of this research. This segment was researched through the 6 questions whereby 5 questions had 1 to 5 scale and the 6th issue offered possibility to respondents to suggest changes that would lead to the improvement of cooperation with representatives of the customer relationship service for each of the observed companies. Customer Relationship Management (CRM) is one of the three Supply Chain macro processes. According to [6] the other two processes are Supplier Relationship Management (SRM) and Internal Supply Chain Management (ISCM). Research results has indicated that the Company 3 has been rated as the best regarding this issue, while Company 2 has been rated as the worst. Respondents consider the Company 1 as a superior in terms of obtaining the correct documentation and resolving complaints regarding the quality of the product (Figs. 13 and 14).

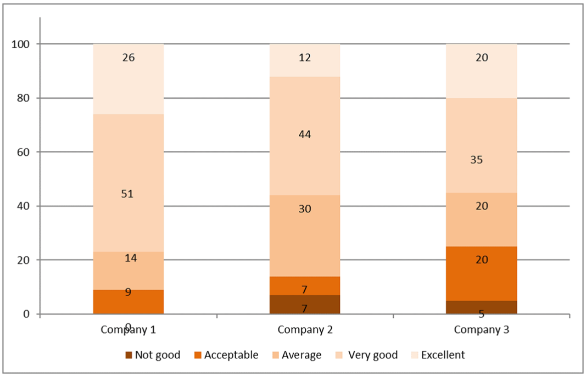

Fig. 13. Distributors' satisfaction with obtaining the correct documentation.

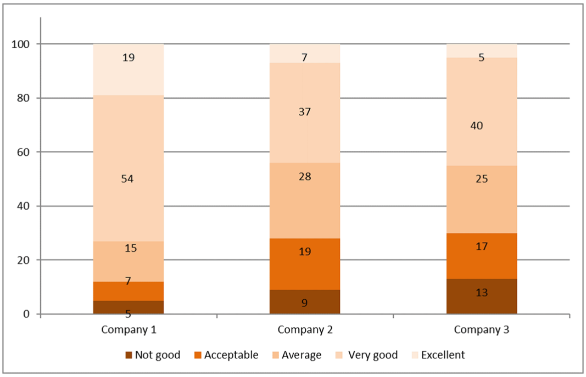

Fig. 14. Distributors' satisfaction with resolving complaints regarding the quality of the product.

Because of statistically significant difference in responses afterwards have been separately analyzed the issues related to the correct documentation and the resolving of complaints regarding the quality of the product. Having in mind that there has not been statistically significant difference regarding responses obtained for the other issues, we have not additionally analyzed responses on those issues.

Considering distributors' satisfaction with obtaining the correct documentation 77% of respondents who answered this question rated Company 1 with highest rates (*Very good* and *Excellent*) on this issue. At the same time 56% of respondents gave the highest rates to Company 2 and 55% of respondents rated the same Company 3 (Fig. 13). From this analysis, we can see that Company 1 stands out regarding distributors' satisfaction by obtaining the correct documentation.

The quality of the delivered products is an essential non-financial performance indicator related to manufacturing which requires additional analysis of distributors' satisfaction by resolving complaints regarding the quality of the product [8]. Research results indicate that Company 1 resolves the complaints about the quality of the products the most efficiently and that the number of complaints is the smallest in comparison to the analyzed competitors. We set this conclusion on the base of 73% of respondents who rated Company 1 with the *Very good* and *Excellent*, while Company 2 were similarly rated by 44% and Company 3 by 45% of respondents out of the total number of participants in this survey.

The analysis showed that distributors are mostly satisfied in terms of cooperation with these three beer producers and have not given any significant advantage to any of them. By analyzing the results of the survey it can be seen that 79% of the respondents stated that they will continue to cooperate with Company 1, while 70% of the respondents stated the same for Company 2. However, it is disturbing that only 57% of the respondents pleaded for a certain continuation of cooperation with the Company 3. Of concern are the responses of respondents ranging from 9% (Company 1) to 20% (Company 3) regarding continuing of business cooperation. It can be seen that there are problems in the relations between the observed three beer producers and their distributors and there is necessity to embrace suggestions of the surveyed distributors in order to improve business cooperation. A large number of respondents answered that they would recommend these three beer producers to their business partners if there are tendencies to eliminate identified problems in business relations. Based on the results of this research three analyzed beer producers intend to undertake activities to solve the problems regarding empties handling and obtaining the correct documentation which are main problems in relation with the distributors.

4 Conclusion

In accordance with the previously determined research objectives and methodological approach in this research has been analyzed the satisfaction of the distributors' regarding business cooperation with the three leading beer producers on the Serbian market as an emerging market. Similar trend of increasing beer production and consumption that is characteristic for emerging economies is present on the Serbian market, including increasing number of craft breweries and microbreweries.

Limitation of this research is reflected in the small number of respondents and low response rate; respondents were well known distributors of the three analyzed companies and they were not completely objective and anonymous. Further research should be directed toward increasing number of respondents, analysis of new fields and additional questions. Satisfaction of the final consumers should also be analyzed in accordance with Customer Relationship Management (CRM) which is implemented in each of the three analyzed companies.

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Application of Process Mining in Industrial Maintenance: An Approach for the Analysis of Equipment Shutdown

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Abstract. This study aims to propose a structure that allows data provision to a maintenance area and that can be used by process mining tools in an industrial production environment. The structure uses a suitable data collection device provided by a Brazilian manufacturer, the data collected was stored in a database (DB), and then imported into the process mining software "*DISCO*®" to verify if the generated information is relevant and can be used for decision making. The proposed structure was able to create paths for the extraction and availability of the data in a satisfactory way since it presents interoperability between the collection mechanism and the process mining tools. Based on the data collected, it was verified that the structure, despite meeting the expectation, needs to be restructured in such a way that the inserted data are registered according to the analysis structure of the process mining tools. This issue is important because the amount of data generated is very expressive and the manual cleaning of the data would require a lot of time.

Keywords: Industrial maintenance · Process mining · Decision-making

1 Introduction

The current highly competitive industry scenario requires companies to maximize efficiency in their processes in order to reduce costs. The performance and competitiveness of manufacturing companies depend on the reliability, availability, and productivity of their production facilities. More recently, the maintenance function has come to be more considered in the industrial business scenario, since the maintenance strategy of the manufacturing plant can positively or negatively influence manufacturing competitive priorities such as cost, quality and flexibility [1].

In this scenario, maintenance has played a relevant role in the survival of companies, as it helps to reduce the cost of the production process and guarantees the maximum availability of equipment and product quality. However, the process of designing maintenance plans can be very complex and requires a high level of expertise by the Maintenance Engineers to quickly define maintenance actions without neglecting the major cost factors, production losses, maintenance costs and cost of spare parts [2].

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In recent decades, progress in information and electronics technologies has led to the introduction of several other maintenance policies, for example Condition-Based Maintenance (CBM), which is the most modern technique discussed in the literature, based on acquiring information on the operating conditions of the equipment [3].

Among the modern techniques that can be used in maintenance is process mining. The use of this technology can serve as a further tool to aid in the continuous improvement of processes, using specific data mining techniques applied in logs from the support systems used, to obtain information about the executed process, facilitating the identification of features that may not be clearly visible by traditional methods [4].

The information system integrated to the process mining tools can turn out to be a differential in the industrial environment, supporting decision making. This study aims to propose a structure that allows the provision of data to the maintenance area and that can be used by process mining tools in an industrial environment.

1.1 Maintenance Management

Maintenance management is a complex process that requires an effective combination of technical and economic expertise; a part of maintenance management is interpreting the available data and transforming it into useful information to manage the equipment in the best possible way. For this, the data must be collected and analyzed in a structured way, otherwise, it cannot be used effectively.

Maintenance actions involve elementary interventions performed by the technician in response to the state or condition of the equipment and may include preventive or remedial actions. Maintenance actions are largely linked to the type of maintenance policy, for example, corrective maintenance actions are often performed through the Fault Based Maintenance (FBM) policy. On the other hand, preventive repair actions are performed in the Time/Use Based Maintenance policy (TBM/UBM) [5].

In the context of Maintenance Management, it is sought to identify the most efficient and effective strategies in order to continuously improve operational capacity, reduce maintenance costs and increase its competitiveness [6]. Thus, the main objectives of maintenance management are: to estimate the evolution of the conditions of the equipment over time [7] or to make predictions and diagnoses of failures and their relationships with failure modes [8].

With the advancement of technology, various maintenance strategies are proposed and applied in productive processes, where the challenge is to define the most efficient and effective strategy to improve the operational capacity of processes, save maintenance costs and improve industrial competitiveness [6]. An adequate maintenance action in the ideal moment is necessary to reduce the number of process failure cases and increase the reliability of the equipment [9]. In this manner, identifying the optimal inspection period of the equipment condition is a strategic decision to optimize the maintenance function and reduce costs.

1.2 Process Mining

Process mining is defined as a method for discovering, monitoring, and improving real processes by extracting knowledge from event logs easily and commonly available today. There are three basic types of process mining: process discovery, conformity, and enhancement. The first type of mining process is discovery. A discovery technique takes an event log and produces a model without the use of any prior information. Process discovery is the most prominent process mining technique. The second type of mining process is compliance. Here, an existing process model is compared to an event log of the same process. Conformity checking can be used to verify if the reality, as recorded in the log, conforms to the model and vice versa. The third type of mining process is the enhancement. Here, the idea is to extend or improve an existing process model using information about the actual process recorded in some event log [10].

The purpose of process mining is to extract information about the transaction log processes. It is possible to record events in such a way that (I) each event refers to an activity (i.e. a well-defined step in the process), (II) each event refers to a process (i.e. an example of the process), (III) each case may have an executor also referred to as creator (the person who performs or initiates the activity), and (IV) events have a timestamp and are fully ordered [11].

Process mining techniques allow the extraction of information from event logs. For example, transaction logs from a business resource planning system can be used to discover models that describe processes, organizations, and products. Mining process is closely related to Business Activity Monitoring (BAM), Business Operations Management (BOM), Business Process Intelligence (BPI), and Data/ Workflow Mining [12].

The idea of process mining is not new, Cook and Wolf investigated similar issues in the context of software engineering processes, they describe three methods for process discovery: one using neural networks, one using a purely algorithmic approach, and one Markovian approach. The authors consider the last two approaches to be the most promising. The purely algorithmic approach builds a finite state machine where states are fused if their futures (in terms of possible behavior in the next steps) are identical. The Markovian approach uses a mix of statistical methods and algorithms and is able to handle the noise [13].

Process mining has characteristics that make it stand out from other approaches to analysis: (I) it is process-centered; (II) is truly intelligent; (III) is based on information obtained from knowledge recorded in the event log instead of opinions [10].

2 Proposed Approach

For the accomplishment of the present study, a partnership was made with an industrial company that produces automotive safety belts and is located in the southern region of Brazil. The company has its headquarters in Japan and operates in the world market since the 80's. The proposed structure is focused on the Maintenance area and the objective is to achieve a reliable database of machine shutdowns in this industrial environment including also in this scenario the operators of such machines.

The structure uses an adequate data collection device provided by a company that works with information systems in Brazil. The data collector will record events both automatically by the machines and also manually by the operator or maintainer, through a predetermined procedure for the correct registration of events. The data collected by this device will be stored in a database (DB), following the structure defined for event registration. The data stored in the database will be imported by process mining software to generate information for decision making. Such a sequence can be seen in Fig. 1.

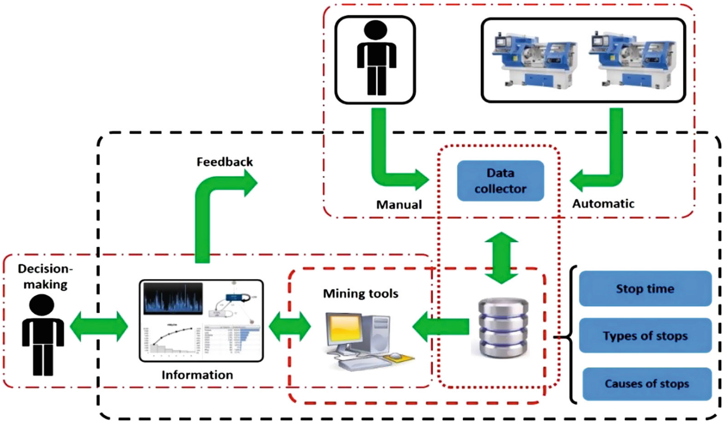

Fig. 1. Overview of the proposed approach.

It is noted that the structure presented is characterized as an event cycle that starts with the data recording device (data collector) which is manually fed by the operator or maintainer of the machine or also automatically by the information system integrated into the machine. The collector records the data and transfers it to a database that has the following characteristics: stop times, stop types and causes of stop.

The database is programmed to receive the collector data and make them available in CSV file for use in the process mining software. The relationship between the data collector and database must be adequate since the stored data must be in a format that a process mining software can read correctly without interoperability problems. Figure 2 demonstrates the semantics to be employed in mining applications.

Log	Description in apps
CenterWork	Case
Current date	Timestamp
Final date	Timestamp
Employee	Resource
Type stop	Activity
Reason for stopping	Other
Stop Time	
Right / left side	

Fig. 2. Ratio of log events to process mining applications.

The objective is not to have noise or data considered useless for analysis, but this issue may arise in the records and consequently distort the results. From the moment the system is in operation it is possible to make the necessary adjustments and verify if there are interoperability problems or inadequate procedures by operators.

After importing the data into the mining applications, the information will be generated and can be used by the decision maker and in parallel to the continuous improvement of the process. It can be noticed that there are three elements external to the system: the operators, the machines and the managers, the latter being dependent on the reliable data of the first and the second, since a wrong decision can lead to a loss of efficiency of the process. The research proposal intends to generate reliable and well-structured data to be imported by process mining tools.

2.1 Structure of Scheduled Stops

Next, the types of machine stops that may be occurring in the production process will be described and visualized in Fig. 3. The data collector will record the amount of time the machines will be stationary and also the amount of time that they will be in operation, so the production time for this study will also be considered as a "stop".

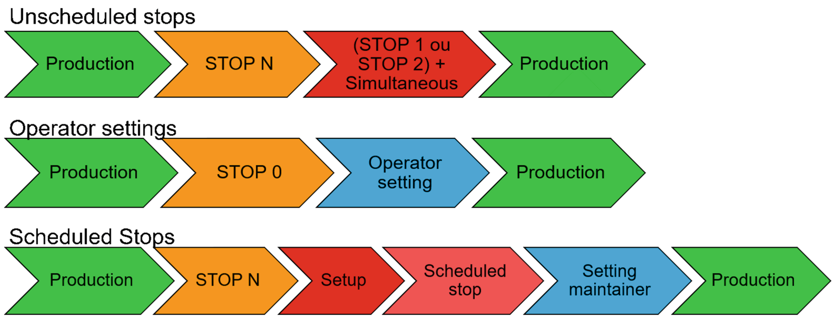

Fig. 3. Structure of stops.

The first time to be registered will be of the machine working which will be represented by the "Production". Probably this "type of stop" will have an amount of time much superior to the others because it is the time in which the company produces without interruptions.

When the machine stops for some unplanned reason there are two types of stops with the names of "Stop 1" or "Stop 2" generated by the operator or machine maintainer. The machines have two sides that produce simultaneously, when a problem occurs on one side it is necessary to interrupt the other side also, in this case, a stop named "Simultaneous" is generated. When the operator checks the side that generated the stop, it launches the reason code related to the stop and the side that stopped, when the system receives this information, it automatically launches a "Simultaneous" stop to the other side of the machine.

Before STOPs 1 or 2 are generated there is an amount of time in which the machine is left unattended, this stop is called “Stop N” which represents the time from the moment the machine is automatically stopped until the moment the operator arrives to solve the problem, after the operator launches the code, the timer stops counting.

The “Stop 0” stop is when the operator manually shuts down the machine to make small corrective interventions of events that are difficult to forecast. Such interventions occur constantly and the operator of the machine must be attentive to the operation of the same because a small occurrence can generate a great loss both in the machine and in the products that are being produced.

The registration of the reasons for the stops are done by the denomination “Stop C” launched by the operator or maintainer, or by the system when no one launches, it means the reason the machine stopped working, it is not a stop time but an activity of data registration. The launch of the reasons is extremely important because it is through it that the professionals who work in the company can identify the root causes of maintenance problems.

Another stop in the process is “Setup” which represents the machine’s shutdown by the operator for a setting, tool exchange or configuration in the information system. This type of shutdown is common and its presence can be controlled or planned in a manner appropriate to the production process. Finally, you have the scheduled stop described in the event log as “PProg”, this stop will already be inserted into the machine’s programming, so it will stop automatically without operator intervention.

Another so-called “setting” stop which means when a shutdown occurs again in less than 30 s of operation after any maintenance or any other intervention on the machine. The system verifies that it is not necessary to request the code from the operator and automatically launches the last stopping code entered by the operator for that machine.

3 Process Mining with Test Logs

To test the efficiency of the suggested structure, a period of two months of machine stop log data was analyzed, totaling 22,215 events, structured in 3 cases. Each case represents a work center, contemplating three shifts. For this database was used the software considered one of the main mining process software currently available.

Figure 4 shows the data loaded in the software, the columns represent the description and the records available in the event log, selecting a column enables the operator to select one of the options in the upper bar according to the semantics already described in Fig. 2.

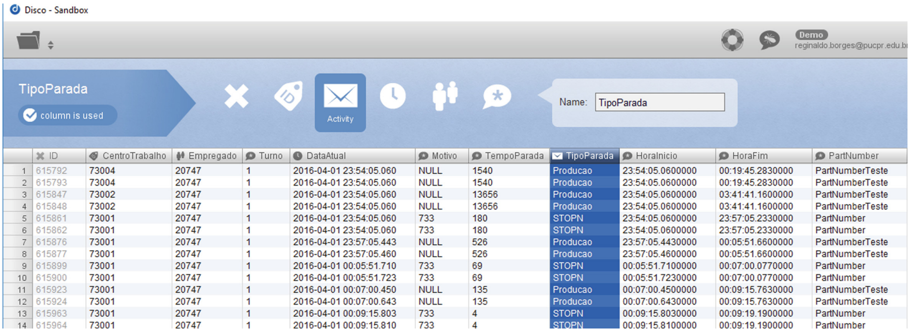

Fig. 4. Log data loaded in software DISCO®.

After setting the data, the process model was generated through the Fuzzy miner, the model generated was of the spaghetti type, because the log has a very complex structure, this because it has many activities and many of them with a large volume of repetitions. When faced with this type of structure the analysis becomes more time consuming and difficult to understand, so a strategy would be to carry out a fragmented analysis, through a subdivision of the data according to specific need.

This information is important to demonstrate which are the most harmful reasons to the productive process because they generate stops and consequently loss of production. Table 1 presents a sketch of the reasons for stops made manually by the operator of the machine or maintainer, highlighting nine of them as crucial and representing 69.51% of the occurrences, practically a Pareto 70/30 relationship exists, this information helps the managers to direct efforts to reduce such stops and thereby reduce the

Table 1. Log STOP 0 amount.

Order	Code	Name	Freq.	F. Rel. (%)	Cum. F (%)
1	717	Filamentation “Urdume”	60	11,15	11,15
2	715	Filamentation “Selvage”	53	9,85	21,00
3	733	Non-production attendance	47	8,74	29,74
4	740	Break “fio borda”	46	8,55	38,29
5	763	Machine improvement	40	7,43	45,72
6	736	Exchange of “beam”	38	7,06	52,78
7	723	Sensor stop fault	37	6,88	59,66
8	707	Open spring stop	32	5,95	65,61
9	720	Mechanical corrective maintenance	21	3,90	69,51
10	710	Correction of “passamento”	18	3,35	72,86
11	747	Lack of “Beam”	18	3,35	76,21
12	719	Electrical Corrective Maintenance	13	2,42	78,63
13	738	Set up	11	2,04	80,67
14	739	Break of “fio urdume”	11	2,04	82,71
15	762	Filamentation “Fechamento”	11	2,04	84,75

time the machine stands still. These types of stops end up interfering in the average time the machine is in operation, so as with the adjustments, the numbers must be as small as possible.

The event log shows three cases (73001, 73002 and 73004) that represent the work centers, which were considered as cases because the objective was to collect the machine stop information regardless of the product being produced. This information is important because it is possible to verify which sector or work group of the company presented a greater number of occurrences with this enabling the direction of preventive actions.

For each case, a filter was applied and it was verified that in the case 73004 the data was more worrisome because the average time of operation without stops of the machines was of approximately 42 min being that the other cases recorded approximately 60 min. One of the key factors for case 73004 to be below average is the large number of adjustments made in this sector of the company.

Figure 5 shows the causal network with the application of the filter in case 73001, which differs from the other cases since the sequence of activities do not follow the same path. In this model the start is realized through Stop N, which is a waiting activity, i.e. the machines are not in operation and await a possible repair. The starting activity in the model must always be "Production" because the machine in operation represents the beginning of the process.

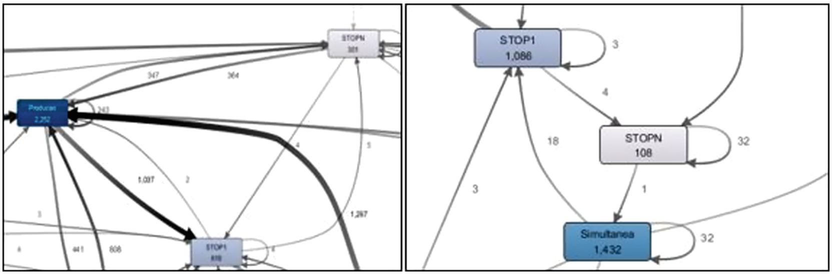

Fig. 5. Map of the case 73001 and Work center model 73004.

During analysis of the log structure, it was found that the sequence was not being interpreted correctly by the process mining tool used Table 2 shows a sequence of events from work center 73002 in which the same employee identified by code 20566 performed all the activities described. The model for this work center was generated and the STOP 1 and "Simultaneous" events do not present a dependency relation as can be observed in Fig. 5. This question is important because it demonstrates that the log structure is not correctly configured to clearly and accurately project data records. One of the issues that may be interfering is the semantics used in the log, as it can generate interoperability problems between the designed structures with the resources available in the process mining tool.

Table 2. Log STOP 0 amount.

CentroTrabalho	Empregado	Data	Hora	TipoParada
73002	20566	2016-04-01	03:44:53.620	Producao
73002	20566	2016-04-01	03:44:53.627	Producao
73002	20566	2016-04-01	03:45:44.370	STOP1
73002	20566	2016-04-01	03:45:44.387	Simultanea
73002	20566	2016-04-01	03:46:13.360	STOPC
73002	20566	2016-04-01	03:46:16.123	Producao
73002	20566	2016-04-01	03:46:16.130	Producao

Another important issue verified with the use of the process mining tool is the details that can be verified for each activity. Table 3 shows data from the activities of STOP 1 and STOP2, in which it can be seen that the motive 733 appears in almost 100% of the data. This reason means "no production attendance" but it is generated when the true reason is not registered, that is, a grid failure is detected in the data records because the causes that give rise to such stops are lost.

Table 3. STOP 1 and STOP 2 records.

	Type	Frequency	Freq. relative (%)
Activity	Stop 1	2350	84,00
	Stop 2	445	16,00
	Total	2795	100,00
Reason	733	2791	99,86
	734	3	0,11
	746	1	0,03
Shift	1	772	27,62
	3	765	27,37
	2	750	26,83
		508	18,18
Work center	73004	1204	43,07
	73002	791	28,30
	73001	800	28,62

As for the shift, it was noticed that there are records in an unspecified shift, such data representing about 18% of the records that will be lost in the process. An important information for the company's maintenance manager is the sketch of the work centers, it is noticed that center 73004 presents a great discrepancy from the others, which determines an abnormality and lack of standard in the process.

4 Conclusions

The structure proposed a priori met the initial requirements because it was able to collect the information and make it available for use of process mining software. However, some issues need to be revised because it has been observed in the shift data that the log structure shows a shift recording failure since about 17% of the information is not being incorporated into the three work shifts. In a detailed analysis, there will be a loss of quality in the information generated and consequently possible wrong decisions about the subject can be made.

Another issue related to the structure of the event log is the need for better semantics so that the data entered are recorded according to the analysis structure of the process mining tools. This issue is important because the amount of data generated is very expressive and the manual "cleaning" of the data would require a lot of time. The test data allowed to extract the causal network using the Fuzzy Miner of the application, it was noticed that the model did not present exactly the reality regarding the stops for maintenance, this discrepancy could be a consequence of the incorrect launch of the stop codes entered by the operator or maintainer.

Therefore, there are some crucial elements that hinder a more realistic analysis of the case: (I) inefficient structure of the event log; (II) conflicting activities and; (III) incorrect entry of the event by the operator.

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The Importance of Non-technical Skills in Agile Project Teams

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Abstract. Agile project management grew up around technical practice, with roots planted in software development. Agile project management has emerged from application of principles and values expressed in Agile manifesto. Every software development organization today seems to practice the agile software development methodology, or a version of it. It goes without saying that technical skills are essential for any software developer, but non-technical skills matter to, and can be just as important. The main objective of this research was to determine how agile project team members, in software development, perceive the importance of various non-technical, soft skills and how they self-assess their level of possession of different non-technical skills. We empirically addressed this question, on a sample of 190 respondents, agile team members, in one software development company from the Republic of Serbia.

Keywords: Agile project management · Agile teams · Non-technical skills · Soft skills

1 Introduction

With the increased use of agile project management in software industry and the importance of team performances for project success it is of utmost importance to clarify and asses the value of individual soft skills in environment where traditionally hard engineering skills were predominant, and not much attention was given to this soft side. Hard skills, often described as a science and comprising processes, tools and techniques applied to projects are the main focus of many project management methodologies. Soft skills described as an art, are very often ignored during software project management [1]. Some of the main futures of software development are:

- Software development requires a self-organized collocated team of people working on different tasks, with strong interaction. Team work is considered a necessity for the success of the project. This non-technical skill is often considered a primary one for the success of any software development project;
- Software development projects involve a large number of stakeholders, with whom the software development team must communicate on a daily basis, and the communication skills are very important;

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– Software development requires a large amount of virtual communication that further increases the risk of failure when it comes to the possibility of misunderstanding in the communication process. The key skill here is to ask the right questions and to give and receive feedback.

The vast majority of employees in the software industry choose their profession because they enjoy more interaction with technology, and less with people, which makes their human skills less developed. For this reason it is very important for soft skills to be developed to the extent to which the specific activity of the company requires, so that the projects don't fail due to lack of soft and non-technical skills and unconsciousness about their significance. Agile project teams require soft skills, leadership competencies and an understanding of how to apply those skills in a more malleable, people-focused setting.

The main goal of the research is to determine which soft skills are of high importance for agile project teams in the software development and what is the gap between the importance and the current performance level with the individual soft skills. The research was conducted in one software company from the Republic of Serbia on a sample of 190 employees. The company that participated in the research deals exclusively with software development.

2 Theoretical Background

2.1 Agile Project Management

In 2001, prominent software development practitioners convened to arrive at a consensus on how the software development industry could produce better results and overcome limitations [2] of traditional software development process in order to increase the quality, enhance flexibility and accelerate time to market. The Agile thinking is expressed in agile manifesto [3] consisting of 12 principles and 4 values, for agile software development and compacts the basic idea of agile movement. That agile values are: (1) individuals and interactions over processes and tools, (2) working software over comprehensive documentation, (3) customer collaboration over contract negotiation, (4) responding to change over following a plan. And agile principles are: (1) early and continuous delivery of valuable software, (2) welcome changing requirements, agile processes harness change for the customer's competitive advantage, (3) deliver working software frequently, (4) people interaction daily (business and developers), (5) build projects around motivated individuals, (6) face-to-face communication, (7) working software is the primary measure of progress, (8) constant pace, (9) continuous attention to technical excellence and good design enhances agility, (10) simplicity, (11) self-organized teams and (12) at regular intervals, the team reflects on how to become more effective.

Agile project management can be defined as the work of energizing, empowering, and enabling project teams to rapidly and reliably deliver business value by engaging customers and continuously learning and adapting to their changing needs and environments [4] in an iterative fashion [5]. Agile project management institutes a set of management practices based on iterative cycles and incremental development, where requirements and solutions evolve and prioritize through collaboration between self-organizing, cross-functional teams and their customers [6, 7]. The ideology of agile is a good fit with the business reality of the 21st century [5]. Organizations today must increasingly view their competency development challenges through one unified lens: the need to be agile [8].

The Agile manifesto places a keen focus on a highly skilled, motivated team in constant interaction with the product and the customer at every phase of the software development project. As a result of this collaborative, customer-centric view, agile teams require more than the technical expertise needed to gather requirements, and develop and test new products. It requires soft skills, leadership competencies and an understanding of how to apply those skills in a more malleable, people-focused setting. These soft skills include, amongst others, communication skills, team building skills, flexibility and creativity skills, leadership skills and the ability to manage stress and conflict.

2.2 Importance of Soft Skills

Today's competitive global market and changing work environment demand that engineers possess soft skills in addition to technical skills, and they must be able to understand project goals, communicate them and have the ability to accomplish them with available resources. Currently, engineers learn leadership and management skills while working—learning "soft skills the hard way" [9]. Soft skills, also referred to as "micro-social" skills, are universally recognized as being critical to successful project management. Soft skills, essentially, are any skills that have you interacting effectively with people you need to work with or influence. Hard skills are the technical skills required within the confines of a domain. They encompass the following dimensions: processes, tools and techniques [1]. These skills, although of crucial importance, are to be considered along with the broader soft skills according to Belzer [10]. It could be said that hard skills are sciences and soft skills are art. Sampson [11] writes, "The skills required for project management are now often divided 50/50 into traditional 'hard' skills, such as risk management and scheduling, and soft, people oriented skills, such as interpersonal communication". There is more to project management than scope management, time management, and risk management. Project management also involves soft skills, such as managing people, communication, leadership, facilitation, mentoring etc. For agile project team, to be a good and effective, especially in software development, a certain amount of technical know-how is necessary, but team also need a variety of nontechnical abilities, soft skills, that can help them navigate the challenges inherent in project management, from scope creep and delays to conflicts among team members. Agile has amplified the need for all roles to practice soft skills, including coaches, Scrum Masters, product owners, and team members.

3 Research Methodology

Specifying the research questions is probably the most important part of research as it identifies the scope of research and it guides the research protocol construction. Research questions are formulated to be relevant and important for practitioners and researchers in this field, as follows:

– RQ1: Which soft skills are of high importance for agile project teams in the software development company?
– RQ2: What is the gap between the importance and the current performance level with the individual soft skills?

The survey was conducted in a software company from the Republic of Serbia, on a sample of 190 employees, members of different project teams. The company that participated in the research deals exclusively with software development and they predominantly use agile project management methodology to manage their projects.

The main objective of this research was to determine the gap between the importance of individual soft skills and the current level of analyzed soft skills. In order to achieve this, the IPA (Importance-Performance Analysis) has been done. Importance-performance analysis (IPA) is the base for the model comprising of multiple attributes, which was firstly introduced by [12].

For research purposes the original questionnaire was developed. The questionnaire was structured in 2 sections. In the first section respondents gave their background information. In the second section respondents were asked to assess individual soft skills, thanking in to account their importance in the project work, in the first instance, and the level of their performance with the particular soft skill. 32 soft skills were identified, grouped into four factors: communication skills, interpersonal skills, intellectual skills and leadership skills.

To capture respondents' subjective estimates, a unipolar, six-point Likert type scale was used [13] to measure respondents perception. With the first scale, respondents rated soft skills according to their importance with scores from 1 – completely unimportant, to 6 – extremely important. With a second measuring scale, respondents rated the current level of their soft skills that on the scale from 1 very bad/bad in this too – 6 very good at this.

4 Results and Discussion

Achieved overall mean values of importance and performance by evaluated dimensions of soft skills, are calculated on the whole sample and shown in the Table 1.

Table 1. Importance-performance means scores for four factors of soft skills.

Soft skills dimensions	Importance		Performance	
	Mean	Std. D	Mean	Std. D
Communication skills				
1. Verbal communication	5.66	.558	4.65	.763
2. Nonverbal communication	4.64	1.145	4.24	.960
3. Written communication	5.49	.674	4.88	.758
4. Storytelling	4.69	.938	4.26	.996
5. Visual communication skills	5.00	.902	4.35	.978
6. Active listening	5.61	.570	4.73	.842
7. Public speaking	5.37	.767	4.07	.992
Interpersonal skills				
8. Socialization skills	5.31	.796	4.77	.951
9. Assertive skills	5.26	.761	4.52	.846
10. Team work	5.76	.530	5.55	.632
11. Mentoring	4.66	.840	5.06	.902
12. Facilitation	4.22	.996	4.72	1.240
13. Selling skills	3.75	1.018	5.17	.875
14. Managing difficult conversations	4.21	.901	5.45	.843
15. Motivation	4.37	1.038	5.11	.888
16. Networking	4.38	1.028	5.17	.917
17. Conflict resolution	4.47	.857	5.54	.581
Intellectual skills				
18. Planning	4.65	.787	5.60	.582
19. Time management	4.75	1.024	5.28	.771
20. Research skills	4.62	.925	5.43	.673
21. Active learning	4.91	.847	5.30	.726
22. Knowledge assesment	4.53	.873	5.02	.915
23. Knowledge management	4.44	1.013	5.31	.892
24. Innovativeness	4.23	.993	5.04	.994
Leadership skills				
25. Team building	4.25	.952	5.08	.903
26. Couching	4.27	.951	5.45	.681
27. Delegation	4.67	.948	5.13	.897
28. Giving feedback	4.10	.981	5.29	.822
29. Performance management	4.37	.972	5.40	.825
30. Change management	4.34	.975	5.48	.660
31. Team management	4.72	.850	4.51	.642
32. Knowledge transfer	3.35	1.104	2.37	1.007

These values were then used as coordinates to create IPA matrix of importance-performance. The overall average values, of the importance of evaluated soft skills, have been entered on the vertical (y) axis, while the overall performance average of the evaluated soft skills values was inserted on the horizontal (x) axis. As a points of intersection of (x) and (y) axis, in the coordinating system of IPA matrix, the median of all components of importance and performance were used, based on which we got four quadrants. The components are then analyzed according to the quadrant on which they are located. Components in the upper left quadrant M (1.1) were rated as very important, but the current level of soft skills is below average. Components in the upper right quadrant M (1.2) were rated as very important and the level of the current soft skills was above average. Components in the lower left quadrant M (2.1) are marked as less important and the level of the current skills was below average. Finally, the soft skills in the lower right quadrant M (2.2) were estimated above average on the scale of the current state but also estimated below average on the scale of importance (Fig. 1).

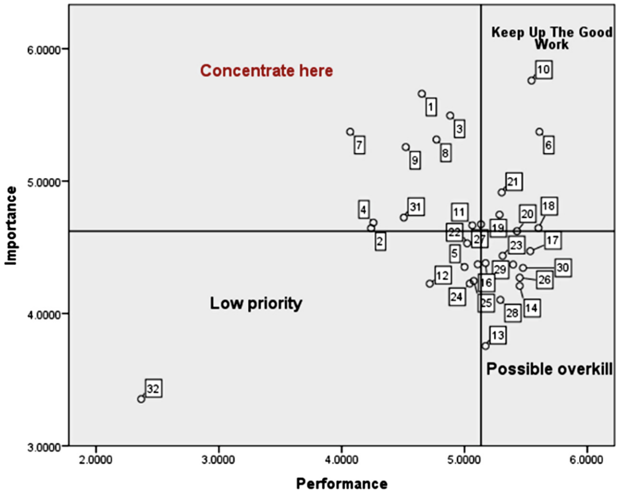

Fig. 1. Results of IPA analysis.

One of the most important quadrants is "Concentrate Here", as it shows which soft skills should be more developed, as they are considered very important. Those are mainly Communication skills (verbal communication, written communication, storytelling and public speaking), but also Interpersonal (socialization skills, assertive skills and mentoring) and one Leaderships skill (change management). These soft skills are rated as very important but their current performance is lower.

At the second quadrant (Keep up the Good Work) there are the soft skills which are perceived as important while their current level is also good. This means that the soft skills are developed and managed in the right way by the organization. These are mainly Intellectual skills (planning, time management, research skills and active learning), but also active listening and team work.

The "Low Priority" quadrant contains those soft skills that are not so important and their current state is also low. These skills are those which should be of low priority to managers, as they are not of great significance. The following soft skills belong here:

nonverbal communication, visual communication skills, knowledge transfer, facilitation, knowledge assessment, innovativeness and team building

Finally, the fourth quadrant is "Possible Overkill". This quadrant contains those soft skills with low importance but high performance. Since these skills are rated as not so significant, the management could decrease the investments that are made for the development of those skills, and forward it for the essential skills that take place mostly in quadrant II. There is plenty of attributes in this quadrant, mainly Interpersonal (selling skills, managing difficult conversations, networking and conflict resolution), leadership skills (couching, giving feedback, performance management and change management) and Intellectual skills (knowledge management).

In order to analyses if the respondents of different age, education, level of seniority and years of experience differ in their evaluation of importance and the current state of the analyzed soft skills, ANOVA test was performed. For testing gender differences, independent sample t-test was applied.

The results of the Independent sample t-test showed that man and women differ only in Importance they give to Communication skills ($t = -2.105$, $p = 0.022$). The results indicate that women more than men consider that Communication skills, specifically items nonverbal communication and written are important.

Furthermore, the ANOVA test was conducted to test if there is a difference between respondents of different age in their perception of the importance of the analyzed soft skills and their assessment of the current performance of these skills. The significant results were obtained only in case of the Importance of Intellectual skills ($F = 2.991$, $p = 0.032$), specifically the item storytelling, and post hoc LSD test showed that older respondents give more importance to those skills than younger respondents. Regarding the level of seniority, similar results were obtained. The only significant variable was again Importance of Intellectual skills ($F = 2.921$, $p = 0.036$), specifically items storytelling, active listening and public speaking, while post hoc test showed that seniors give more importance to those skills than juniors. In the case of the years of experience and education level, no significant results were obtained.

5 Conclusion

It is obvious that the only certain thing that characterized today's business is change, and this is particularly expressed in software industry. Software development is a sector that has witnessed the highest rate of project failure in the world. A lack of time and planning, an absence of resources and an insufficient budget are all common reasons for failures with software projects. But the lack of the project team with competent skills is a particularly key, and recurring, problem. As the field of research surrounding project management continues to grow, it is becoming more evident that success of project team cannot be attained with a hard skill set only. Soft skills are valuable in the projects for so many reasons. They create a healthy environment for employees, helping them to work efficiently but it also creates a strong relationship with clients and stakeholders. The results obtained in this research have shown that in a software company, under analysis, there is a high level of awareness among employees, who predominantly have technical background, that, in addition to technical knowledge and expertise, it is very important to possess different soft skills. Managers should reflect to those soft skills which are identified as highly important but with lower performance level. The soft side of agile is just as important as the technical side of agile. Both sets of skills are required and dependent upon each other for success in the agile environment.

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Study of the Dimensions of the Learning Organization in a Small Manufacturing and Service Enterprise

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Abstract. Learning organizations develop the ability to teach all of its members. They are aware of the process of transforming learning into applied knowledge, which is done continuously. Learning organizations are able to create, acquire, perform knowledge transfer, and modify their behaviour in a way that reflects new knowledge. This paper deals with the study of whether the experiences, knowledge and skills of the people working in a small manufacturing and service enterprise develop through learning and change processes. In other words, the paper examined whether the enterprise applies the process of continuing learning as well as the process of creating and sharing knowledge, whether it encourages flexibility and experimenting allowing the employees to take on certain risks, or the development of each employee, or thinking in a completely new way. The aim of the study was to verify whether the enterprise performs an adequate assessment, testing and measurement of the training of its employees and of the enterprise in general, to obtain the most realistic and objective information about the system itself that is implemented in the enterprise and to propose possible measures to improve the work of employees in terms of their education, training, teamwork, flexibility and quick adaptation to changes and current circumstances. To measure the characteristics of learning organization, the Dimensions of the Learning Organization Questionnaire (DLOQ) tool was developed by Watkins and Marsick [1], based on their theoretical model of learning organization.

Keywords: Knowledge · Learning organization · Dimensions of learning organization · Small enterprise

1 Introduction

Modern organizations find their response to the challenges of business operation in contemporary economic conditions in a new approach to the development of employees, that is, in the process of providing, using and sharing knowledge within the organization. New technologies require new knowledge. A lot of knowledge is outdated even before it is used, and it only increases the gap between supply and demand. Creating new knowledge and overcoming the outdated knowledge is an imperative [2].

Knowledge and learning in the present times of constant change are the key to survival and success for each enterprise. The industrial economy is transformed into the

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knowledge economy. Every enterprise must learn and be a learning organization to be able to adapt to these changes and survive on the market.

The concept of a learning organization can be defined in a number of ways, depending on the author and his understanding of things. Regardless of a variety of definitions, what is common to all of them, is the description of the learning organization, that organizations are constantly changing and that all of their members are constantly working on acquiring new knowledge, which is necessary for achieving competitiveness on the market.

There is no clear rule or model how to create a learning organization, but there is no doubt that the organization's way of thinking requires certain changes. The power to force an organization to make changes in perspective, includes changes in the organization, changes in the nature of work and changes in how people learn and what they do with new knowledge.

The paper investigates the presence of the dimensions of the learning organization [1], which represent the basic prerequisite for the development and motivation of employees. The research has answered the question whether the experience, knowledge and skills of people working in a company are developed through the processes of learning and change. In other words, there was examined whether the company practiced the continuing learning, creation and exchange of knowledge, supporting flexibility and experimentation so that the employees were ready to take certain risks, encouraging the development of each employee and encouraging the employees to think in a completely new way.

The aim of the research was firstly to check whether the company was performing proper assessment, checking and measuring of the improvement of its employees and the company in general, secondly to obtain as realistic and objective information as possible about the system of the company and finally to propose possible measures for improving the work of employees in the form of their education and training, teamwork, flexibility and rapid adaptation to changes and current circumstances.

2 Learning Organization

Learning organization is an organization whose employees learn new things and apply the newly acquired knowledge to improve the quality of products and services. The organization is constantly expanding the potential of employees, developing new models of thinking, where employees collectively learn and expand their capacity to create the future.

The acknowledgement that firms operate in a knowledge economy assigns a strategic significance to knowledge productivity. The ability to add value to products and services through knowledge plays a central role. The development of core competencies is the crucial objective here and requires that firms acquire, create, disseminate, and apply knowledge to improve and innovate processes, products, and services. Given the vital importance of the learning processes involved, leaving the necessary learning to random opportunity would be imprudent. A systematic approach with a clear purpose therefore appears necessary [3].

Organizations are becoming trained to create, adopt, transfer and modify their behaviour in accordance with business requirements. All employees are engaged in identifying and solving problems in order to be able to change and improve their capacity for growth, learning, and realization of common goals. By learning, organizations enable employees to use their most appreciated values, skills, competences and talents. The learning organization is suitable for business in a dynamic business environment because it has a high level of adaptability and flexibility for changes and innovations related to work processes and products.

The basic characteristics of learning organizations are the following [4]:

- Continuing learning, which implies that employees are constantly learning, sharing and applying their knowledge as well as acquiring new knowledge based on their work.
- Generating and sharing knowledge about organizations' formation of the system for creating and sharing of knowledge.
- Systematic, critical thinking implies that organizations encourage employees to think in an innovative way, to observe relationships between elements and to check the starting assumptions.
- The learning culture requires organizations to create a culture in which learning is supported with the organization's strategy and represents the basis for rewarding and promotion.
- Encouraging flexibility and experimentation, which implies that organizations encourage employees to take risks, be innovative, contribute new ideas, apply new processes, and develop new products and services.
- Employee evaluation by means of the formation of organizational systems and the internal environment that encourages the development of all employees.

Contributing new ideas and information represents one of the primary features of learning organizations. To be innovative, the companies must constantly explore the external environment, learn from previous experiences, recruit new talented employees and invest resources in training and development of the employees. Likewise, new knowledge must be continually spread throughout the organization and made available to everyone. Employees must be encouraged to use new knowledge, behaviour patterns, and operational processes to achieve organizational goals and to be result-oriented.

By actively applying the concept of learning, the development of both employees and teams, as well as organizations in the whole it supported and accelerated. The achieved level of learning is the basic indicator of the organization's ability to transform itself and respond to the demands and challenges of rapid change. In this way, the learning organization survives in the uncertain and dynamic business environment of modern business. Continuous improvement of the ability to change, developing collective and individual learning and applying the results of the learning to achieve the best results, represents the essence of the concept of learning organizations.

Kerka [5] considers that most of the conceptualizations of the learning organizations phenomena are based on the premise that learning is the most useful, most effective and most consistent when its effects are shared among individuals in the organization and when every new experience represents a chance to learn something new.

Armstrong and Foley [6] were dealing with what a learning organization is, how organizations learn, and how to develop a learning organization. The objective of the present study was to identify the components that underpin the development and operation of a learning organization, that is, the foundations, or organizational learning mechanisms that support the development and maintenance of a learning organization.

3 Seven Dimensions of the Learning Organization

Watkins and Marsick [7] state that the building of the organization's structure must start from the employees, and then proceed to consideration of the structure. Three key aspects stand out in the model; the first is continuing learning at all levels in order to create and manage knowledge, which leads to improved performance of the organization, which ultimately results from changes in financial assets and non-financial intellectual capital.

Watkins and Marsick [7] argue that organizational learning is played at three levels. The first level is an individual level, which consists of two dimensions of organizational learning, continuing learning and dialogue and research. The second level is the team or group level, which is reflected in team learning and collaboration. The third level is the organizational level, which has four dimensions of organizational learning: embedded systems, affiliate organization, empowerment and leadership that supports learning.

The three levels can be further considered as belonging to one of the two components in Watkins and Marsick [7] model of learning organization. At the structural level, learning activities can serve as a function for filtering and involving both individual and team learning into the organization's mission or effectiveness [8].

Watkins and Marsick [7] explain that every learning organization looks different, however, they point out that most of the organizations considered to be learning organizations, share the following features [8]:

– the leaders model the risk taking and experimentation,
– decentralized decision making and authorization of employees,
– possessing a set of skills and auditing of learning capacity,
– knowledge sharing systems and their use in business operation,
– awards and structures that encourage employees' initiatives,
– consideration of long-term consequences and impacts on the work of others,
– operation of inter-functional working teams
– opportunities to learn from experience on daily basis and
– the culture of providing feedback and openness.

The framework of Watkins and Marsick learning organization integrates two basic organizational components: the people who make up the organization and the structure that the organization forms. These organizational components are also considered as interactive components of organizational changes and organizational development.

The authors of the model emphasize seven action imperatives as the basic building blocks of culture that transform organizations into learning organizations:

1. Create continuous learning opportunities,
2. Promote inquiry and dialogue,
3. Encourage collaboration and team learning,
4. Empower the organization members toward a collective vision,
5. Establish systems to capture and share learning,
6. Connect the organization to its environment,
7. Provide strategic leadership for learning.

4 Survey of the Dimensions of the Learning Organization in a Small Manufacturing and Service Company

The aim of the study was to verify whether the enterprise performs an adequate assessment, testing and measurement of the training of its employees and of the enterprise in general, to obtain the most realistic and objective information about the system itself that is implemented in the enterprise and to propose possible measures to improve the work of employees in terms of their education, training, teamwork, flexibility and quick adaptation to changes and current situations.

The paper deals with the research to find out whether the experiences, knowledge and skills of the people working in a small manufacturing and service enterprise develop through learning and change processes. In other words, it examined whether the enterprise applies continuing learning, creating and sharing knowledge, whether it supports flexibility and experimenting where employees are ready to take on certain risks, whether it encourages the development of each employee and the employee's thinking in a completely new way.

The enterprise in which the research was conducted is located in the vicinity of Novi Sad. It has been operating for over 25 years and mainly deals with the production of electricity distribution equipment, metal constructions and assembling of electrical installations and equipment. The enterprise has 65 employees, all of which participated in the research. Although it is a relatively small number or respondents, the results are considered to be valid because all of the workers participated in the research.

The Dimensions of the Learning Organization Questionnaire (DLOQ) was used to measure the characteristics of the learning organization. The Questionnaire was developed by Watkins and Marsick [1] based on their theoretical model of learning organization [7, 9, 10]. The original measurement tool contains 43 items, and in our study 18 questions were used, relating to how an organization supports and uses learning at the individual, team and organizational levels. The questionnaire used is attached to the paper.

The survey was anonymous, with respondents answering questions using a 5-point Likert scale to rate how satisfied they were with each of the job aspects offered. Numbers had the following meanings: 1 Completely incorrect; 2 Mostly incorrect; 3 I'm not sure; 4 Mostly true and 5 Completely true.

In the observed organization, female respondents were prevalent (56%), the prevalent age of respondents was between 35 and 44 (37%), followed by respondents aged 25 to 34 (29%), then respondents over 45 (20%), and finally respondents aged 18 to 24 (14%).

When analysing the qualifications of the respondents, most of them were university graduates (48%), followed by the respondents with secondary education (42%), while the smallest percentage were those with primary education (10%).

When it comes to seniority, 24.62% of respondents had less than 5 years of work experience, 44.62% of them had 5 to 10 years, while 30.77% had more than 10 years. Out of all 65 employees, 15 were in the managerial position (23.08%), while others were in operational positions (76.92%).

4.1 Discussion of Research Findings

Six hypotheses have been tested with three questions from the questionnaire for each. The first two hypotheses refer to the Individual Learning Level, the third hypothesis to the Team Learning Level and the last three hypotheses are related to the Organizational Learning Level. The results are discussed as follows:

- Hypothesis H1: The enterprise creates opportunities for continuing learning. Based on the obtained results it can be seen that the hypothesis has been confirmed. The enterprise has teamwork and employees are rewarded for learning. Based on this, it can be seen that the effort and commitment of employees are appreciated, which means that the employees are very motivated because they are offered opportunities for training and education. Learning is sufficiently represented, but the employees feel that they have not been given enough time to master everything.
- Hypothesis H2: The enterprise applies the principles of promoting research and dialogue. By analysing the obtained results, it can be seen that the hypothesis has been denied. There is no trust among the employees, they are not honest with each other, and do not respect the opinion of their colleagues. The enterprise should firstly improve interpersonal relationships and communication between employees.
- Hypothesis H3: The enterprise encourages co-operation and team learning. Based on the obtained results, it can be concluded that the hypothesis has been denied. Teamwork, as an integral part of the enterprise operation, is not considered to be an important chain link by the organizations, so they do not have the basis for quality teamwork because in most cases they look upon themselves on individual level, i.e. an individual's goals are put above the goals of the team and organization.
- Hypothesis H4: The enterprise possesses a built-in system for collecting and sharing of the learned knowledge. By analysing the obtained results, it can be concluded that the hypothesis has been denied. The organization does not share all the knowledge with its employees, does not have performance measurement systems, does not perform the measurement of the results of time and resources that have been spent on the trainings. The organization should first become aware of what knowledge and learning represent for the organization itself, and then it should educate its employees about the same.

– Hypothesis H5: The enterprise authorizes members of the organization. By analysing the responses received from the employees, it can be seen that the hypothesis has been denied. The enterprise does not encourage its employees who are prepared to take a risk when doing their jobs, neither it shares all the knowledge it possesses to all of its employees and finally, it does not consider as a positive thing that there are employees who are willing to propose something on their own initiative. Consequently, it can be seen that the enterprise is not flexible and that it does not like changes. They are not prepared to take a risk and change anything unless they are completely confident of their success. They think "A bird in the hand is worth two in the bush.", but in fact they should stick to the words "The biggest risk is not taking any risk".
– Hypothesis H6: The enterprise connects the organization to the environment Based on the obtained results, it can be seen that this hypothesis has also been denied. The enterprise has excellent communication with the environment, but it neither wants its employees to get knowledge from such sources, nor to solve its problems in this way. The best solution for the enterprise would be if the employees learned and implemented from their business partners everything they do not have, that is, if they exchanged their business experiences.

The overall findings of the survey show that there are serious problems when it comes to the possibility of continuing learning, promoting research, fostering collaboration and team learning, and sharing knowledge. It can be concluded that teamwork is practiced to a small extent, that employees are not taught to how to cooperate and share both good and bad things. Also, they are not adequately valued and there is no real chance to have their ideas accepted, or they are not given an opportunity to improve their work or the entire business of the company, even if they have relevant knowledge [11].

4.2 Proposed Improvement Measures

In order to provide conditions for effective learning in the enterprise and opportunities for the employees to apply the acquired knowledge, as well as to make the managers support and encourage the learners, it is essential for organizations to create a work environment that encourages learning. Given theoretical and practical research, the measures that an organization should take are as follows [11]:

– Continuing learning opportunities to apply and acquire new knowledge.
– Exchange and generation of knowledge, i.e. the enterprise should have a built-in system to capture and share learning.
– Valuation of employees, i.e. the enterprise should create organizational systems and an internal environment that would stimulate the development of every employee.
– A learning culture with the help of which the enterprise encourages employees to create a culture in which learning is the basis for improvement and rewarding, which is supported by the enterprise strategy.
– Experimenting and encouraging flexibility in which the enterprise would encourage its employees to take risks, to contribute new ideas, to be innovative, to develop new services and products, and to test new processes.

Specific suggestions for the operationalization of the concept of the learning organization in practical operation of the enterprise, on long-term basis, are:

- Creating and communicating a common vision of an organization to all of its employees, which implies the adoption of the vision by the individuals as something that they can personally identify with.
- Information within the organization should be made available to everyone, which reduces clashes and conflicts, and increases the capacity of learning and innovation.
- Offering assistance to individuals within the organization in implementation of changes in such a way as to anticipate the changes (plan ahead) in which case an acceptable dose of consensus will be achieved, both in relation to the essence as well as to the implementation.
- Give the employees power to take the initiative, without fear of consequences, of course within reasonable limits. Freedom to make mistakes.
- Recognize the need to take risks in implementation of changes and stimulate inventiveness even if it goes against the taboos that each organization has.
- Learn how to manage the knowledge within the organization by updating available information, record historical data related to the development of knowledge, and systematize large amounts of information into synthetic and usable forms.
- Build and implement in practice individual and organizational learning strategies.

5 Conclusion

Learning should be shared with others in order to achieve a high rate of return on learning. Daily developments should be used as learning opportunities and various sources should be used for research and learning.

The learning organization is the one that supports the learning of all its employees and is constantly changing. Such an enterprise develops the capacity for collective and individual learning, as well as for accepting changes. Seats are constantly changing, new problems arising, the dynamics are high, and some information is uncertain. In order to achieve good results, the most educated and well-motivated employees are willing to learn and adapt to change.

In learning organizations and learners, individuals are empowered to assume responsibility and manage their own learning processes. Since learning is the key to the development of identity and personal potential, and the development of personal potential is the key to the development of organizations and society as a whole, also an individual has a lot of tasks in his organization. Learning responsibility needs to be taken in the way of looking for learning content, setting goals for learning, actively seeking conditions or ways to achieve these goals and overcoming learning barriers. Learning should be made a conscious and explicit activity and it should be continuously assessed in terms of progress in the achievement of the learning goals.

This research has, of course, certain limitations. On the one hand, the number of respondents was small, but on the other hand, the research provided a realistic picture of the organization, because all the employees took part in the survey. First and foremost, everyone in the organization, and above all, the managers, should be concerned about everything that can be concluded about the organization and the processes within it. An organization that does not apply the principles of promoting research and dialogue in modern times, or does not encourage collaboration and team learning, does not have a built-in system for collecting and disseminating knowledge, does not empower members of the organization, or does not connect to the environment, such an organization does not have a realistic basis to believe in its long-term survival and business development.

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Appendix

Questionnaire used in the research:

1. The employees are given time to learn
2. The employees help each other to learn
3. The employees are rewarded for their learning
4. When presenting their opinion, the employees ask other employees about their opinion
5. The employees give open and honest feedback to each other
6. The employees invest time in building mutual trust
7. Teams/groups are convinced that the organization will act in accordance with their recommendations
8. Teams/groups have the freedom to adjust their goals as needed
9. Teams/groups reconsider their thinking as a result of group discussions or gathered
10. The organization develops systems to measure the difference between current and expected performance
11. The organization measures the results of time and resources spent on training
12. The organization makes available the acquired knowledge to all of its employees
13. My organization gives the control over the resources, the employees need to perform their work, to the employees
14. The organization encourages risk-taking employees
15. The organization recognizes employees with the initiative
16. The organization encourages employees to look for answers throughout the organization when solving a problem
17. The organization encourages employees to think globally
18. The organization cooperates with all stakeholders in the environment to meet mutual needs.

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Human Resource Development in the Knowledge Economy

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Abstract. Acquiring and sharing of knowledge becomes the key to cutting-edge results on the market. Organization growth, innovation and recognition stem from the ability of its employees to acquire and use knowledge. The underlying business challenge becomes how to attract, develop and retain employees with knowledge. The strategic focus has shifted from "knowledge management" to "managing people with knowledge". In this regard, the strategic development of human resources should provide a framework for the "image" of a modern organization operating within a competitive market, in the knowledge society. It means that it should ensure that people want the change, that they understand it as a challenge and a new opportunity and that they are ready to enter the game where the rules are not finally set, but constantly changing. The knowledge economy requires a new concept of business. The first step on this path is to initiate and motivate employees to accept changes, which involves learning and knowledge management. The goal of learning is to turn knowledge into routines. However, it is worth trying vice versa as well, since the established routines may present a major obstacle to the learning process and changes. For this reason, it is the task of employees and managers to constantly question the purpose of existing routines and turn new knowledge into new routines. This is one of the most challenging implementations of the concept of learning organization. This paper deals with the research of the process of education, training and development of employees in a company in Serbia in the light of the changes brought by the knowledge economy. The aim of the research is to find out whether the organization carries out quality education, training and development of employees, to obtain as objective information as possible regarding this process, as well as to propose possible measures for improving the work, motivation and satisfaction of the employees.

Keywords: Learning · Knowledge · Human resources development · Knowledge economy

1 Introduction

Under the influence of high technology and competitive relationships globally, today's organizations have changed their attitudes towards work processes, costs and resources. Consequently, knowledge has become the key resource, with education as the way of work and survival. Namely, the shortened life cycle of products, accelerated technological changes and the intensification of competition on a global scale, are making

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knowledge quickly obsolete. The answer to this problem cannot come from a formal school system, which by its nature must have a certain stability and the length of the cycle. That is why school education today is only the basis for upgrading a number of educational activities throughout the entire work life, which is aimed at adapting the existing knowledge and skills to new requirements of work. Education is thus one of the basic factors of organization flexibility and key leverage of human resource development. The management increasingly recognizes that continuing education and training of employees is one of the most efficient ways of achieving competitive advantage, the basic assumption of entering the market competition and developing competitiveness for sympathy and trust of consumers.

Amongst the range of issues identified and explored as regards challenges for the future are: competitive advantage and adding value through integrated human resources strategy; organizational structure, organizational culture, and learning culture; the interrelationship between work and learning and lifelong learning; performance versus learning; high quality workplace learning processes; development of knowledge and non-knowledge workers and where to locate human resources development [1].

2 Human Resources Development in Modern Management

The human resource development in the knowledge economy opens a lot of opportunities for individuals, the education system, organizations and the society as a whole [2].

In order to keep pace with the turbulent changes in the environment, today organizations have accepted training and education as a reality without which they could not survive. It is no longer the matter of acquiring specific skills for faster and quality assignment of work tasks. It is rather the matter of the entire spectrum of various educational activities focused on the development of potentials and flexibility and mobility of employees. It is no longer disputable that education and training are a good investment for an organization.

When it comes to the development of human resources, not only individual trainings, but also group education and development should be discussed, because they are meant to be beneficial both to the organization and the employees in implementing a particular business mission. In order for a company to preserve its market position and increase its competitive advantage, it must be able to create new knowledge rather than simply rely on the existing one.

The procedure of strategic training of employees and their development, encourages creativity, inventiveness and provides the organization with an entirely new form of business operation that enables uniqueness and diversity. The organizations that want to keep pace with time and/or changes need to accept the model of continuing education.

In the knowledge society, knowledge becomes the most important resource and the key factor in business success. It is both, individuals and organizations who are equally interested in employee development. Accordingly, the development of employees, as a generator of new knowledge, is placed in a broader strategic context of human resources management, or global management of an organization [3].

The holistic approach to business operation and human resources management can ensure the fulfilment of the key requirement for survival on the market, that is, creating, sharing and using the knowledge. It implies unlimited support by top management and an active collaboration between the managers of all functions and levels who are supposed to accept the human resources management with equal enthusiasm. Therefore, employee development and training are highly ranked in the system of values of every modern organization that is positioning itself in the knowledge society [4].

In this regard, the strategic development of human resources should provide a framework for the "image" of a modern organization operating within the competitive market, in the knowledge society. It means that it should ensure that people want the change, that they understand it as a challenge and a new opportunity and that they are ready to enter the game where the rules are not finally set, but constantly changing.

Acquiring and sharing of knowledge becomes the key to cutting-edge results on the market. Organization growth, innovation and recognition stem from the ability of its employees to acquire and use knowledge. The underlying business challenge becomes how to attract, develop and retain employees with knowledge. The strategic focus has shifted from "knowledge management" to "managing people with knowledge".

3 Learning and Knowledge Upgrading as an Imperative for Knowledge Economy

The knowledge economy requires a new concept of business. The first step on this path is to initiate and motivate employees to accept changes, which involves learning and knowledge management.

The goal of learning is to turn knowledge into routines. However, it is worth trying vice versa as well, since the established routines may present a major obstacle to the learning process and changes. For this reason, it is the task of employees and managers to constantly question the purpose of existing routines and turn new knowledge into new routines. This is one of the most challenging implementations of the concept of learning organization.

It is managers who must have enthusiasm to be able to transfer it to employees, which is of great importance, because such an attitude will in some way be the driving force for changing the philosophy on which the organization is based.

An increased workplace learning is necessary for companies to be able to competently answer the increasing demands and expectations of their customers and to successfully compete in today's global environment. "Smart" or successful companies realize that the learning plan is strategically as important as the financial or marketing plan. Knowledge becomes crucial, and above all, learning skills become more important than data. Breakthrough issues and constant testing of new business concepts are more important than good answers [5].

The answer to business challenges in the modern economic conditions, organizations find in a new approach to employee development, in the process of providing, using and sharing knowledge within the organization. New technologies require new knowledge. A lot of knowledge becomes obsolete even before it is applied, which only increases the gap between supply and demand. To create new knowledge, and to overcome the old knowledge, is an imperative [3].

Learning is part of any job, and employees are required to continuously learn and adapt to constant technology changes, so characteristic of the knowledge economy. Now, the requirements being imposed on organizations around the world force them to deliver learning much faster, with lower costs and higher efficiency. The amount of time, money and effort spent on the development of new technologies is constantly increasing. Now just imagine what the investing of an equal amount of time, money and effort in the development of human resources would mean [5].

4 Education for Employees in the Practice of Modern Organizations

It has become the rule for successful companies that each employee needs to spend some time during the year on his education. Learning, under circumstances of strong turbulence and accelerated changes in the society, is increasingly becoming a "must have" for organizations to be able to achieve and sustain their core competence and in that way, to respond to new market challenges. In the knowledge economy, it is not enough to learn only. Today, organizations must learn faster and better than the competition.

Our society insists on general education. Earlier, all schools were equally good, because it was only important to acquire a certificate. The economy was not harmonized with the school system and no testing of knowledge through practice was performed. Therefore, today, a large number of employees do not have the required knowledge and are not sufficiently qualified.

The practice has changed now. Certain competences and specific knowledge are required in accordance with modern trends. Organizations regularly invest part of their income in employee education. An organization can adapt to or initiate changes in its environment only if it is able to learn.

Modern European society is exposed to technological, demographic and political pressures that require change, which creates potential learning situations for everybody. In addition to continuing education, organizations, as well as individuals, need to develop mechanisms for storing and exchanging information about what they have learned. In this way, continuing learning is provided even beyond institutionalized, and otherwise formalized forms of learning. Continuing learning becomes the path for constant changes, innovations and development within an organization.

The World Bank (2008) refers to "education and training" as one of the four parameters in the knowledge economy index [6]. Permanent education becomes one of the most important forms of human resource management and development. Continuing learning becomes the only path for constant changes, innovation and development. By adopting new standards, people realize that they must acquire new knowledge and new skills. Therefore, it is important for the management to establish such an organizational climate and communication channels to ensure the free flow of information. It ensures that those who have knowledge help those who do not, in their education and solving of current problems in the organization.

One of the most important things in the organization's education process is to determine which knowledge, skills, and abilities its employees need in order to successfully perform their job. Then, it is necessary to investigate which employees have inadequate knowledge and skills, or no knowledge and skills at all. Also, it should be determined whether additional education will solve the problem, or a different kind of intervention is needed, such as a job change, recruitment of new employees, and so on. Therefore, managers have to monitor employees' skills and knowledge as a resource that is constantly improving and renewing. The objectives of improving knowledge and skills in the organization must be clearly defined in accordance with the organization's development plans.

It is on the basis of defined goals that education programs are made. A good education program deals primarily with the needs of employees and their organizations, as well as with training of people for jobs to be done in the present as well as in the future.

5 Review of the Research of Human Resources Education in the Production Organization

The paper deals with the research of the process of education, training and development of employees in a company in Serbia in the light of the changes brought by the knowledge economy. The company was founded more than 50 years ago and has been the leader in meat and meat products manufacturing. Currently, it has about 800 employees.

The aim of the research is to check whether the organization carries out quality education, training and development of employees and to obtain as objective information as possible about this process, as well as to propose possible measures for improving the work, motivation and satisfaction of the employees.

The survey was conducted indirectly, through a questionnaire developed for the purpose of this research and contains precise and unambiguously formulated questions.

The questionnaire contained 4 questions related to basic demographic information about the employee (gender, age, level of education and years of service) and 29 questions related to the subject of the research, that is about the level of employee satisfaction/dissatisfaction with his acquisition of new knowledge in his organization, his development, promotion and education, as well as about the level of satisfaction/dissatisfaction with training programs and seminars, organization of business operation and the attitude of the company towards its employees.

Respondents answered each of these questions by circling one of the offered answers: Strongly disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree and Strongly agree. The survey was anonymous and was randomly distributed to employees from different department, or work units from different levels of organizational structure, from the manager to the worker in the company.

In total, there were 90 respondents, the employees of the observed organization. In the survey, men participated in a slightly higher percentage than the women, most of them aged between 40 and 45 years, having work experience of up to 10 years, although the number of both younger employees and those with longer work experience was not negligible. Also, most of the respondents had high qualifications.

5.1 Discussion of the Research Results

The basic hypotheses of the research **OH**: Respondents consider that the organization carries out adequate education, training and development of employees, was checked using five specific hypotheses [7]. Specific hypotheses were related to the approach to employee development in the organization, employee motivation for continuing learning and improvement, and job satisfaction and the role they have in the organization. Two specific hypotheses concerned the organization and carrying out of the training process and the acquisition of knowledge. Below is the summary of the results.

PH1: The organization enables the quality development of its employees – this hypothesis was tested based on the following questions in the questionnaire: Acquisition of new knowledge is available to all employees of the organization; I am regularly informed about the activities for the next period of time; The organization sets goals that are achievable; The organization values and rewards employee involvement in the achievement of goals; The organization provides and encourages professional development of employees; The work and results of the employees are constantly monitored and The organization is open to new ideas and thinking of the employees. The specific hypothesis **PH1 has been confirmed**, that is, the organization has enabled the acquisition of new knowledge for all employees, the organization provides and encourages professional development of employees, the work and results of employees are continuously monitored and the organization is open to new ideas and thinking of employees.

PH2: Employees are motivated and ready for continuing learning, improvement and development - We will look at the motivation and willingness of the employees for continuous learning, improvement and development through the following questions: Past failures discourage me, so I am not ready to try again; I am ready to change my behavior for the benefit of the organization; I always want to learn something new; I believe that I do my job as best I can and with a lot of energy; I consider myself to be very successful and want to be even more successful; My work contributes to the achievement of the organization's goals; and I am proud of the organization for which I work. The survey results show that the specific **PH2 hypothesis has been confirmed**, that is, the employees are not discouraged from previous failures and are certainly ready to try it again; they are willing to change their behavior for the benefit of the organization; they want to learn and they believe that they do their job as best they can, with a lot of energy. Also, the employees in the observed organization consider themselves to be very successful and have a desire to be even more successful.

PH3: The employees are satisfied with their job and their role in the organization - Job satisfaction and constant improvement of the organization's attitude towards the knowledge of its employees was analysed through the following questions from the questionnaire: The job I am in charge of in this organization is full of challenges; I am familiar with the goals and priorities of the organization for which I work; I have a clear vision of my duties and responsibilities in the organization; Employee knowledge and skills are well used at work; I feel valued and respected in this organization; I am satisfied with the opportunity to apply different work methods at work; and The organization I work for takes care of its employees. The specific **PH3 hypothesis has been confirmed**, that is, the employees consider that their work is full of challenges, they are familiar with the goals and priorities of the organization they work for, they have a clear vision of their duties and responsibilities. Their knowledge and skills are well used at work, they feel respected in the organization and the organization takes care of their employees.

PH4: Employees consider that development and training programs are well designed and organized – Three questions were asked in relation to the employees' development and training programs: The goals of the development and training programs are clear; I have the opportunity to develop many different skills in the training programs; and the Seminars are always conducted by experts in their professional field. The overall results show that the objectives of the development and training programs are not clear enough and that in training programs, the employees have no opportunity to develop more different skills, which leads us to conclude that the specific **PH4 hypothesis has not been confirmed**.

PH5: The methods and techniques used in training offer quality acquisition of knowledge - The check of the fifth auxiliary hypothesis was based on the following questions: I have been achieving better results at work since I started taking part in training programs; After completing various training programs, I am more independent in my work; Upon completion of the training program, an assessment of the acquired knowledge is made; Upon completion of the training program, I receive feedback on the results achieved in my work; and In my work I have applied more than 2 methods that were presented in the training programs. The results of the survey show that employees achieve better results at work than when they take part in training programs and that the company evaluates the acquired knowledge after the training program. However, the problem is that after completing various training programs, employees are not more independent in their work, do not apply the methods presented in the training programs and do not receive feedback on the achieved results in their work, which indicates that the specific **hypothesis PH5 has not been confirmed.**

The overall results of the research show that three specific hypotheses (The organization enables the quality development of its employees, Employees are motivated and ready for continuing learning, improvement and development, and Employees are satisfied with their job and their role in the organization) *have been confirmed*. On the other hand, two specific hypotheses (Employees consider that the programs of development and training are well designed and organized and the methods and techniques used in training enable a high quality knowledge acquisition) *have not been confirmed*.

Therefore, it can be concluded that the **general hypothesis** of the research (Respondents consider that the organization carries out adequate education, training and development of employees, **has been partially confirmed.**

5.2 Proposed Measures

The overall results of the survey show that the company has serious problems with evaluating and rewarding the participation of employees in achieving goals, the ability of employees to apply different methods of work, the clarity of the goals of the development and training program, poorly organized and conducted trainings, and the lack of feedback on the achieved results in work after completing the training program. On the other hand, the organization sets goals that are achievable, provides and encourages the professional development of employees, is open to their ideas and thoughts and takes care of the employees. Also, employees are regularly informed about the activities for the next period, they are familiar with the goals and priorities of the organization, they have a clear vision of what their duties and responsibilities are and, what is extremely important, they are motivated and ready for continuing learning and development.

With such motivated and satisfied employees, the company could, with the appropriate learning, training and education programs, encourage greater creativity, inventiveness and dedication of the employees, and provide the organization with uniqueness and diversity.

As a proposal of measures for more successful operation of the company, at first, it is necessary that the human resources department, in cooperation with other departments, comes up with a quality program for evaluation of the employees' knowledge, expertise, skills and abilities and in accordance with it, re-assigns the employees to corresponding work positions [7].

Evaluation is a process to check the extent to which the desired educational goals have been achieved. This is an important step in the observed company, which must carry out the evaluation during the educational activities, immediately after the completion and after the implementation of the acquired knowledge in practice. It is very important that the line manager, after the training, allows participants to give their suggestions for improvement and that the training is perceived as a support for more efficient work and a chance for personal improvement.

6 Conclusion

In today's turbulent environment and era of knowledge economy, organizations have accepted training and education as a reality without which they could not survive. Education training is a good investment for the organization. In order to contribute to overall organizational goals, education in the organization should be based on educational needs. The survey of educational needs should include job analysis, organization analysis and employee analysis. The necessary skills, abilities and behaviours must be the basic catalyst for the company's activities.

Permanent improvements and innovations at and around work quickly depreciate expertise achieved upon completing a programme for vocational education. The need for staff with broad and versatile abilities demands ongoing continuing education. Understanding that technological and other forms of knowledge quickly become obsolete highlights the importance of knowledge assets as well as the need to update knowledge [8].

This paper deals with learning process in a particular organization, that is, the development and training of employees, the analysis of the organization's attitude towards the need for continual development and training of employees and how employees perceive their place in the organization. It was also important to check the progress of the training and development process from operative aspect, and how well the acquired knowledge is applied. The results indicate the need for thoughtful conducting of training and development within the organization and an adequate process of evaluating the completed training.

The results are useful, first and foremost for the organization. However, they can also be significant for the researchers dealing with this topic. The results indicate the need for thoughtful conducting of training and development within the organization and an adequate process of evaluating the results of the completed training, which is an imperative for business operation in the knowledge economy. The advantage that the organization has on the market is easily neglected, and so is the knowledge of its employees. This knowledge, if not nourished and used, will quickly become obsolete and represent a burden to the organization.

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Affective Attachment and Time Perspectives as Predictors of Achievement Motive

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Abstract. In recent years, the motive for achievement has always been an interesting topic for researchers to explore. In addition, how much, why, and how it develops, to how it is related to other psychological constructs. The main goal of the research is to determine whether Affective attachment and Time perspective are significant predictors of Achievement motive. Main hypothesis is stated as: Affective attachment and time perspectives are significant predictors of achievement motive. The survey was conducted on a sample of 149 respondents from different sociodemographic features. The survey was conducted on March 2018. Data analysis included descriptive statistics, frequency analysis and linear multiple regression analysis. It was assumed that affective attachment and time perspectives are significant predictors of achievement motive. The results showed that Positive future and Hedonistic present are positive predictors of the total Achievement motive, while the Affective attachment and its dimensions aren't significant predictors. The main hypothesis is confirmed.

Keywords: Achievement motive · Affective attachment · Time perspectives · Predictors

1 Introduction

The achievement motive has attracted the attention of the researchers for many years. In social and pedagogical psychology, wide range of studies examined the nature and relations of this motive with other psychological constructs. It was found that the safe attachment to parents in childhood is significantly positively related to a number of factors that include persistence in task solving, motivation, effective use of time, focused attention, positive attitudes toward school and enthusiasm. On the other hand, human's events and experiences in time make sense of them. For example, they may use previous instances of an event to predict its occurrence in the future. Zimbardo et al. [1] have developed a model of how people organize and apprehend time.

Based on this, we have verified the assumption that a specific model of time perspectives with affective attachment, contributes to the level of achievement motive and expression of its dimensions. According to Butler [2], the person with high achievement motive tries to gather lots of data about himself or herself by measuring his "competence" via certain standards in his or her environment.

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Past researches have already shown that time perception plays an integral role in the selection and achievement of social goals, with important implications for emotions, cognition and motivation [3]. In this respect, the past, the present and the future are definite frameworks that affect coding, storage and experiential events, but also on the formation of expectations, goals and possible scenarios.

The achievement motive is one of the most empirically researched motives within psychology. Psychologist Murray is considered one of the first researchers to point out the existence of this motive. Because of the significance of the achievement motive in career development, this paper analyzes the influences that are relevant to the achievement motive. We have set a general hypothesis: Affective attachment and time perspective are important predictors of the achievement motive.

According to Murray [4], the achievement motive is similar to other motives which are in human natures, like self-assertion motive, combat motivation, motive of prestige, domination, etc. Murray sets the achievement motive among the twenty basic needs, the so-called driving forces of personality, and sets it as a need to achieve a certain goal and overcome obstacles in the way of accomplishment, by investing a long repetitive effort, then as an urge to manipulate and compete with other people and other's ideas.

Physiological need is a concept that was derived to explain and cultivate the foundation for motivation. Abraham Maslow's hierarchy of needs theory represents the human needs into five subgroups, hierarchically systemized by importance to a person. According to this theory, in terms of career development, direct material compensation is used to satisfy the needs that are on a lower hierarchical scale, while non-material compensations and career advancement serve to meet higher needs [5]. Alderfer adds a few more key features of the achievement motive. Satisfied need can be a motivator, the culture and personal history of an individual affect the importance of needs - there is no general established hierarchical order, there is a progress through satisfaction, but also a regression through frustration [6]. On the other hand, Herzberg's work motivation theory emphasizes the importance of internal motivation and the limitation of the operation of external factors of motivation [7]. McClelland [8] explained achievement motivation as the need for achievement and adds two needs that are important for work behaviour and business success, and these are the need for power and affiliate motive.

Vroom's expectancy theory of motivation explains that motivation for work is conditioned by an assessment of whether an employee can achieve his or her desired goal (material, social, personal). This theory explains that individuals can be motivated towards goals if they believe that there is a positive correlation between efforts and performance, the outcome of a favourable performance will result in a desirable reward, a reward from a performance will satisfy an important need, and/or the outcome satisfies their need enough to make the effort worthwhile [9]. Here we clearly see the importance of the central factors, but also the training, acquisition of the competencies - knowledge and skills and the correlation between the competencies and the motivation. Managers are not always ready to deal with these employee expectations, which are the basic issues in effective performance management. It is important to note that employee expectations and assessments do not always have to be realistic and rational, which makes harder for managers to increase motivation and improve performance.

According to McClelland [10], the achievement motive is the tendency to make an effort to achieve and achieve something that is considered worthwhile and to stand out before others. He believes that this motive belongs to the acquired motives and is formed by the experience of the individual, as well as by the system of values that governs a certain culture. In addition, the motive of achievement can be at a different level developed by individuals of the same society and can be distinguished by members of different societies.

2 Literature Review

2.1 Affective Attachment

We will start an overview of the affective attachment development by noting that attachment is not an unambiguous notion. Namely, some authors speak primarily about strategies or patterns of behavioral affection, others explore internal models of attachment, perceiving it as a relatively permanent behavioral disposition, while others consider that affective attachment is not "in the head" of only one person, nor it can be understood observing only his or her behavior, but it is within the dual relationship in which a person participates.

Bowlby considered that the basic biological function of attachment was the acquisition of protection by adult individuals. Today, thirty years from the first Bowlby settings of affective attachment, we are still witnessing the empirical vitality of the theory as well as its ability to communicate between the etiological approach to human behavior, developmental research on the characteristics of the early interaction of the mother-infant, the neurophysiology of emotions, other higher mental functions and numerous psychoanalytic formulations on the development of personality and psychopathology [11].

The relationship through affective attachment provides the possibility for the mother to shape the physiology and behavior of the infant through the pattern of interaction with it. Therefore, an attachment is a system through which key ontogenetic, physiological and psychological tasks are achieved, such as the development of auto-regulation of affect. Thus, Shor believes that the construction of the attachment relationship in the first year of life is a central event for further socio-emotional development, because within a secure attachment relationship, optimal conditions for the maturation of specific nervous structures that are in charge of affective control and mediate in all interpersonal and intra-psychic aspects of future the social and emotional functions. Fonagy et al. consider that the relationship of attachment is of primary evolutionary importance because it provides conditions for the development of the reflective function and self-development [12, 13].

Affective attachment theory recognizes a warm, sensitive and flexible environment as optimal for the development of a safe affective attachment. In the basis of the formation of a safe type of affective attachment, there is the responsibility of the mother, or other parent or guardian. Although some scholars claim that the sensitivity of the mother does not show a pronounced connection to the safety of the child's affective attachment, most research and meta-analytic studies indicate that although it is not the only factor of security of affective attachment, the sensitivity of the environment is its most important precondition [14].

In recent years, scholars have increased the attention from the parent-child relationship to the effects that the stability of the overall family environment can have on the development of security of affective attachment, and, in general, the environment in which the child grows [15].

2.2 Time Perspectives

Psychological interpretation of the time phenomenon represents a controversy for many psychologists, philosophers and other scholars, so, William James in the 1950s put the concept of time into the center of psychology discipline. Tackling objective and subjective times is a fundamental determinant of human experience [16]. Time perspective is a way of connecting with the psychological concepts of the past, the present and the future. Time and its dimensions are not viewed as objective stimuli that exist independently of an individual, but as psychological concepts constructed and reconstructed by an individual [17].

Time perspective is an unconvincing process in which the classic and social experiences are divided into time categories or frames, which helps in creation order and coherence, interconnectedness and meaning among them. These cognitive frames can reflect cyclical, recurring time patterns or unique unrepeatable linear events in human life, and serve to encode, upload and experience experiential events as well as to shape expectations, goals, and imaginative scenarios. The time perspective has a cognitive dimension, which is primarily influenced by sensory, biological and social qualities that are associated with prominent environmental features at a given moment. Individual actions and decisions are the result of situational pressure, intensity and quality of the stimulus, the prevailing biological state, or the social aspect of the situation in which it is located [18, 19].

Zimbardo and Boyd distinguish 6 types of time perspectives: positive future, negative future, positive past, negative past, hedonistic present and fatalistic present. Studies have shown that the current hedonistic temporal perspective is associated with a risky drive and more frequent use of drugs, cigarettes and alcohol or with poor self-control, seeking excitement and novelties in life. The future time perspective is linked to the conscientiousness and adherence to time limits, but also with consistency. The past positive time perspective is associated with higher self-esteem, while the negative and present fatalistic time perspectives have been linked to depression, anxiety, anger and aggression [20–22].

3 Methodology

3.1 Samples

The survey was conducted on a sample of 149 respondents from different socio-demographic features. In terms of employees, the survey covered 77 employees and 72 unemployed respondents. In terms of sex, the survey involved 36 men, of whom 24 were employed and 12 were unemployed. Regarding the categories of women, 53 women were employed and 60 were unemployed. In the terms of age and length of service, it can be said that the youngest respondent was 18 years old, the oldest was 40, and the average age is 24.66 years. In terms of length of service, the maximum number of years of service is 16, and the average number of years of service is 5.29 (Table 1).

Table 1. Samples.

	Minimum	Maximum	AS	SD
Years	18.00	40.00	24.66	3.931
Years of experience	1.00	16.00	5.29	3.141

It was used Zimbardo Time Perspective Inventory to measure time perspectives. This questionnaire measures six time perspectives, such as: Positive past, Negative past, Hedonistic present, Fatalistic present, Positive future and Negative future. Affective attachment was measured by The Experiences in Close Relationships-revised Questionnaire [23]. It's a 36-item measure of adult attachment style. The questionnaire measures individuals on two subscales of attachment: Avoidance and Anxiety. In general Avoidant individuals find discomfort with intimacy and seek independence, whereas Anxious individuals tend to fear rejection and abandonment. The achievement motive is measured by the modified version of the Achievement Motive Questionnaire. Questionnaire measures four dimensions: Competition to others that indicates the tendency of an individual to stand out in front of others and to be more successful than others, Perseverance that indicate the persistence as a human trait, Achieving goals as a source of satisfaction which is related to a tendency toward achieving goals whose achievement is perceived as a reward and planning as a tendency of a person to plan activities to achieve goals [24].

3.2 Procedures and Analysis

The survey was conducted on March 2018 on a sample of different socio-demographic characteristics. Data analysis included descriptive statistics, frequency analysis and linear multiple regression analysis.

4 Results

4.1 Descriptive Statistics

Prior to checking the hypothesis, an overview of the measure of variability and measures of the central tendency is given (Table 2). The intensity of the overall achievement motive is low, however, if the dimensions are observed, it can be seen that the persistence and goal are more pronounced as a source of satisfaction than the competition and planning. In terms of affective attachment, the variable avoidance is more pronounced in relation to anxiety. From the time perspectives, the most positive is the positive past and the positive future, while the negative sides of these time perspectives are least visible.

Table 2. The measure of the variability and the central tendency.

	N	Minimum	Maximum	M	SD
MOP	149	44,00	100,00	75,38	11,762
Persistence	149	11,00	25,00	19,81	3,562
Competition	149	7,00	25,00	17,02	4,569
Planning	149	5,00	25,00	17,04	4,485
Goal	149	12,00	25,00	21,50	3,120
Avoidance	149	41,00	96,00	71,57	10,613
Anxiety	149	23,00	99,00	65,18	16,875
PP	149	1,00	5,00	3,62	,925
PB	149	1,33	5,00	3,51	,843
PH	149	1,33	5,00	3,12	,828
PF	149	1,00	5,00	2,65	,953
PN	149	1,00	5,00	2,49	1,222
NB	149	1,00	5,00	2,48	1,152

The assumptions in the research relate to determining the intensity of the predictability of affective attachment and time perspective according to the criterion of the overall achievement motivation and its dimensions. A multiple linear regression was used to check general and specific hypotheses.

General hypothesis: Affective attachment and time perspectives are significant predictors of the overall achievement motive. The coefficient of determination indicates that the time perspectives and dimensions of affective attachment explain 34.7% of variance of the variable the overall motive of achievement (Table 3).

Table 3. Regression model.

Model	R	R^2	Adjusted R^2	SE
1	,589[a]	,347	,310	9,769

[a]Predictors: (Constant), achievement motive, affective attachment, time perspective

The ANOVA results indicate that the above mentioned percentage is statistically significant (Table 4).

Table 4. ANOVA.

Model	Sum of squares	Df	Mean of squares	F	P
Regression	7115,303	8	889,413	9,319	,000[b]
Residual	13362,120	140	95,444		
Total	20477,423	148			

[b]Predictors: (Constant), achievement motive, affective attachment, time perspective

Observing the partial contributions of the predictors, it can be ascertained that two time prospects are distinguished as significant positive predictors, and these are positive future and hedonistic present (Table 5).

Table 5. The partial contributions of the predictors.

Model	Non-standardized coefficients		Standardized coefficients	t	P
	B	SE	Beta		
Avoidance	,068	,085	,062	,805	,422
Anxiety	,067	,053	,097	1,277	,204
PP	1,152	,918	,091	1,255	,212
PB	5,124	1,051	,367	4,874	,000
SH	3,376	1,054	,238	3,204	,002
SF	−1,906	1,039	-,155	−1,835	,069
PN	−,689	,885	-,072	−,779	,437
NB	−1,249	,953	-,122	-1,311	,192

5 Discussion

The achievement motive has attracted the attention of the researchers for many years. In social and pedagogical psychology, wide range of studies examined the nature and relations of this motive with other psychological constructs.

It was found that the safe attachment to parents in childhood is significantly positively related to a number of factors that include persistence in task solving, motivation, effective use of time, focused attention, positive attitudes toward school and enthusiasm. On the other hand human's events and experiences in time make sense of them. For example, they may use previous instances of an event to predict its occurrence in the future. Zimbardo and colleagues have developed a model of how people organize and apprehend time. Based on this, we have verified the assumption that a specific model of time perspectives with affective attachment, contributes to the level of achievement motive and expression of its dimensions [16].

Pirson's correlation was used to determine the correlation between the mentioned variables. At first glance, there are the much greater number of significant correlations between the achievement motive and its dimensions and time perspectives, in relation to the correlations of the achievement motive and its dimensions with the dimensions of affective attachment.

Past researches have already shown that time perception plays an integral role in the selection and achievement of social goals, with important implications for emotions, cognition and motivation. In this respect, the past, the present and the future are definite frameworks that affect coding, storage and experiential events, but also on the formation of expectations, goals and possible scenarios [25].

The general hypothesis states that affective attachment and time perspectives are significant predictors of the overall achievement motivation. Observing the partial contributions of the predictors, it can be ascertained that two kinds of time perspectives are distinguished as significant positive predictors, and these are positive future and hedonistic present [26].

Psychologists have developed theories about the conceptualization of an individual over the time and the effect on which these features are derived from behavior. In recent decades, some recent psychological theories emphasize that time is focused on the psychometric measurement of the perspective of human time and its impact on motivation, self-regulation and happiness. In spite of the fact that previous research has largely explored associations between the future period and achievements, the interest in people imagining upcoming events are not new, the future as a significant predictor of the achievement motive is not surprising. The Frencesko also states that the direction of the thinking about the achievement motive is present and future [27–29].

In the case of persons characterized by a positive future, it is characteristic that they are dedicated to the work related to the achievement of future goals, inclined to delay the satisfaction and, most often, do not matter to them the immediate enjoyment. Also, they are more often academically and commercially successful, and therefore, there is the positive impact on the height of the motive of achievement. On the other hand, people with a high achievement motivation will organize their activities as pleasant, exciting and stimulating [30].

6 Conclusion

It was assumed that affective attachment and time perspectives are significant predictors of achievement motive. It can be concluded that the Positive future and Hedonistic present are positive predictors of the total Achievement motive, while the Affective attachment and its dimensions aren't significant predictors. The main hypothesis is confirmed. As a suggestion for future research, repeat the research on the influence of affective patterns on achievement motive, as the link between temporal perspectives and achievement motive has been confirmed and shown to be consistent from previous research. In order to overcome the methodological limitations of the research, it is necessary to increase the sample, but also to bring the achievement motive with some other constructs in the field of organizational behavior, such as motivation, leadership style, aspiration for power, etc.

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Data Fusion for Industry 4.0: General Concepts and Applications

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Abstract. The 4th Industrial Revolution represents a new industrial era through the combination of Cyber-Physical Systems, Internet of Things, and the Internet of Services. Data are the new raw material of the 21st century, and it is necessary to turn these data into meaningful information to provide a more flexible, reliable, and efficient operation. To overcome challenges related to acquisition and analysis of a large amount of data, the data fusion strategy has gained focus as a data preprocessing phase to support the fast-growing data-intensive applications. This article presents a systematic mapping of general concepts and applications of data fusion in the context of Industry 4.0 assisting the research community in future studies as well as practitioners and students, providing support for the use of data fusion strategy.

Keywords: Industry 4.0 · Data fusion · Multi-sensor data fusion

1 Introduction

The objectives of Industry 4.0 are to achieve a higher level of operational efficiency and productivity, as well as a higher level of automatization [1]. Industry 4.0 targets the implementation of interconnecting, smart, and self-controlled structures of processes and systems [2]. It stands for vertical integration and networked manufacturing systems for smart production, which provides the abilities of self-organization, self-learning, and self-adaption [3]. Recent developments have resulted in higher availability and affordability of sensors, data acquisition systems, and computer networks [4]. Therefore, the use of these technologies resulted in the generation of a high volume of data [5, 6]. In order to turn these raw data into meaningful information, data analysis techniques can be applied to discover relations among features [7] in which, in terms of manufacturing systems, can be used to predict a system's behavior and/or improve its overall performance, predict abnormal events, generate warnings and advise systems and/or operators, assisting in diagnosis and maintenance tasks [8, 9]. However, according to [3], manufacturing data mainly include structured and semi-structured data, and the increasing amount of information available in industrial plants leads to the adoption of data fusion and data analysis [10] for addressing specific requirements and needs. Data fusion is a technique that combines multiple sources to obtain improved information, resolving

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conflicting values and finding the underlying true values [11], which results in less expensive, higher quality, or more relevant information [12]. [13] point out that data fusion has taken in advent of industrial prognosis, emerging lately as a data preprocessing phase to support the fast-growing data-intensive applications. In this way, a systematic mapping was conducted in order to consolidate information regarding the data fusion techniques adopted in the context of Industry 4.0. More specifically, this paper aims to investigate: (i) taxonomies of data fusion in the context of Industry 4.0; (ii) models, architectures and frameworks proposed by the literature, and (iii) data fusion applications and use cases. Hence, this study could assist the research community in future studies as well as practitioners and students, providing support for the use of data fusion strategy.

The rest of the paper is organized as follows. In Sect. 2 the systematic mapping method used in this paper is described. Section 3 presents the results obtained according to the objectives, and in Sect. 4 we conclude with a summary and present the importance of data fusion for Industry 4.0.

2 Methods

In order to develop an efficient and well-structured bibliographic analysis, ProKnow-C methodology [14] was applied to investigate the data fusion in the context of Industry 4.0. The ProKnow-C method is structured in four steps: (i) selection of the bibliographic portfolio that provides the literature review; (ii) bibliometric analysis of the bibliographic portfolio; (iii) systemic analysis of the bibliographic portfolio; and (iv) elaboration of the research objectives.

In this work, three research axes were selected, represented by the keywords: Data Fusion, Decision Fusion, and Information Fusion. For each of the three axes, the focus was placed on three subgroups: (i) search for reference models, architectures, and frameworks; (ii) state of the art and review; (iii) applications in manufacturing and factory shop-floor. Based on the research axes, the keywords were established, and Scopus and Web of Science databases were considered to compose the bibliographic portfolio. For each of these databases, eight searches were performed within the title, keywords, and abstract, and with the publication date limited to between 1988 and 2019, resulting in a total of 1257 articles. Then, by eliminating duplicate articles and from the analysis of the title, keywords, and abstract in order to verify its significance with the topic researched, the number of articles was reduced to 134.

For the analysis of the article's relevance, a search on Google Scholar was conducted, and based on the results, the representativity of each article in the set of 134 works was calculated. It was defined as a threshold for the article to remain in the current portfolio, a representativity of at least 60%, which resulted in an amount of 74 articles selected for this research, based on its scientific relevance.

3 Results

In the era of Industry 4.0, manufacturing resources (e.g., robots, machine tools, smart devices) are becoming interconnected [15], creating a collaborative community where intelligent machines, systems, and networks are capable of exchanging and responding to information, with the aim of managing industrial manufacturing processes [16, 17]. This scenario is resulting in the adoption of new digital technologies within its processes and assets to merge the physical and digital worlds [13]. Consequently, the generation of a large amount of multi-source heterogeneous data is imminent, and the fusion of these data becomes a significant challenge for the manufacturing shop-floor. To assist in this task, [18] point out that data fusion techniques play an essential role in finding vital data from the widely sensed or collected data, in order to improve its quality, extract useful information and aid decision making.

3.1 Data Fusion

According to [19], researchers proposed a variety of definitions or explanations for data fusion from different fields or viewpoints [20–24], however, there is no generally accepted definition. For being a multidisciplinary research area [25], the terms data fusion and information fusion are typically employed as synonyms and used interchangeably in the literature. In some cases, the term data fusion is used for raw sensor data, while information fusion is applied to specify analyzed data, so the latter implies a higher semantic level than the former [12]. [26] states that decision fusion is a subclass of data fusion, and both are closely related. According to [12] decision fusion takes symbolic representations as sources and combines them for a more accurate decision. These techniques are intended to make a high-level inference on events, and the merging process requires that uncertainties and constraints be accounted for at the same time.

One of the most accepted definitions of data fusion was provided by the Joint Directors of Laboratories (JDL), which stands for "multi-level, multifaceted process handling the automatic detection, association, correlation, estimation, and combination of data and information from several sources." [27] defined information fusion as "the study of efficient methods for automatically or semi-automatically transforming information from different sources and different points in time into a representation that provides effective support for human or automated decision making." Other terms related to data fusion include data combination, data aggregation, multi-sensor integration, multi-sensor data fusion, and sensor fusion [12, 28].

Data combination can be roughly associated with any process that involves the fusion of data and knowledge from several sources to enhance the valuable information content of the resultant data [29]. According to [30], data aggregation comprises "the collection of raw data from pervasive data sources, the flexible, programmable composition of the raw data into less voluminous refined data, and the timely delivery of the refined data to data consumers." Data aggregation can be considered a subset of data fusion which summarizes the sensor data in order to reduce or eliminate redundant data. [31] defines sensor/multi-sensor data fusion as a set of techniques and tools in order to combine sensor data or any other data derived from the sensory measurements. The aim is to improve the quality and accuracy of the collected data, such that the final representation is better than, or at least not worse than, any data collected by a single sensor [32]. Lastly, multi-sensor integration refers to "the synergistic use of the information provided by multiple sensory devices to assist in the accomplishment of a task by a system" [33].

Hence, the term data fusion and information fusion are generally used interchangeably, while data aggregation can be considered a data fusion subset that aims to summarize data. Sensor/multi-sensor data fusion is also a subset in which each data source is a sensor, and multi-sensor integration is related to the use and interaction of fused data with the environment, Fig. 1 depicts the relationship among terms associated to data fusion.

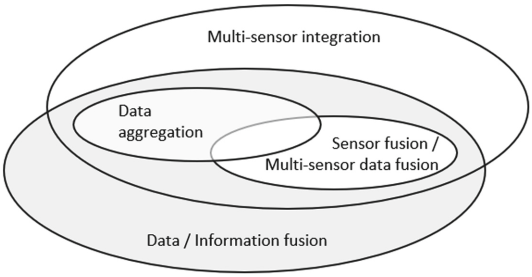

Fig. 1. The relationship among terms associated with data fusion, adapted from [34].

In regards to Industry 4.0, according to [35], data fusion is a key enabling technology in order to process an enormous volume of data collected from a variety of channels (e.g., machine, physical environment, virtual space, historical database, among others). The fast development of computer science and advanced sensor technology has increased the adoption of multiple sensors for condition monitoring, fault diagnosis, and prognosis [36]. In this context, multi-sensor data fusion is generally performed to provide the prognostic models with consolidated information correlated with the condition of the industrial assets and production processes [37]. Nevertheless, multi-sensor data fusion is a challenging task, according to [38], decisions derived by a sensor fusion-based monitoring system are neither clear, nor understood, or traceable: phenomena are recognized, whose causes and interdependencies are hidden. Most of the issues arise from the data to be fused, imperfection, and variety of the sensor technologies, and the nature of the application. Besides, the input data to the fusion system may be imperfect, correlated, inconsistent, and/or in disparate forms/modalities [21]. Therefore, one of the crucial points is related to the ability of the system to manage the diversity issues (e.g., sensor failures, corrupted data, compatibility of sensors) [39]. In order to deal with these difficulties, efficient data fusion methods should be employed to increase data reliability. According to [21, 40], these methods may be categorized as (i) probabilistic; (ii) statistic; (iii) knowledge base theory; and (iv) evidence reasoning methods. Some of these methods include: Bayesian analysis, maximum likelihood methods, state-space models, possibility theory, evidential reasoning, evidence theory, K-Nearest Neighbor, least square-based estimation methods (e.g., Kalman filtering, optimal theory and regularization), cross-covariance, covariance intersection, aggregation methods (e.g. artificial neural network, genetic algorithms and fuzzy logic), Dempster-Shafer theory, recursive operators, among others [41].

3.2 Data Fusion Models, Architectures and Frameworks

Data fusion models, architectures and frameworks play a significant role to aid the development of data fusion systems, which results in higher efficiency of the processed data and the significance of the made decision at the output level [42]. According to [12], data fusion can be classified based on: (i) relations between the input data sources [43]; (ii) the input/output data types and their nature [44]; (iii) abstraction level of the employed data [45]; (iv) the different data fusion level defined by the Joint Directors of Laboratories (JDL) [39]; (v) architecture type. [34] describe the architectures and models categorized into three main domains: (i) data/information-based model (e.g., JDL Model, Dasarathy Model, etc.); (ii) activity-based model (e.g., Boyd Control Loop, Intelligence Cycle, etc.); and (iii) role-based model (e.g., Object-Oriented Model, Frankel-Bedworth Architecture, etc.).

The Joint Directors of Laboratories Data Fusion (JDL DF) model is the most common and popular model in the data fusion community [12]. It was formerly proposed by JDL and the U.S. Department of Defense (DoD) in order to support developments in the military field. The original JDL DF model is composed of four processing levels of abstraction: Level 1 (object refinement); Level 2 (situation assessment); Level 3 (impact assessment); and Level 4 (process refinement) [39]. Despite its popularity, the JDL model has many limitations, such as being too restrictive and specially focused on military applications [21]. [46] proposed the first revision of the original JDL DF model, broadening the definitions of fusion concepts and functions beyond the original focus on military and intelligence applications. One of the main changes was the introduction of Level 0 (source preprocessing) to the original model. The five fusion levels were categorized into two stages, the low-level fusion process (Level 0 and 1), and the high-level fusion process (Level 2, 3, and 4) [47]. According to [48], the Data Fusion Information Group (DFIG) model is the current instantiation of the JDL model, and the goal was to separate the information fusion from the management functions, Fig. 2 depicts the DFIG model, and its levels described as follows [49]:

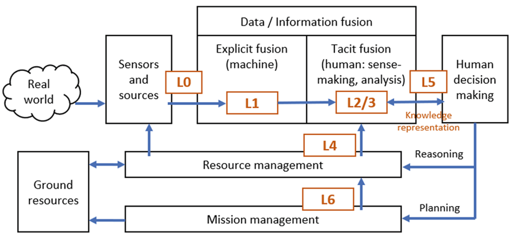

Fig. 2. DFIG model, adapted from [49].

- Level 0 – Data Assessment: estimation and prediction of signal/object observable states on the basis of pixel/signal level data association;
- Level 1 – Object Assessment: estimation and prediction of entity states on the basis of data association, continuous state estimation and discrete state estimation;
- Level 2 – Situation Assessment: estimation and prediction of relations among entities, to include force structure and force relations, communications, among others;
- Level 3 – Impact Assessment: estimation and prediction of effects on situations of planned or estimated actions by the participants; to include interactions between action plans of multiple players;
- Level 4 – Process Refinement (an element of Resource Management): adaptive data acquisition and processing to support sensing objectives;
- Level 5 – User Refinement (an element of Knowledge Management): adaptive determination of who queries information and who has access to information and adaptive data retrieved and displayed to support cognitive decision making and actions;
- Level 6 – Mission Management (an element of Platform Management): adaptive determination of spatial-temporal control of assets and route planning and goal determination to support team decision making and actions over social, economic, and political constraints.

Over the last decades, different models, architectures, and frameworks have been proposed for data fusion. Table 1 presents a collection of the common ones, including a brief description of every case. Detailed information regarding these models, architectures, and frameworks can be found in the respective references.

Table 1. Data fusion models, architectures, and frameworks.

Models, architectures, frameworks	Description	Refs.
Durrant-Whyte architecture	Relations between the input data sources: complementary; redundant; or cooperative	[43]
Dasarathy's model	Data fusion functions: Data In-Data Out; Data In-Feature Out; Feature In-Feature Out; Feature In-Decision Out; and Decision In-Decision Out	[44]
Luo and Kay's architecture	Distinction between multi-sensor integration and multi-sensor fusion. Specified the integration of multiple sensors in four levels of abstraction: signal; pixel; feature; and symbol levels	[45]
Thomopoulos architecture	Architecture for data fusion based on three modules: Signal level fusion, Evidence level fusion, and Dynamics level fusion	[50]
Pau architecture	Data fusion framework based upon behavioral knowledge formalism with a hierarchical approach, where several stages must be completed to establish the overall output	[51]
Waterfall model	Hierarchical architecture composed of three levels of abstraction: Level 1 (sensing, signal processing); Level 2 (feature extraction, pattern processing); and Level 3 (situation assessment, decision making)	[52]
Boyd control loop (OODA)	Cyclic model composed of four stages: Observe; Orient; Decide; and Act. Representation of the classic decision-support mechanism of military information systems. Applicable for designing information fusion systems	[53]

(*continued*)

Table 1. (*continued*)

Models, architectures, frameworks	Description	Refs.
Intelligence cycle	Cyclic model composed of four stages: Collection; Collation; Evaluation; and Dissemination. Applicable for modeling data fusion process	[54, 55]
Omnibus model	Cyclic model as a unification of the Intelligence Cycle, JDL model, OODA loop, Dasarathy's and Waterfall model. Makes explicit the activities referred to information fusion tasks. Applicable for designing information fusion systems	[56]
Visual data-fusion model	Extension of JDL model, human as a central participant in the information fusion process	[57]
Object-centered information fusion model	Cyclic model to provide a set of roles (i.e., Actor, Perceiver, Director, Manager) and specify the relationship among them. Addressed issues on the design of data fusion systems with a top-down approach	[58]
Frankel-Bedworth architecture	Architecture composed of a local and global perspective, based on their objective's differences. The local process includes an Estimator role (Sense, Perceive, Direct, Manage, and Effect) while global process includes a Controller role (Orient, Prefer, Expect)	[59]
Endsley model	Widely used to model situation awareness (SAW), consists of three phases: Level 1 (perception of the elements in the environment); Level 2 (comprehension of the current situation); and Level 3 (projection of future status)	[60]
Unified data fusion model (deconstructed JDL)	Revision of JDL functional levels: Level 1 (identification of objects from their properties - object fusion); Level 2 (identification of relations between objects - situation fusion); and Level 3 (identification of the effects of these relationships between these objects - impact fusion)	[61, 62]
JDL-user model	Extension of JDL functional levels to support the human-in-the-loop decision process (Level 5)	[63, 64]
Extended-OODA loop	Extension of OODA loop, which enables multiple concurrent and potentially interacting data fusion processes, can be applied to obtain a high-level functional decomposition of a system that uses data fusion for decision making	[65]
Dynamic-OODA loop	Extension of OODA loop associated with cybernetic models of command and control (C2), for the military field. The model includes functions of sensemaking, command concept, planning, information collection, and decision	[66]
The Laas architecture	Architecture for sensor fusion and mid-level classification of functional modules to be used in real-time systems. Consists of four abstraction levels: Logical robot level; Functional level; Level control; and Decision level	[67]
Steinberg and Bowman model	Revision of JDL functional levels: Level 0 (Signal/Feature Assessment); Level 1 (Entity Assessment); Level 2 (Situation Assessment); Level 3 (Impact Assessment); and Level 4 (Performance/Access Assessment)	[68]
TRIP model	A link between human requirements and data collection was provided, due to the transformation of information needs to task assignment of sensor resources	[69]

3.3 Data Fusion Use Cases

In the context of Industry 4.0 most of the architectures and applications [16, 70, 71] refer to data fusion as a multi-sensor data fusion, where the focus is placed on data-driven prognosis which means the capability to estimate and anticipate events of interest regarding industrial assets and production processes [13]. In this line, there are currently several industrial applications of data fusion techniques. [72] introduced a method to detect machinery fault based on Dempster-Shafer's theory of evidence with the ability to increase the accuracy of decision-making by merging information from multiple sources. [73] proposed an algorithm based on the estimation of a common Gaussian-mixture distribution, which is applicable in several industrial, chemical, or manufacturing processes, as well as sensor networks. [74] demonstrated the development of a concrete data link between manufacturing and office planning to facilitate the deployment of an integrated information system throughout the plant.

4 Conclusion

This paper presented a systematic mapping of data fusion concepts, as well as the most relevant frameworks and architectures in the scientific literature. It was also described some application areas in the context of Industry 4.0. The main idea of data fusion is to integrate data from different sources in order to obtain enhanced information. One of the challenges of the 4.0 industry is to convert raw data into useful information towards a smart and flexible production system, this is where data fusion plays an important role. In order to achieve higher performance and flexibility in the manufacturing area, data analysis can be used to provide prognostic models for outcome predictions of assets and production processes. Nevertheless, manufacturing data is usually semi/non-unstructured, therefore, the preprocessing phase is essential not only to find the underlying data values but also to enhance data quality and extract new features, which, in terms of data analysis could be useful to increase the overall efficiency of a prediction model.

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New Technologies in Corporate Communications

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Abstract. Technology development is reshaping different types of communication – including business, marketing and corporate communication. In this paper we investigate the adoption of the latest technologies in corporate communications of the most valuable companies in the world. The usage of new technology trends in corporate communication was analyzed in real business systems. We examined the implementation of artificial intelligence, machine learning, augmented reality, virtual reality, live video streaming and chatbots by the following companies: Amazon, Microsoft, Alphabet Inc., Apple, Berkshire Hathaway, Facebook, Tencent, Alibaba Group, Johnson & Johnson, JPMorgan Chase. The results indicate that companies are preparing to develop and integrate the latest technologies to achieve more interactive and immersive experience when communicating to their internal and external stakeholders. This study contributes to the theory and practice which investigate the new generation of information and communication technology, that aim to enhance interaction in the customer experience.

Keywords: New technologies · Corporate communications · Interactive experience

1 Introduction

The advance of technology changed the corporate communications through the history. In internal communications, it has changed the work processes. The communication changed its medium and from paper, the companies are moving to paperless communication. In external communication, companies are using digital channels and digital media for their marketing and PR activities. These changes also created new job positions. The Social Media Managers and Digital Marketing Strategists are only a few jobs that did not existed just 20 years ago.

The main research question in this study is: what are the new technologies that companies use in their corporate communication strategies and secondly, how does this affect the enhancement of the experience of their stakeholders.

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2 Theoretical Perspectives and Research Questions

2.1 Corporate Communications

Van Riel and Fombrun [1] state: "Communication is the lifeblood of all organizations: it is the medium through which companies large and small access the vital resources they need in order to operate. It is through communication that organizations acquire the primary resources they need (such as capital, labor, and raw materials) and build up valuable stocks of secondary resources (such as "legitimacy" and "reputation") that enable them to operate."

These authors emphasize that the main responsibilities of corporate communications are:

- Establishing the corporate branding.
- To strive to minimize the differences between desired and actual corporate identity.
- Delegating the communications tasks to the right persons in the company.
- Creating communication strategies that will guide decision making on communication issues.
- Ensuring external and internal support for corporate objectives.

According to Christensen and Cornelissen [2], Shelby defined corporate communication as sum of different types of communication that include PR, employee, customer and stakeholder communication.

2.2 New Technologies

In this paper we analyze several technology trends that marked last decade. The implementation of artificial intelligence, machine learning, augmented reality, virtual reality, live video streaming and chatbots is examined.

Artificial intelligence (AI) definitions address two dimensions: thoughts/reasoning and behavior. For computer to be intelligent it needs to possess the following capabilities: natural language processing (NLP) for fluent communication, knowledge representation, automated reasoning and machine learning [3]. Virtual reality (VR) represents computer simulation of real world environments. These simulations are interactive and are capable of responding to user inputs making it interactive in real time [4]. Unlike virtual reality, augmented reality (AR) implements fragments of virtual reality and incorporates them into real world. Using technology it aligns real and virtual objects while running interactively in real-time [5]. Live video streaming was waiting long for Internet and computers to reach the needed capabilities in order to have stable and high-quality connection required for video streaming. It was seen as potential groundbreaking application for the Internet [6]. And finally, chatbots are computer programs that mimic human conversation and interaction. Although they exist since 1960s, in the last few years they have experience prominence in the last couple of years [7].

2.3 New Technologies in Corporate Communications

The purpose of this paper is to examine how new trends in technology are being used for corporate communications by most valuable companies.

RQ 1: How are the most valuable companies using new technologies in corporate communications?

3 Method

We identified the 10 most valuable companies in the world for 2019 based on market capitalization which is calculated by multiplying the number of shares issued by the company by the value of one such share [8]: Amazon, Microsoft, Alphabet Inc., Apple, Berkshire Hathaway, Facebook, Tencent, Alibaba Group, Johnson & Johnson and JPMorgan Chase

Finally, we analyzed the implementation of new technology trends in corporate communication practices of the observed companies, as presented in case studies available online. The total of 5 technology trends were examined: artificial intelligence (AI), augmented reality (AR), virtual reality (VR), live video streaming and chatbots.

4 Analysis

Table 1 shows what type of new technologies are examined companies using in their corporate communications.

Table 1. New technology usage by the most valuable companies.

Company	AI	AR	VR	Live video streaming	Chatbots
Amazon	flywheel	AR view	VR kiosks		
Microsoft	Microsoft teams	holoportation technology			
Alphabet Inc.	@meet bot		Employee training		@meet bot
Apple	Siri				Business Chat
Berkshire Hathaway					
Facebook	AI chatbot suspended	Spark AR AR adverts	Facebook Spaces	Facebook Live!	Facebook Messenger
Tencent	opened AI lab		VR video streaming	Tencent Video	QQXiaoBing Baby Q
Alibaba Group	Alibaba Cloud	Taobao Buy	Taobao Buy	Taobao Buy	AliMe customer service chatbot
Johnson & Johnson	Andy		Employee training		Andy
JPMorgan Chase	AI research team				

4.1 Artificial Intelligence

Amazon uses AI and machine learning throughout the company. It is used for their popular products such as Alexa, the Amazon Go Store and Amazon recommendation engine. This type of technology is shared through the whole company so it can be integrated [9].

Microsoft's unified communications platform Microsoft teams uses AI, and with this software they introduced the concept of Intelligent Communications. It uses AI called Microsoft Graph that handles the massive flow of information through internal communication channels [10].

On the other hand, Facebook suspended their AI powered chatbot project after two chatbots developed and begin to communicate in their own language [11].

Alibaba invested in developing seven AI laboratories in order to pursue their goal to become the dominant in artificial intelligence, machine learning, network security, natural language processing and more. Alibaba uses AI to optimize its supply chain, develop products and deliver personalized recommendations [12].

The AI technology is integrated in Apple's Siri, a digital personal assistant. JPMorgan Chase has formed a research team in order to investigate and find potential areas within their organization in order to implement the AI technology [13].

4.2 Augmented Reality

During 2018, Amazon introduced AR view, a new tool that allows their users to project the images that they are considering to buy into their living space via augmented reality [14]. Similarly to Amazon, Alibaba started using AR to change the shopping experience [15].

Microsoft [16] used so-called holoportation technology which is still under development and currently in use in their offices. This is a type of 3D capture technology that allows high-quality 3D models of people to be projected anywhere in the world in the real time [17].

Facebook believes that there is more to AR beyond selfie filters, video-games and movie experiences. They believe that they can bring people together with AR ads that will be distributed through this social network [17].

4.3 Virtual Reality

Amazon used VR kiosks in selected shopping malls to promote their Amazon Prime Shopping Day. It takes customers through fun experience while showing them the special Prime Day offers [18]. Google VR (Alphabet Inc.) with their products such as Daydream, Tilt Brush, Earth VR and VR 180 Cameras wants to bring new experiences to the world. They also used VR technology to test possible employee training. The VR technology is tested for simple tasks such as how to use an espresso machine [19]. Johnson & Johnson is also using VR technology for employee training [20].

In 2018 Facebook launched VR meeting rooms called Facebook Spaces. When you enter Facebook Spaces you find yourself around the table where you can play games, do art, take photos or videos or chat with friends [21]. The Facebook staff says that they sometimes have international meetings through Facebook Spaces [22].

4.4 Live Video Streaming

Facebook already integrated Facebook Live! platform for video streaming with its internal communications platform – Workplace. Several benefits that are singled out are two-way meetings with the whole organization and engaging employees to drive cultural change [23].

China has the largest live streaming market in the world with more than 450 million active live streamers. In ecommerce, live streaming is used for product presentation, while the consumers are able to shop for products when they see it [24].

4.5 Chatbots

Google (Alphabet Inc.) developed an AI powered chatbot that can save a lot of time that employees normally use on scheduling, modifying, canceling an looking up for their schedule [25].

In 2016 Facebook introduced Bots on Messenger platform [26]. Facebook Bots began the revolution of customer support, sales and marketing. It is predicted that by 2020, the 85% communications between customers and businesses will be regulated by robotic process automation (RPA) [27].

Apple revealed the Business Chat, chatbot made for their instant messaging service, iMessage. Apple is offering customer support through Business Chat Servers, and it also integrates online shopping by using their Apple Pay feature [28].

Johnson & Johnson in 2018 introduced the AI powered virtual assistant for contact lenses, the chatbot named Andy. This chatbot interacts with customers who are considering contact lenses and becomes smarter with new interactions [29].

5 Discussion and Conclusion

The insight into current situation in examined companies indicate that they are preparing to develop and integrate the latest technologies to achieve the more interactive and immersive experience when communicating to their internal and external stakeholders.

Artificial intelligence is often integrated in different products and it is used across different parts of companies. The most often it is used to power and enhance the chatbots. The implementation of augmented reality is diverse. While Microsoft works on holographic projection of people, Facebook wants to bring their advertisements into real life. Virtual Reality is integrated in online retail sector, while Facebook is making efforts to bring VR into organizational context. Live video streaming is being developed by social media giants such as Facebook and Tencent, which are making products who are going to be used by other companies. On the Alibaba example we can clearly see that video streaming is making its way into retail industry and changing the habits and the overall shopping experience for the end users.

It can be noticed that interest and development of new technologies is strongly influenced by the type of company, its products and their target market. That means that companies are focused on integrating those technologies that can boost their products, but also to offer superior experience to their customers.

There is a small number of examples for new technology use in internal corporate communications, so it will be very interesting to see how these technologies will be used by companies to communicate with their employees in the future.

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A Risk Management Model for Quality Management Systems Based on ISO 9001:2015

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Abstract. Based on a systematic review of the literature previously conducted, the authors identified a gap in the risk-based thinking application in the context of ISO 9001:2015. In this context, this article aims to develop a risk management model that helps organizations in the achievement of ISO 9001:2015 requirements, adapting their Quality Management Systems. To achieve the paper's goals and validate the model the authors conducted an Action Research in a Brazilian company, developing and adapting the proposal during five cycles of plan, do, check and act (PDCA), according to the analysis: (1) company diagnosis and model proposal; (2) internal experts analysis and model adequacy; (3) first part audit; (4) third part audit; (5) analysis of the model implementation process and its stability. The method ensured the model adequacy for the company and the authors described an implementation guide as a support for organizations to develop the risk management model in their QMS.

Keywords: ISO 9001:2015 · Risk-based thinking · Action research

1 Introduction

The adoption of ISO 9001:2015's Quality Management System (QMS) calls attention to aspects related to the main changes embedded in the standard. Some authors relate that risk-based thinking is one of the key requirements; for the organizations, the most beneficial and challenging requirements are the risk-based thinking (section 6.2) and the Organizational Context (section 4) [1, 2]. Concerning to Small and Medium-Sized Enterprises (SME) the challenge is even bigger [3, 4].

According to a systematic review of the literature previously conducted, the authors identified the most frequent methodologies used by organizations and proposed by academic researchers, analyzing their consistency with ISO 9001:2015 requirements [5].

Most of the organizations opt for the use of widespread methods like Failure Mode and Effects Analysis (FMEA) and ISO 31000 model but, besides the standard does not require the use of specific methods [2, 6–8], the isolated use of the referred methods cannot guarantee the requirement's achievement. The best option is the combination of qualitative and quantitative methods with a better adaptation to each organization's context [5].

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With the risk-based thinking requirement the Top Management assume even more responsibility for the QMS, once that ISO 9001 requires it as part of the organizational culture, in a long-term thinking [2, 3, 6, 8–10].

In this context, this article seeks to assist the organizations and practitioners in the implementation of the risk-based thinking and also in the adequacy of their already established methods. The main objective of this paper is to propose an integrated model for risks approach, suitable for small and medium-sized enterprises with QMS based on ISO 9001:2015. To guarantee the model adequacy the authors followed the Action Research method, described in the following section.

2 Methods

The Action Research is a cyclical process method, focused on the proposition of guides or practical rules to solve real organizational problems, where the researcher participates in a collaborative and interactive way [11, 12]. The method is based on the PDCA cycle and each sequence is composed by activities of planning, acting, analysing and reflecting [13]. Figure 1 synthesizes the five cycles conducted in this Action Research, where the data were collected by semi-structured interviews, participant observation and documentary analysis.

Steps		Description		
3	Results	• Synthesis chart of the validation cycles (2º, 3º and 4º); • Results analysis.		
2	Action Research Cycles 		Cycles Description	Proposal adjustments
		5º	To verify the stability of the implemented systematic	No changes (final version from 4º cycle)
		4º	To analyze the systematic through an external expert (third part audit)	Strategic Level: start the process during the organizational context meeting; stakeholders requirements as an input for risks analysis
		3º	To analyze the systematic through an external expert (first part audit)	Strategic Level: focus on the Planning; to define a frequency for the model; reassess the priorization Operational Level: focus on the Planning; change analysis as an input for risks analysis
		2º	To analyze the systematic through internal experts from the operational, tactical and strategic levels	Structural adequation: two distinct models for the approach in the operational and strategic levels
		1º	To diagnose the study object and to propose the systematic	No changes
1	Pre-Step	• Systematic Literature Review (SLR) – Risk and ISO 9001 [5]; • Study object definition: national SME from the electronic systems field; • Construct, objects, attributes and experts definition C-OAR-SE [14-15]; • Data collection methods: participant observation, interview and documentary analysis.		

Fig. 1. Action Research synthesis.

As part of the pre-step, the authors based on [5], identifying the most frequent methods and methodologies used by organizations and suggested by researchers. As that practices do not attend to all the standard requirements, the authors gathered relevant aspects for the risk-based thinking from ISO 9001:2015 requirements, academic researchers' suggestions and organizational practical issues, seeking to form the basis for the risk management model.

The study object of the Action Research was a small and medium-sized company from Brazil, focused in the field of electronic systems. The research was conducted inside the organization, where the researchers worked together from October 2017 to April 2019, conducting the five cycles and incorporating the needed changes to the proposal, according to the interviews results, observations and documents analysis. The first version of the model is presented in the Fig. 2.

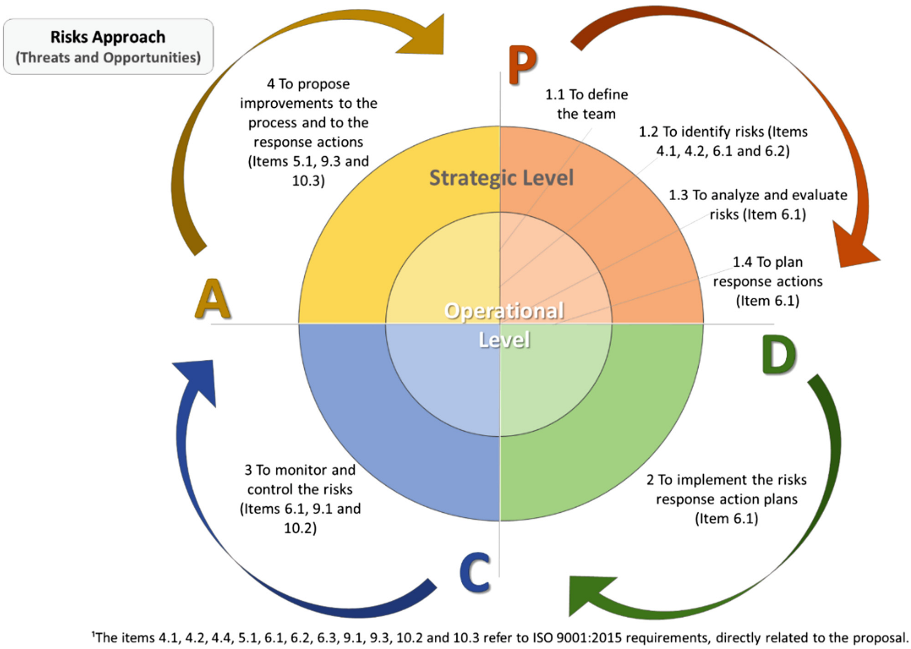

Fig. 2. Proposed model for risks approach in the context of ISO 9001:2015 requirements.

During the proposal implementation the authors could identify many aspects that impact the study object's results, incorporating them in the model, such as: difficulties in the operational level led to the establishment of a more practical and oriented process; lack of knowledge about risks concepts and practices led to a program of training for the entire company. All of the cycles were very important to the researcher analysis and model adjustments but, the main adaptations were proposed by the external experts from the first- and third-part audits.

As the standard requires organizations to consider their contexts and in accordance with suggestions of the external expert from third-part audit, one of the main changes in the model for the strategic level was the integration of the Organizational Context establishment meeting with the Risks Approach process.

The company underwent the transition process and were certified in the third part audit, in July 2018. The last cycle occurred 09 months after the audit, period when the study object was still implementing the systematic and also preparing for the maintenance audit, scheduled for July 2019.

The last cycle enabled the authors to conclude that the risk management model is stable and still under an implementation process in the study object. The researcher observed more commitment, especially for the strategic and tactical levels. Also, the recurrence of some aspects in the operational level, as the operators thinking that QMS activities are sole responsibility of the Quality Department; this aspect requires organizations to work on a cultural change, to promote the awareness that each employee has the same role in the maintenance of the organization QMS.

3 Results

The Action Research led the authors to an integrated and adapted systematic for risks approach, synthesized in the Figs. 3 and 4, suitable for small and medium-sized enterprises in their strategic and operational levels.

The risk management model has its steps based on the PDCA cycle. Its first and longer step is the Plan (P), which defines the steps for the risks approach and how to realize them; it is divided in 05 items as follows:

1.1. Define the team: for the STRATEGIC LEVEL a composition of team managers of the QMS processes including the leadership and people involved in the Quality Control and Assurance; while the OPERATIONAL LEVEL should consider all operators, under the monitoring of each QMS process leader;
1.2. Establish the frequency: the risk-based thinking is a concept that must be in the daily activities of the organizations and, especially for the OPERATIONAL LEVEL, there is not a specific meeting for the risks approach; for the STRATEGIC LEVEL, the model should be carried out during the meeting for Organizational Context establishment (semi-annual or annually);
1.3. Identify risks: STRATEGIC LEVEL risks refers to threats and opportunities that may affect organizations in long-term; to identify that risks, strategic team should consider the internal and external aspects provided by the Organizational Context analysis, requirements from stakeholders and the QMS Quality Objectives; this step can be conducted through brainstorming, practical knowledge or check lists. For the OPERATIONAL LEVEL the risks can have a short/medium-term impact, so the team should consider as the main input for their identification, the Change Analysis, that can be formulated in a check list; also, daily situations such as costumers satisfaction analysis, processes improvement, operators suggestions and internal audits reports;
1.4. Analyze and evaluate risks: for BOTH STRATEGIC AND OPERATIONAL LEVELS, this step should be carried out by their respective teams, by prioritizing the identified threats and opportunities, establishing a rank based on a score, to define which risks are relevant for the organization; this process can be supported by the Risk Matrix method;

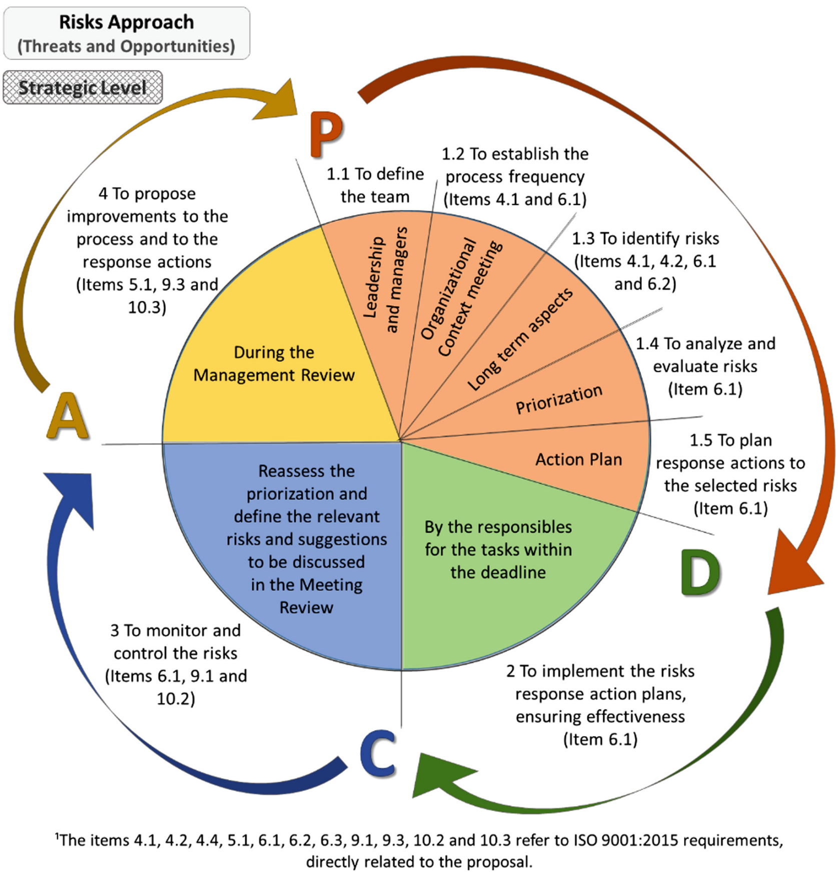

Fig. 3. Final version of the model for risks approach in the strategic level.

1.5. Prepare the Action Plans: the response actions to the selected risks should be planned by the respective teams from BOTH STRATEGIC AND OPERATIONAL LEVELS, defining the activities, responsible and deadlines; the response plans must involve actions of: eliminating, mitigating or accepting the threats; or boosting, exploring and disregarding the opportunities.

The second step of the systematic is Do (D), which refers to the accomplishment of the established action plans. BOTH STRATEGIC AND OPERATIONAL teams should forward the plans to their respective responsible, monitoring the process (e.g.: through a Microsoft Office® Excel spreadsheet).

The Check (C) should be held in parallel to the two previous steps, by monitoring and controlling the risks and their action plans, ensuring the effectiveness of the response actions realized. For the STRATEGIC LEVEL, the team should reassess the risks prioritization and if needed, define new actions, responsible and deadlines for the action plans; BOTH OPERATIONAL AND STRATEGIC LEVELS should determine

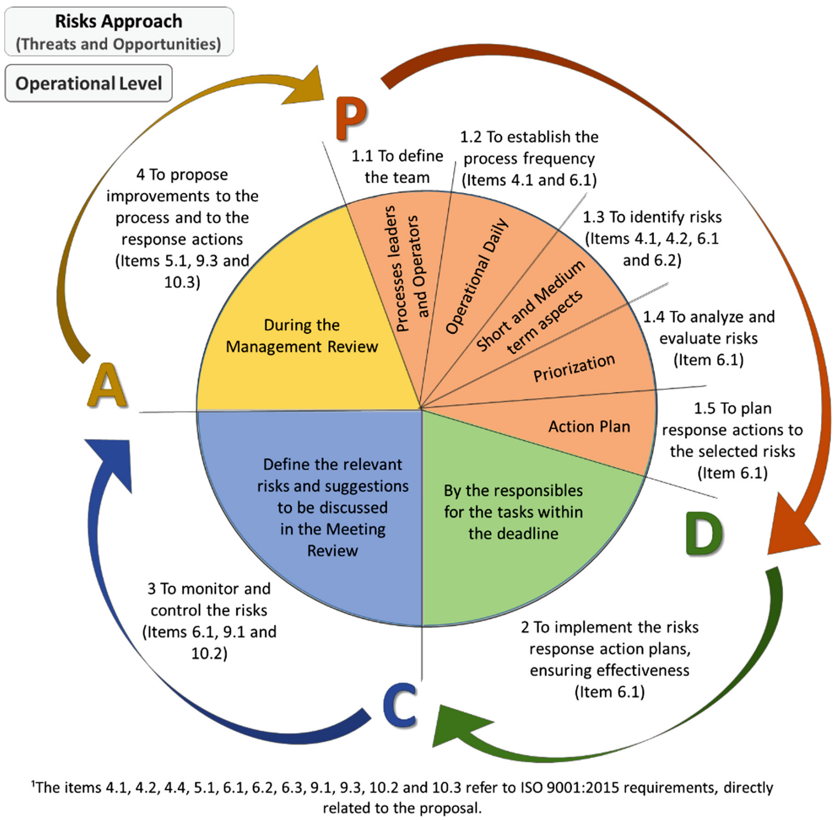

Fig. 4. Final version of the model for risks approach in the operational level.

what are the relevant issues (recurrent risks and suggestions for the approach) to be sent to the Meeting Review team.

The final step Act (A), encompass the analysis of the risks approach effectiveness and the identification of improvements for the systematic. It is a single step for BOTH OPERATIONAL AND STRATEGIC LEVELS and should be held in the Meeting Review by its usual team, seeking to continually improve the risks approach.

4 Conclusion

The action research ensures the model validation and its adequacy to organizations in the context of the study object. The authors described a guide for organizations to develop the risk management model in their QMS, meeting ISO 9001:2015's requirements and achieving real internal results.

Besides the similarity between the strategic and operational models, the implementation process is different for each level. The model presented in this article brings a generic approach, allowing organizations to implement risk-based thinking in an adapted manner, according to their specific needs.

It is important to mention that using the model is a way to adequate the QMS and to contribute with the organizations comprehension and practice of the risk-based thinking; it is also needed an organizational culture change led by the Top Management, which has to encourage and ensure the engagement of the team.

The authors suggest for future researches the implementation and adaptation of the model in organizations from different fields and sizes and that are certified by other standards, such as ISO 13485:2016, ISO 14001:2015 and ISO 22000:2019.

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Evaluation of Main Sources of Ideas for Innovation in Manufacturing Companies Using PROMETHEE Method

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Abstract. Innovation has been recognized and widely acknowledged as one of the main drivers of the knowledge society. In order to achieve sustainability and development companies get involved in different types of innovation (i.e. Closed innovation, Open innovation). Also, there are different areas of innovation that should be considered by companies (i.e. products, technologies, organization, services). This paper aims to evaluate different internal (i.e. Closed innovation) and external (i.e. Open innovation) sources of innovation ideas based on the importance of different innovation areas. For this purpose, data taken from European Manufacturing Survey are used. For evaluation of various innovation idea sources Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) was employed. Empirical results revealed that manufacturing companies are more oriented towards internal sources of innovation ideas. More specifically, CEO/management of a company represents the most important internal source of ideas for innovation, while customers represent the most important external source of ideas for innovation. Results presented in this paper could serve for strategic orientation of manufacturing companies that want to get involved in innovation activities.

Keywords: Innovation · Manufacturing · MCDM

1 Introduction

In the past, innovation activities of manufacturing companies were strongly associated with their internal innovation capabilities [1]. Companies that follow this approach are closing their boundaries and trying to generate innovation ideas within their own competences. In this sense, companies can rely on various internal sources of innovation ideas. Prior research has pointed out main internal sources of innovation ideas, namely: CEO/management [2], production [3], R&D/engineering [4], and customer services [5]. However, this closed approach to innovation is not considered as viable in a period of fast diffusion of valuable knowledge [6]. Therefore, companies are opening their boundaries in an attempt to put more focus on external sources of knowledge [7]. The use of external sources of knowledge is complementing internally generated ideas, therefore increasing capacity of a company to innovate successfully. As Chesbrough

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defined, open innovation is considered as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" [8]. Following this trend in innovation, companies can engage in cooperation with different external partners, namely: customers [9], suppliers [10], business or organization consultancies [11], and research institutions, universities [12]. Although, this approach to innovation management has got a lot of attention in previous research, there is still a missing link between internal and external sources of innovation ideas and their importance for manufacturing companies. Also, it is significant to make distinction between different areas of innovation as companies get involved in diverse innovation activities. Innovation field is divided into following areas: new products [13], new technical production processes [14], new organizational concepts [15], and new product-related services [16]. The aim of this paper is to analyze various internal and external sources of innovation ideas in terms of their contribution to different innovation areas that are of interest for manufacturing companies. For this purpose, multi-criteria decision-making method was used. More specifically, Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) was employed to obtain results.

The remainder of the paper is structured as follows. Methodology and data used in this paper are presented in Sect. 2. Section 3 presents the research results and discussion, while Sect. 4 presents the conclusion of this paper with identified limitations of the study and suggestions for further research.

2 Methodology and Data

This research is conducted under the international project European Manufacturing Survey (EMS) [17]. EMS is a survey focused on modernization and innovation in manufacturing companies taking into account all aspects of a manufacturing process in a standardized and systematized way [18–20]. The survey targets a random sample of manufacturing companies with more than 20 employees. For this research, manufacturing companies (NACE Rev 2 codes from 10 to 33) from Serbia are considered with a total population of 2043 companies. The list of companies of this population was acquired from the Serbian Business Registers Agency. To obtain a representative sample, 828 companies evenly distributed across all manufacturing sectors, company sizes and districts of Serbia were contacted. The total number of companies that returned the questionnaires is 285, thus representing a response rate of 34.4%.

In order to evaluate main sources of innovation ideas based on importance of innovation areas Multi Criteria Decision Making analysis is performed. More specifically, Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) developed by Brans was employed for this purpose [21]. The PROMETHEE family of outranking methods, including the PROMETHEE I for partial ranking of the alternatives and the PROMETHEE II for complete ranking of the alternatives, were developed by Brans [21]. PROMETHEE II is described in this part of the paper, since majority of researchers have referred to this version of the method [22]. This method is based on a pairwise comparison of alternatives in respect to each defined criterion. The implementation of PROMETHEE II requires two types of information. Decision maker needs to define weight and preference function for each criterion. Weight determines the importance of each criterion. As mentioned before, for the purpose of this research criteria weights are derived based on the importance of different innovation areas for manufacturers that participated in EMS. Preference function serves to translate difference between the evaluations obtained by alternatives into a preference degree ranging from zero to one. There are six types of preference functions proposed: (1) usual criterion, (2) U-shape criterion, (3) V-shape criterion, (4) level criterion, (5) V-shape with indifference criterion and (6) Gaussian criterion [23]. The procedure of PROMETHEE II method is as follows [21]:

Step 1: Determination of deviations based on pairwise comparisons

$$d_j(a,b) = g_j(a) - g_j(b) \tag{1}$$

Where $d_j(a,b)$ denotes the difference between the evaluations of a and b on each criterion.

Step 2: Application of the preference function

$$P_j(a,b) = F_j\left[d_j(a,b)\right], \quad j = 1, \ldots, k \tag{2}$$

Where $P_j(a,b)$ denotes the preference of alternative a with regard the alternative b on each criterion, as a function of $d_j(a,b)$.

Step 3: Calculation of an overall or global preference index

$$\forall a, b \in A, \quad \pi(a,b) = \sum_{i=1}^{k} P_j(a,b) w_j \tag{3}$$

Where $\pi(a,b)$ of a over b (from 0 to 1) is defined as a weighted sum $p(a,b)$ of each criterion, and w_j is the weight associated with the expressing the decision maker's preference as the relative importance of the j-th criterion.

Step 4: Calculation of outranking flows

$$\phi^{+(a)} = \frac{1}{n-1} \sum\nolimits_{x \in A} \pi(x,a) \tag{4}$$

$$\phi^{-(a)} = \frac{1}{n-1} \sum\nolimits_{x \in A} \pi(x,a) \tag{5}$$

Where $\phi^{+(a)}$ and $\phi^{-(a)}$ denote the positive outranking flow and negative outranking flow for each alternative, respectively.

Step 5: Calculation of net outranking flow

$$\phi(a) = \phi^{+}(a) - \phi^{-}(a) \tag{6}$$

Step 6: Determine the ranking of all the considered alternatives depending on the values $\phi(a)$. Higher value of $\phi(a)$, means better ranking of the alternative. Thus, the best alternative is the one having the highest $\phi(a)$ value.

3 Results and Discussion

In this study, we evaluated main internal and external sources of ideas for innovation based on the importance of different innovation areas in which these ideas are generated. For the purpose of this research, representatives of manufacturing companies were asked about the importance of different innovation areas (i.e. products, technologies, organization, services). Criteria weights were derived based on this information. They were also asked which are the main internal (i.e. R&D/engineering, production, customer service, CEO/management) and external (i.e. customer or user, supplier, research institutions or universities, business or organization consultancy) sources of innovation ideas in each of aforementioned innovation areas. Information that were considered for the evaluation are presented in Tables 1 and 2 for internal and external sources of ideas respectively.

Table 1. Evaluation matrix for internal sources of innovation ideas.

Criteria	New products	New technical production processes	New product-related services	New organizational concepts
Min/Max	Max	Max	Max	Max
Weight	0.29	0.27	0.22	0.21
Preference function	V-Shape	V-Shape	V-Shape	V-Shape
P value	19	35	23	38
R&D/engineering	36	27	9	21
Production	27	49	14	25
Customer service	13	6	36	4
CEO/management	32	38	24	52

Table 2. Evaluation matrix for external sources of innovation ideas.

Criteria	New products	New technical production processes	New product-related services	New organizational concepts
Min/Max	Max	Max	Max	Max
Weight	0.29	0.27	0.22	0.21
Preference function	V-Shape	V-Shape	V-Shape	V-Shape
P value	52	11	44	10
Customer	60	21	51	16
Supplier	11	18	12	4
Research institutions, universities	5	10	3	13
Business or organization consultancy	8	10	7	12

The data presented in Tables 1 and 2 are necessary for the use of PROMETHEE method and it considers the following information:

- Criteria: defines evaluation criteria (i.e. innovation areas)
- Min/Max: defines weather criterion should be maximized or minimized
- Weight: defines the importance of criteria. For this purpose, criteria weights are derived based on the importance of different innovation areas for manufacturers
- Preference function: defines which preference function was associated to each criterion
- P value: defines preference threshold for each criterion
- Following this, alternatives (i.e. internal/external sources of ideas) are presented with the corresponding number of generated ideas for each source of idea across all innovation areas.

For the purpose of better understanding, the results presented consider only internal sources of ideas (Table 3), only external sources of ideas (Table 4), and both internal and external sources of ideas combined together (Table 5).

Table 3. Ranking of internal sources of innovation ideas.

Alternative	ϕ	ϕ^+	ϕ^-	Rank
CEO/management	0.4049	0.4936	0.0887	1
Production	0.0845	0.3106	0.2262	2
R&D/engineering	−0.0428	0.2492	0.2920	3
Customer service	−0.4465	0.1872	0.6338	4

Table 4. Ranking of external sources of innovation ideas.

Alternative	ϕ	ϕ^+	ϕ^-	Rank
Customer	0.8285	0.8285	0.0000	1
Supplier	−0.1989	0.1743	0.3732	2
Business or organization consultancy	−0.3102	0.0688	0.3791	3
Research institutions, universities	−0.3194	0.0705	0.3899	4

Table 5. Ranking of internal and external sources of innovation ideas.

Alternative	ϕ	ϕ^+	ϕ^-	Rank
CEO/management	0.4781	0.5674	0.0893	1
Customer	0.4367	0.5483	0.1117	2
Production	0.2775	0.4208	0.1433	3
R&D/engineering	0.1061	0.2924	0.1863	4
Customer service	−0.2076	0.1608	0.3684	5
Supplier	−0.2970	0.0641	0.3612	6
Business or organization consultancy	−0.3748	0.0283	0.4031	7
Research institutions, universities	−0.4189	0.0239	0.4429	8

Analyzing results presented in Table 3, we can conclude that CEO/management of a company represents the most important internal source of innovation ideas, since it has the highest ϕ value (0.4049). All other sources of innovation ideas can be considered much less important for manufacturing companies as their corresponding ϕ values are dramatically lower (i.e. production) or even negative (i.e. R&D/engineering and customer service). This implies that if we consider only internal sources of innovation ideas, manufacturers should put their focus on CEO/Management of a company to generate ideas.

In the same manner as analysis of internal sources of innovation ideas in Table 3, we can conclude from the results presented in Table 4 that customers are the most important external source of innovation ideas for manufacturing companies. Other external sources (i.e. suppliers, business or organization consultancies, and research institutions, universities) do not have significant contribution in generating innovation ideas.

Finally, we combined internal and external sources of innovation ideas in order to understand in more comprehensive way their contribution in generating innovation ideas (Table 5). From Tables 3 and 4 we have learned that CEO/management and customers represent the most important internal and external source of innovation ideas for manufacturing companies, respectively. This is also confirmed with the results presented in Table 5. In addition, considering these results we can claim that CEO/management represents the most important source of innovation ideas taking into account both internal and external sources. The other important thing that needs to be highlighted is the fact that following customers all internal sources of innovation ideas are listed, while external sources beside customers are placed at the bottom of the list. Based on these results, we can argue that manufacturing companies are more oriented towards internal sources of innovation ideas. However, this does not mean that companies are not opening up to external sources of knowledge. Manufacturing companies are recognizing the necessity to collaborate with external parties in order to better position themselves on the market.

4 Conclusion

This paper analyses and evaluates the main sources of innovation ideas in manufacturing companies based on the importance of different innovation areas for manufacturing companies. Both internal and external sources of innovation ideas were considered. Data taken from the EMS are used for this purpose. Using empirical data, it has been shown that manufacturing companies are more focused on internal sources of innovation ideas, but that external sources are not neglected. More specifically, CEO/management represent the most important internal source of innovation while customers represent the most important external source of innovation ideas for manufacturing companies. Besides that, other internal and external sources of innovation ideas are positioned based on their contribution to generating innovation ideas. In this way, we have created a link between internal and external sources of innovation ideas in terms of their position in manufacturing companies when it comes to the point of generating innovation ideas. Results presented in this paper could serve for strategic orientation of manufacturing companies that want to get involved in innovation activities.

This research is investigating only sources of innovation ideas in manufacturing companies. The focus is put only on the beginning phase of the innovation process. Further research could go in the direction of analyzing whether these ideas have been transformed into innovations. Also, it would be interesting to understand which sources of ideas are predominantly accountable for the success of the innovation.

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Development of Digital Entrepreneurship and New Business Models as a Result of the Expansion of Information Systems

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Abstract. We have witnessed that the Internet has brought with it many consequences, through its development. Rapid changes in the business environment increase the pressure on businesses to adapt their business logic and processes to stay ahead of the market and their competitors. Certainly, one of the biggest consequences of the development of the Internet, as a globally accessible network, is digital entrepreneurship, with its new forms of business, or business models that have had an impact on all of humanity, especially in the last decade of the 21st century. Digital entrepreneurship is a phenomenon that occurs through technological means, such as the Internet and information and communication technology. As the phenomenon of digitalization causes different implications for rapid change, it is of utmost importance for entrepreneurs and their research as they need to be aware of new results, they need to know how to connect new results and identify new opportunities for their businesses. Digitization has created numerous opportunities for entrepreneurial activity, where entrepreneurs need to be aware of them in order to be prepared for sustainable innovations. Digitization has not been reduced to just one new development in entrepreneurship, as business models appear to be facing a major shift towards the entire digital environment. This paper aims to explain the phenomenon of digital entrepreneurship, as well as the development of new models, including all the influential factors that contribute to it.

Keywords: Information and communication systems · Digital entrepreneurship · Business models · Innovation · Changes

1 The Role and Importance of Information Technology in the Development of Entrepreneurship

Entrepreneurship in recent years has received increasing attention from researchers. Although researchers generally agree on the importance of innovation in the entrepreneurship process, few researchers are concerned with how new approaches to innovation can facilitate this process [1]. It can be said that information technologies

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have a fundamental impact on today's society. Information technology is now an integral part of an individual's daily life. Business and communication rely on the many benefits of information technology. Some of the most significant advantages are reflected in the modernization of business activities with the potential reduction of employees, in rational use of capacities, resources and energy, in the quality distribution of materials, goods and services, as well as in better financial operations of the company. Information technology changes the competitive outlook of all business processes during production and in the process of providing enterprise services. In today's business environment, information technologies are becoming the most significant driver of innovation, growth, competitiveness and are the source of new business opportunities, both for large and small and medium-sized enterprises [2]. What stands out as very significant is that in the last decade, more and more small and medium-sized enterprises have been one of the most important pillars of economic stability and economic growth around the world, and in Europe this sector is being given considerable importance [3]. Therefore, the European Commission has built a strategy for innovative and competitive SMEs and fosters the development of an entrepreneurial spirit, that is, an entrepreneurial economy based primarily on innovation and knowledge, thereby boosting the competitiveness of SMEs in the market [4]. Information technologies are important because they not only support the business of the company, but also enable faster and easier business. They enable the management team to make more transparent and easier decision-making, to solve problems that arise more efficiently, and to adapt faster in the conditions that the market requires. The application of modern technologies in the business of small and medium-sized enterprises in the Republic of Serbia is very important as they not only keep pace with European and world enterprises, but also expand their business beyond the borders of our country. This is especially reflected in their ability to connect to each other's supply chains, increase their productivity, as well as gain competitive advantage, both domestically and internationally. Entrepreneurship, as a process of designing and starting a new business, plays a key role in the development and commercialization of new technologies [5]. In the process, creative ideas become useful solutions innovations, that is, solutions to problems for clients. Innovation, which refers to the process of translating a creative idea or invention into a product/service, creates value that customers are willing to pay for and is essential both in starting a new business venture and in an existing business [6, 7]. Entrepreneurship and innovation are not only linked in this way - innovation requires entrepreneurial skills and innovation is an essential attribute of entrepreneurship. Over the past decade, the inseparable relationship of the innovation process, especially open innovation and entrepreneurship, has attracted much attention. Open innovation is the use of purposeful inflows and outflows of knowledge to accelerate internal innovation, to expand markets for the external use of innovation [8]. It has just led to a modern way of doing business, which must be followed today in the business environment, in order to keep up with the competition, to bring about a new concept of innovation, supported by information technologies and systems. The importance of information technologies and systems, which have the support of the Internet, speaks to the relationship of time and acceptance of the same by the users. For example, digital technologies have grown faster than electricity and mobile phones. Smartphones reached a diffusion rate of 40% in 10 years, while electricity for almost 40 years required a diffusion rate of 10%. Digital diffusion technology has grown rapidly over the years and is expected to expand from 8% of GDP in 2015 to around 25% by 2030 [9]. New information technologies provide different opportunities for IT entrepreneurs. However, it is sometimes difficult to predict how technologies will evolve [10]. New technology may prove to be unsuccessful or it may develop in an unexpected direction. It is the task of entrepreneurs to learn to act in conditions of great uncertainty when planning for the future of their business. In order to be successful and to survive in turbulent market conditions, a modern entrepreneur is expected to create his/her business model based on perceived opportunities and to know how and in which direction he/she will develop it over time, as well as to adequately provide information support to his/her model.

2 Developing of Digital Entrepreneurship

Entrepreneurship involves identifying and harnessing opportunities, turning those perceived opportunities into market products or services, taking risks and reaping rewards [11]. It can occur in a variety of settings, including new and old ventures, non-profit institutions, and the public sector. In short, new value creation is the defining characteristic of entrepreneurship. Certainly, entrepreneurship research is primarily focused on the individual characteristics of the founders, on the path to success of new business ventures that offer standalone products/services [12, 13]. In traditional forms of entrepreneurship, the key decision of an entrepreneur was to aspire to license their technology or to engage in the full commercialization of their products [14]. Digital entrepreneurs, by contrast, are embedded in an interconnected system when they aim to commercialize their solutions, where platform contexts and network effects are crucial [15, 16]. In recent years, the rise of digital entrepreneurship can be seen, where success requires the positioning of products/services within dynamic digital networks, which show the complex connections between complementary modules and consumers. Digital entrepreneurship is a sub-category of entrepreneurship, in which some or all of what would be physical in a traditional organization is digitized [17]. Given the rapid growth of digital activity across industries, it is predicted that digital entrepreneurship will become more common [18]. As more and more companies start their digital business, the question is how to start a digital venture different from starting a traditional venture. Businesses that are practical, can be considered companies following radically different business models [19]. As practice grows, the question is how starting a digital venture is different from starting a traditional venture, which is increasingly important in finding solutions to problems that are specific to a digital enterprise [20]. These differences, if neglected, can lead to a new venture failing or profitable opportunities being missed. Entrepreneurs and managers considering new digital ventures need to understand the opportunities and dangers that are unique to digital entrepreneurship [21]. To make digital entrepreneurship easier to understand, several key differences need to be noted. One big difference between digital and traditional entrepreneurship is the way it is traded. Another difference is the product/service itself. The new venture is to sell digital goods or services, as a form of entrepreneurship that is digital in at least one segment. Another factor that can cause critical differences between digital and traditional investments is the workplace [22]. When goods and services can be digitized, the need for physical use and jobs is reduced. For better cost control, digital ventures may exist in virtual forms, in which computer-mediated communications are the primary means of communication within the organization, between the organization and key external stakeholders (for example, suppliers and customers) or both. What inseparably accompanies digital entrepreneurship is digital marketing, digital sales and digital products. Even minimal start-ups need to have web accessibility today. Digital marketing involves the marketing of digital assets. Start-up companies may choose to put their marketing efforts into digital media instead of traditional media for a variety of reasons, primarily due to the difficulty of access [23]. Digital marketing avoids certain traditional issues of entrepreneurial marketing, especially when it comes to costs and the ability to continue managing customer relationships, with near perfect precision, which is a great advantage for entrepreneurs. When it comes to digital sales, it is a way of selling that is done through digital means, not traditional means. What is strange is the fact that there are many digital marketing companies but not digital sales. There are still many websites that are full of information about the company and its products but do not offer the means to buy [24]. Digital sales are different from traditional sales and are key to the success of the company. When discussing digital products, there has to be a very broad view to cover everything that entails digital products, but, to put it briefly, digital products are all goods and all services in digital form [25]. New services, ranging from rich content sites to search engines, auction houses and advertising, have flourished in the past decade. New industries have emerged that integrate traditional advertising and communications with graphic design, information technology with the web. And digital goods have grown. Entertainment products (for example, music) have moved from analog to digital, moving the multi-billion dollar industry to the new digital domain. The relationship between digital product, market, software is facilitated by enabling activities that encourage increasing digitalization.

3 Business Models Supported by IT Tools

The last two decades have seen a sharp rise in business model research [26]. However, in both information systems and business literature, the term "business model" is very difficult to define. An extensive review found that business models were often studied without clear definitions of the applied concept. This makes the use of the term "business model" a challenge, both in academic literature and in practice. Generally speaking, a business model can be seen as a "story" that explains how a business works [27]. As several business model studies suggest, the business model should be studied against the entire company value network, making it clear how value is created and delivered to customers and partners [28–30]. Ostervalder [29] provides a comprehensive definition of the business model. It defines a business model as the value that a company offers to one or more customer segments and the architecture of the company, its network of partners to create, market and deliver this value and capital ratio, to generate profitable and sustainable revenue streams. Companies are forced to develop new business models and adapt their logic and processes to stay ahead of the market and its competitors. Value creation and delivery have received considerable attention, both in practice and in the academic literature. One such model is the creation of the Thingiverse community, a business model bringing together digital creators, who share their designs through the Thingiverse platform (as a new IT tool), often for free play [31]. Then, another great example of a new business model aimed at staying ahead of the competition and meeting new market needs is the creation of a G-cluster, which is based on IT technologies [32]. The creators of this business model saw a market opportunity - the launch of a third generation of 3G networks and mobile device manufacturers, with the development of new mobile phones. They realized that the computing power and memory capacity of mobile phones would be relatively low and that there would be several models using different operating systems. They realized that software development for new mobile phones should be different, especially for games that are challenging and if they were able to launch a particular game, they could start running other applications as well. They have developed a new business model, based on a gaming platform, that would allow the content of the game to be sent to mobile phones over the 3G network from the computer center, and players return to the central computer that manages the game. They had a lot of open questions regarding the technology and its development. They were able to connect the G-cluster to content providers, that is, game publishers, with telecom operators, providing a platform that could be used to deliver games over the wireless network. What is most important in creating a new business model, and the founders had this thought, is that it is necessary to change the existing strategy and find an alternative way. Particularly in the field of management literature, there is a growing interest in understanding the phenomenon of open business model innovation, which means developing a business model in collaboration with clients. Such joint creation of a company business model would not only support the integration of customer needs in the company development process, but would also improve the quality of the business models developed. This research shows that most innovations are not the result of a single researcher, but a condition in which many individuals contribute to their individual knowledge, experience and strengths [33, 34]. What is of great importance in creating a company business model is the role of IT tools, which support the open process of designing the business model. Such IT tools are expected to facilitate the process of developing new business models, along with company stakeholders, reducing transaction costs and improving organizational routines when coordinating various development activities [35]. One of the most significant new generation tools is SAP. In the development of SAP (Systems, Applications and Products - a program for complete monitoring of the company's workflow) the ADR (Alternative Dispute Resolutions) method was very helpful (ADR focuses on the development of an IT artifact that represents a set of technological features embedded in the social environment), which was developed as a project research, dealing with the appearance of artifacts, at the preset of information technology and problem formulation [36]. Introducing digital elements into business models can lead to the bright side of entrepreneurship. For example, digital aspects of technology favor the adoption of global approaches [37]. These firms can rapidly expand their products and strive for global politics. Further, digitization allows for the place of a global company [38, 39]. Activities in the entrepreneurship process, such as the acquisition resource, are also changing. The digital technology offering opens up the possibility of creating early prototypes that can be used in reward campaigns and completely changing the management of technological innovation [40]. With so many options, the ability to design a business model takes on a whole new dimension. Certainly, there is a dark side to the digital potential of digital entrepreneurship as the role of each player in such a system is still often unclear and the technological base is still evolving. New entrants to the Internet of Thinks, for example, are aware that there is still a lack of concrete structure and tighter standards. In short, the digital artifact at the core of entrepreneurship may require or seek additional information management skills in entrepreneurship, but it certainly opens new doors to accelerate learning and growth in one such venture [41].

4 Conclusion

The digital revolution has unprecedentedly transformed when it comes to the meaning and forms of entrepreneurship around the world. The application of social networks, mobile technologies, cloud computing, Big Data technology, Internet of Things and other emerging technologies is changing business models, processes and customer relationships. With their new ways of doing business, digital entrepreneurs have had a huge impact on the entire world. Google, Facebook, Microsoft and Apple have not only changed the entire business world, but also shaped the way we interact with other people in our environment every day. At this stage, we live in a world where embedded intelligence can be used to improve the quality of decisions and our perception of reality. Not only does computing, storing and researching information become easier, but also more flexible and cost effective as cloud services continue to evolve and the Internet transforms into the so-called Internet of Things [42]. With blockchain, the transition to “Internet of Values”, that is, “Internet Values” has just begun. By 2020, Internet of Things technology is expected to be implemented in 95% of electronics for new product designs and a worldwide volume of one billion dollars of legalized cryptocurrencies, which will trade in the banking industry [43]. Digitization is not just one new development in entrepreneurship. Very prominently, business models are facing a major shift towards the entire digital environment. Businesses created by emerging opportunities are changing from offline to online business, that is, to a new form of undertaking entrepreneurial activities. Digital entrepreneurship is a phenomenon that occurs through technological means such as the Internet and information and communication technology [44]. In general, any entrepreneurial activity that transfers assets, services or much of the business digitally can be characterized as digital entrepreneurship. Digitization has created numerous opportunities for entrepreneurial activity. Entrepreneurs need to be aware of these opportunities in order to be prepared for sustainable innovation. The emergence of digital entrepreneurship in emerging research is not at all simplistic, especially since it should keep pace with the rapid changes in the digitalization of our society and economy. It should also be noted that as much as an information system is sophisticated and advanced, without synergy with organizational factors it cannot deliver the expected result in any respect, especially in terms of security. Based on the context of the organization, the key task is to perform an adequate integration of information resources with parallel and continuous development and improvement of integrated quality management systems, information security management systems, and other systems recognized for successful business operations of the company. Which information resources a company will choose depends on its needs, goals and capabilities. Hardware, software, business applications, information systems, integrated information systems, databases, employee knowledge, processes or procedures today represent very valuable assets for any enterprise, that is, represent the capital of the enterprise. What is very important to emphasize is that digitalization is not only about the introduction of high technology, but also about the way of thinking and applying digital solutions to elementary things and the basic economy. In the online world, it is important to build a profile, but it is also very important that industrial policies, or governments, embrace the digital economy because it creates a large number of jobs. The digital world is open to all, and creativity will boost the economy of the 21st century.

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Alignment to Management Excellence Model and Organizational Transformation: A Case Study in an Automotive Industry

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Abstract. Based on the need to improve methodologies for organizational diagnosis and modelling, aiming at organizational transformation, the study is based on the use of a framework, which combines instruments that meet the aforementioned demands, and its validation in the handle of nonconformity process of a company in the automotive industry. The importance of this analysis is also justified by contextual situations, such as greater competitiveness in the market, which requires that activities be carried out efficiently, using more technological resources and new methodologies available, in accordance with the strategic needs defined the organizations.

Keywords: Enterprise engineering · Handle of nonconformity · Diagnosis · Modelling · Transformation

1 Introduction

In an environment where different companies and structural models coexist, the demand for improvement and sophistication of applicable study methods is increasing, which implies in the need to create universal and reliable analysis structures, providing alternatives for diagnosis and redesign of organizations [1].

According to [2] Enterprise Architecture (EA) is an approach used to support model-based decision making across the organization. As [3] points out, Enterprise Architecture tools are used to deal with the complexity of modeling and data collection, and [4] describe that the main challenges facing organizations today are the large-scale integration of their corporate systems, together with their models, data, information and their associated knowledge. Also, according to [4], corporate systems generate large amounts of data, that is a valuable asset, and potentially an important source of new information and knowledge to the company, that gain competitive advantage dealing with change and the organizational complexity.

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As the complexity of relationships within organizations increases, so does the need for greater control over their structures and processes. The problem encountered is the lack of systemic approach and holistic view in organizations. The structured, descriptive and explanatory analysis allows predictions and prescriptions on the part of those in charge of the management. From these challenges derives the research problem, which can be summarized in the following question: "What is the best way to carry out the diagnosis and subsequent organizational modeling of a process, which allows the identification of improvement points that are convergent with the strategy of the organization?"

Progress in the areas of information and communication technology has enabled the creation of massive amounts of data associated with the company's processes, which integrated, enable the company to learn and consequently improve, adapt and change. The motivation behind this analysis is the validation of existing theories in Organizational Engineering, firstly from a literature review related to the proposed theme, and later, applying a framework that consists in the steps of data collection, diagnosis, architecture and process modeling, and organizational transformation. According to [5], the Management Excellence Model (MEG) should be considered as a reference model in organizational management, as its main characteristic of being an integrating model. This study evaluates the developed framework application to a specific industry, analyzing how it contributes to the organizational engineering model of the company under analysis, improving its handle of nonconformity process model, as well as the capacity of critical analysis of several layers of the process.

The study is divided in the following main sections. First, it is performed a literature review concerning the instruments of diagnosis and analysis, as well as the definition of organizational transformation. Then, a framework containing these elements is proposed and later applied in the handle of nonconformities process of an automotive organization. The fourth and fifth sections presents the results and suggestions for organizational transformation and the obtained conclusions, respectively.

2 Theoretical Reference

2.1 Model of Management Excellence® (MEG) as an Evaluation and Diagnostic Tool

Created in 1991, the National Quality Foundation (FNQ) is a reference center dedicated to improving productivity and competitiveness of Brazilian organizations, through the dissemination of the Management Excellence Model® (MEG), whose main characteristic is to be an integrating diagnosis model [5], that identifies strengths and weaknesses, which are opportunities for improvement of a management system. This evaluation system aims to determine the level of maturity of the organization's management in relation to its fundaments and themes, which are grouped in two dimensions: Process Dimension and Value Generation Dimension. The Process Dimension evaluation is performed looking at the four stages of the PDCL cycle, defined as: Plan, which refers to the approach adopted by the organization in the design of the processes; Do, which addresses the implementation of processes; Check, which monitors the established processes; and Learn, regarding not only the incorporation of the experience acquired in the execution, but also the control of the proposed processes. In the Value Generation Dimension, the factors Relevance, Improvement, Competitiveness and Commitment are evaluated.

2.2 Organizational Architecture

Organizational architecture can be defined as a tool that seeks, through a holistic view, to align the different variables that compose an organization, specifying items such as: business strategy, key activities, information flow, technology, and functions performed by its employees, in order to demonstrate the roles played by each element in the organization. Not only internal dynamics, but also relationships with stakeholders are analyzed [6]. Different aspects and domains of the construction of an organization are shown, such as its main structure, processes, and technical infrastructures, so an overview of these elements and their connections can be obtained [7]. Its benefits are diverse, including strategic alignment and support for decision-making, as well as management of the transformations aimed by the enterprise [8].

ArchiMate, a notation developed by the Open Group, focuses on the standardized representation of organizational architecture, in order to align the various groups that compose it around the same language. Different domains, their descriptions and relations are contemplated, demonstrating the dependencies between the levels [9].

2.3 Transformation

The concept of business transformation has become increasingly popular, as companies recognize the need to achieve an integrated perspective within and across organizational boundaries, addressing complex challenges [10].

Corporate models are a valuable basis for business transformation, because they generally represent the widely accepted image of a company [11]. In this sense, [12] parallels the digital transformation in people's lives and consequently, how companies must act to overcome the forces of change these days. According to [12] for success in digital transformation, companies must focus on reframing value propositions to the customer and transforming their operations using digital technologies. The main challenges of business transformation are related to the absence of a common definition and language, and corporate level tools to describe perspective, limits, processes and business functions, as well as the recognition of the systemic nature of companies [10].

According to [13], digital transformation has different approaches, and the research on the topic in question has differences such as scope, scale, time, socio-technical aspects and focus on results. Thus, the present study intends to suggest a transformation model for the company under analysis, that aims to increase the value for the client, and to improve the current performance of the organization's handle of nonconformity process.

3 Methodology

The proposed model is composed of the following steps: data collection, diagnosis based on the Management Excellence Model, analysis of the architecture model, and organizational transformation proposal.

3.1 Framework

From the revised concepts and seeking to apply the definitions of enterprise architecture, in order to make possible a transformation plan a framework model is defined, whose steps are summarized in Fig. 1.

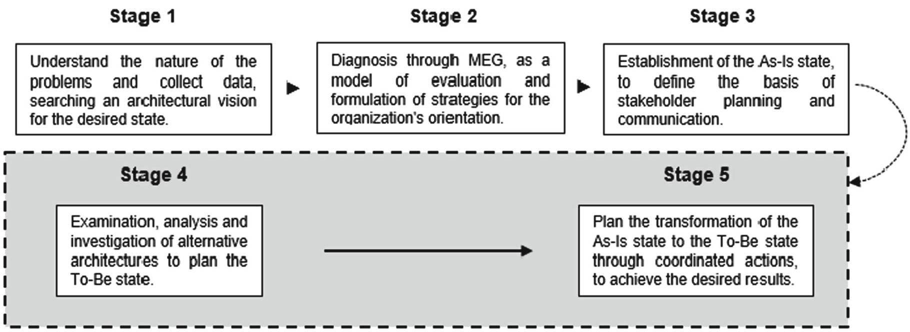

Fig. 1. Proposed framework.

With data collection, it is possible to perform two different diagnoses: the holistic construction of the organizational architecture and the detailed modelling of the studied process allows an understanding of the current state (as-is), while the evaluation of the activities with specific method allows the measurement of the maturity of the structure. Finally, with the understanding of the current organizational state and the points with low levels of maturity, it is possible to present proposals for improvements in the processes. The results affect the architecture of the organization, with optimization of process performance and alignment with the strategic elements.

Applying the proposed methodology, the stage of data collection was performed through documental analysis, with data collected from the company. Then, the process adopted as object of study was submitted to the application of MEG 21, in order to measure the maturity of its stages and to raise the points of fragility. The analysed documentation also allowed the structuring of the organizational architecture, particularly in relation to the current integration state of the processes with the company strategy. Finally, a study was made of all the material produced, and the main fragilities were observed with the purpose of proposing improvements in the handle of nonconformities process, impacting the organizational architecture.

The company unit used for the framework testing is the Brazilian branch of an automotive multinational, responsible for the Powertrain production. The process analysed was the handle of nonconformity, that is performed by the Quality team.

4 Results

4.1 Maturity Assessment

The Management Excellence Model® (MEG) was used as an evaluation and diagnostic tool. In its Process Dimension, we have the results according to Table 1.

Table 1. Results of the maturity evaluation in percentages.

Process maturity level	(%)
NC evaluation and registration	38
Disposal and containment	63
Quality analysis - root cause	75
Actions to solve the root cause	63
Effectiveness Monitoring	50
Follow up and project registration	75

Analysing the results of the evaluation, it was observed that the processes of "NC evaluation and registration" and "Effectiveness Monitoring" were the ones that obtained the lowest maturity level, in relation to the other activities analysed. Therefore, it is concluded that improvement efforts should be focused on the processes mentioned above.

4.2 Architecture

Based on data collection, associated with the use of ArchiMate notation, the organizational architecture modeling was performed. In this specific case study, a more careful analysis was carried out in relation to the Motivation and Business items, shown in Figs. 2 and 3, respectively, according to the need of alignment of the processes and the strategic objectives of the organization.

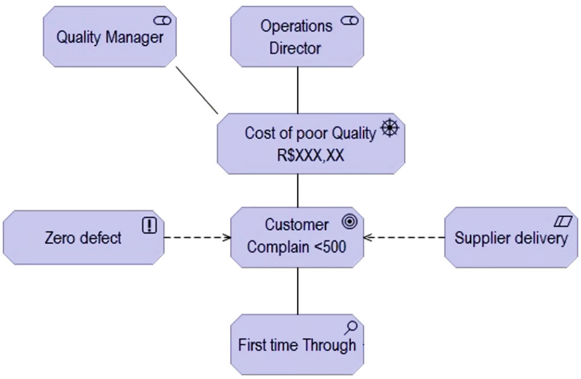

Fig. 2. Motivation elements.

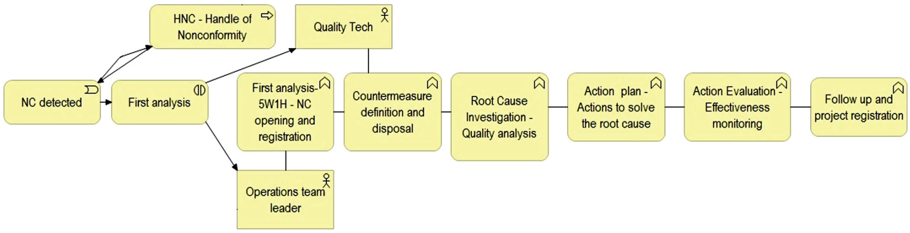

Fig. 3. Business elements.

Motivation. The occupants of the positions of Quality Manager and Plant Manager were classified as stakeholders, for their interest in the satisfactory performance of the process. The motivating element is the search for the elimination of the "Cost of low quality", which is associated with the principle of "Zero defect", a priority adopted by the organization. The goal is to reduce customer claims to below 500 parts per million, a measure that is appropriate for large-scale projections. The evaluation method used in the process is First Time Through, where it is expected that the produced items do not present defects, and the constraint identified is the inputs delivered by the suppliers, whose quality must be in line with the standards stipulated by the company.

Business. The business process, which functions as a kind of trigger to the beginning of the implementation of corrective measures, in this case is defined as the detection of nonconformity. The first analysis functions as a business interaction event, as it involves the participation of two actors, the Quality Technician and the Operations Team Leader. Next, a series of business functions are performed, which together form the process. In the case analyzed, these functions are the 5W1H analysis, the definition of countermeasures and disposal, the investigation and subsequent corrective action of the root cause, the evaluation of the measure taken and lastly the due registration of the entire project, as the good practice demands.

4.3 The Current State of HNC Process

During the documental analysis of the company, it was possible to evaluate the Handle of Nonconformities process.

The HNC process deals with identification of the root cause of certain problems, from the moment a defective part is detected on the production line. The process also tries to treat the occurrence in such a way as to avoid a high volume of defects, as well as to propose a plan of action and a definitive solution proposition. It is perceived, here, a convergence of the process the ideas proposed by [14].

All steps are documented on internal systems, so that those involved in any of the steps can access the information they deem necessary. However, despite the alignment of the definitions proposed by [14], based on the MEG 21 diagnosis, the handle of nonconformity process demonstrates a low level of maturity in the "Opening and Registration of NC" and "Efficiency". These phases are included in the task of identifying the NC, at the end of the filling tasks and in the task of assessing the effectiveness of the action plan, respectively. These are the points defined as focal points for the transformation proposal.

4.4 Transformation - Proposal for Improvements Current State of HNC Process

Analyzing the various layers generated by ArchiMate through the data collection and the evaluation result of MEG21, the transformation action proposed by this study is related to the handle of nonconformity system incorporated by the company. It was identified that the "Opening and registration of NC" and "Effectiveness Monitoring" stages require a lot of time from the quality technicians due to the filling of several documents, as well as the maintenance of a very large structure to manage and guarantee all the management system of quality. In this sense, a serious improvement action to adhere to the theory of [2] is the automation of data collection and document generation. Increased reliability and data quality would come from the use of 4.0 industry concepts, such as the inclusion of IoT tools, in conjunction with smartphones applications. These initiatives are consistent with studies by [12] and [10], because they bring the digital transformation into the company, adding value to the customer and transforming its HNC process with the use of digital technology, which would optimize the process time and improve the quality of the data generated.

Another pillar of industry 4.0 that can be used is artificial intelligence, with the adoption of systems that contribute to the "Effectiveness Monitoring" stage realization. This would be a good way to ensure process excellence through decision-making, since systems that work based on well-structured data do not become exhausted, nor do they fail to act for lack of initiative. In addition, the artificial intelligence system can help the company's managers in the decision-making process, generating concrete and statistically proven arguments. In this way, it becomes easier to convince everyone that the decision being made is data-based, which hinders the emergence of choices that seem extremely good at first, but which find no support in numbers.

5 Conclusion

In this study, based in the literature review, it was possible to propose a framework model for organizational diagnosis and analysis, which fosters improvements suggestion, looking forward to organizational transformation. The application of the proposed framework in an industrial case, in a first moment allowed a holistic organizational view. Then, narrowing the study to the specific process of handle of nonconformity, some improvements were proposed, generating a transformation plan that can possibly increase the performance of the studied process. The analysis results derived in the suggestion of automating the data collection and document generation processes, increasing data reliability and quality using smartphone applications, as well as using industry 4.0 concepts through systems with artificial intelligence.

Considering that the analysis of the study was performed in a specific branch of the industry, the results should not be generalized. However, based on the methodology developed, other organizational models can be analyzed in the future.

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Developing a Maturity Model for Digital Servitization in Manufacturing Firms

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Abstract. In today's rapidly changing markets, manufacturing firms are increasingly challenged by the convergence of digital technologies and servitization, which is defined as Digital Servitization. Enterprises struggle to grasp this phenomenon's vision, constantly facing pressures to obtain and retain competitive advantage, inventing and reinventing new products and services, reducing costs and time to market, and enhancing quality at the same time. They need to define improvement actions to be taken to navigate through the transformation process and prioritize between different activities. Prior research has highlighted the importance of how to proceed into this transformation, however less emphasis has been put on suggesting suitable activities that fit the organization's current status and future goals. To overcome this challenge, we propose a maturity model for digital servitization that serves as an assessment tool. Based on a literature review and qualitative expert interviews, this study proposes a maturity model that allows a holistic view on the areas affected by digital servitization. The model consists of four dimensions, strategy, business processes, customer experience, organization and culture that consist of a requirements list with 13 indicators. The contribution of this study enables practitioners to diagnose and assess their activities with the digital servitization transformation.

Keywords: Digital servitization · Maturity model · Digital transformation

1 Introduction

The growing digital disruption across industries is blurring boundaries and forcing industrial enterprises to improve their agility and responsiveness to gain ability to manage the whole value-chain. Recent research suggests that the application of digital technologies (DTs) can further advance servitization by enabling sophisticated and novel service offerings [1, 2]. In fact, the adoption of digital technologies such as the Internet of Things (IoT), Data and Analytics, Artificial Intelligence can alter the features of the delivered services significantly [3–5] and enable novel business models [6],

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thus, reshaping industry competition [7]. Indeed, DTs shape servitization strategies, structures and activities aiming at increasing the service delivery efficiency and value of service offerings [1]. For instance, KONE, one of the largest global elevator companies, developed, sophisticated condition monitoring and predictive maintenance services together with IBM. Both these services are based on IoT technology and have resulted in lower downtime and speed up equipment restoration [5].

The convergence of DTs and servitization is called digital servitization and refers to the development of new services and/or the improvement of existing ones through the use of DTs by enabling new digital business models, finding ways of co-creating value, generating knowledge from data, improving a firm's operational performance and gaining competitive advantage over rivals [8, 9] and received lots of attention over the last years from the research community and practitioners. Despite the phenomenon's growing relevance, the issue of defining how digital servitization changes a company's strategy, processes, and culture remains unexplored [10].

Evidence shows that organizations often struggle with understanding the impact of digital servitization on their business and industry [9]. One key barrier is their inability to decide where to begin their own transformation process. To date, to the best of our knowledge, the existing research has not provided tools, such as maturity models for practitioners to master this transformation. Specifically, more attention has to be focused on helping organizations to decide when and why they need to take an action to progress and teaching them which actions should be considered. The introduction of such maturity model in the digital servitization, could therefore allow managers to position and compare their current state to the best-practices in related business fields and map their new strategy accordingly, which will increase the firm's overall performance.

Hence, the aim of our research project is to develop a maturity model (MM) that can ease the decision making, and assess the digital servitization maturity in manufacturing companies based on highly relevant requirements. To achieve our goal, we follow the maturity development process of [11] and aim to answer the following two research questions:

– RQ1: What are the key requirements for digital servitization in manufacturing?
– RQ2: What stages can be observed in the process of digital servitization?

In pursuit of answering the two research questions, our paper is structured as follows. Section 2 sets the theoretical background. Section 3 describes the research method, and Sect. 4 presents the maturity model for digital servitization. Section 5 discusses the findings and suggests avenues for further research.

2 Theoretical Background

Technologies and software have been inherently involved in servitization since its infancy [12], shaping servitization strategies and structures. For example, Rolls-Royce has used a variety of sensor-based technologies to facilitate smart solutions [2, 4]. However, the role of technology was neglected in the early servitization literature, and for a long time these issues were investigated separately either focused on the customer value or manufacturing process value [13]. The increasing interest, both from practitioners and scholars, on the convergence of digital transformation and servitization has set the path for a new phenomenon, named digital servitization, to flourish.

Digital servitization refers to the development of new services and/or the improvement of existing ones through the use of digital technologies, by enabling new digital business models, findings ways of co-creating value, generating knowledge from data, improving a firm's operational performance and gaining competitive advantage over rivals [1, 8, 9, 14, 15]. It is seen as profound and fundamental change that affects multiple business units within the organization, e.g. strategy, processes, organization and culture, etc.

Although, the phenomenon of digital servitization has been of a great interest for researchers of various disciplines the last years [16], its transition and implementation seems far from easy, creating numerous challenges. Since this transformation is not a linear process, there are different courses of actions. Evidence shows that enterprises often struggle to decide where to begin their own digital servitization journey and no tools are provided, such as maturity models, for practitioners to master this change. It would be beneficial for managers to know about these difficulties, in order to make an informed decision about prioritizing between different steps and to lay the foundation for successful change.

Descriptive models (maturity models) for practitioners need to be developed to support companies towards their digital servitization journey by defining how the adoption of digital technologies changes the whole organization in practice [10, 17]. Therefore, we need to know more about how companies actually face such a transformation, what makes them successful, and how organizations approach their transformation. A maturity model provides some guidance in this respect, since it gives an overview of the different areas and maps out typical paths of how organizations go about their digital servitization.

According to [11], maturity models consist of a sequence of maturity levels for a class of objects and represent an anticipated, desired, or typical evolution path of these objects shaped as discrete stages. Their application enables firms to achieve competitive advantages [18], by generating awareness of the analyzed aspects (their state, importance, potentials, requirements, complexity), and by serving as reference frame to implement a systematic and well-directed approach for improvement, ensuring a certain quality, avoiding errors, and assessing one's own capabilities on a comparable basis. There are several MMs but in this study, we use the Capability Maturity Model, which defines a set of process areas that reflect organizational capabilities which have to be developed to achieve the maturity goal of the service development process. [19], as the main reference due to its wide acceptance in industry.

The development of a MM entails critical requirements that occur throughout the digital servitization process and should be rooted in both scientific grounding and practical relevance. In the case of digital servitization, these critical requirements also impact the manner that a company relates to the other chain elements such as customers, partners, competitors [20] and internal relationship changes. Hence, this study has identified four main dimensions (strategy, customer experience, business processes, organization and culture) to analyze how they should be considered during the digital servitization process of manufacturers. The four dimensions were defined by using the

St.Gallen Business Engineering Map as a guide to group the critical requirements within the same type of relationship. The critical requirements for all the dimensions are obtained from the literature and are used to create an initial concept of the maturity model.

3 Research Methodology

Our research aims at developing a MM for digital servitization in manufacturing. The development of MMs is established [21], and numerous models for a variety of purposes have been developed [11, 22]. In contrast to the large number of MMs, the research on how to develop these models is rather sparse [11]. We identified the two popular development processes [11, 21], as it is indicated by literature, on how to conduct MM design. We decided to apply [11] to develop our MM since they follow a Design Science Research (DSR) development process according to DSR guidelines [23]. Despite [11] propose a seven-step development process, we decided to reduce the complexity of the model by merging three process steps (the conception of transfer and evaluation, the implementation of transfer media and the evaluation) into one, the evaluation step. In addition, we incorporated the "determination of a development strategy" in the second step, the comparison process, because it is based on its results. The procedure applied in our research consists of four steps, and we describe each of them in Table 1 according to the tasks performed and the techniques used.

Table 1. Procedure model.

	Problem identification	Comparison of existing MMs	Model development	Model evaluation
Performed activities	Problem identification and motivation	1. Deduction of maturity model requirements 2. Identification and evaluation of existing maturity models	Conceptualization of maturity levels	Evaluation
Use techniques	1. Initial literature review 2. Exploratory expert interviews	In-depth literature review	Model development & expert interviews	Expert interviews

In the first step (*Problem identification*), we specified the research problem and focus of the MM, provided its practical relevance and justified the value based on an initial literature review and exploratory interviews with experts to get better insights.

Based on the problem identification, in the second step (*Comparison of existing MMs*), we gather requirements by conducting a systematic literature search using the

Scopus database, which is widely acknowledged as a world leading source and provides the best coverage in this research field. We applied the search combination of servitization ("servitization", "product (-) service system* (PSS/IPSS)", "integrated solution*", "service transformation", service infusion") and different terms for digital transformation and technologies ("digital technology/ies", "digitization", "Artificial Intelligence", "Big Data", "Cloud", "Digital Technologies", "digitalization", "Industry 4.0," Internet of Things", etc.). The search, between 2000 and 2019, yielded 86 usable articles. These articles were used to derive an initial list of requirements, which was structured according to the four MM dimensions derived in the theoretical background section. For the coding process the software Atlas.ti was used. Moreover, we operated a second literature review (using keywords such as "digital servitization", "servitization", "business/enterprise/organizational transformation", "digital transformation", "assessment model", "maturity model") to identify any shortcomings or lack of transferability of existing MMs, which are devoted to same or similar domains. In particular, 16 studies emerge from the field of servitization, [22, 24] and 11 from digital transformation. Subsequently, we analyzed the MMs according to their domains and functionalities as well as their capability to address the defined research problems.

In the third step (*Model development*), we used model adoption mechanisms [25] in the rigorous creation of a MM (structure and content). After formulating the model, the study sought expert opinions to confirm support for the model. Emails with a questionnaire to guide open conversations were sent to ten individuals, academics and practitioners involved with digital servitization for over a decade. There were six respondents who provided in-depth feedback through interviews regarding the model, which had a duration of 60-120 min each one. The majority of the responses acknowledged the importance of evaluating manufacturers' use of digital servitization and supported the overall structure of the model. Comments included suggestions for definition of stages, notes about wording, suggesting the possibility of needing less stages, need for clarifying requirement description, questions about how the model will be measured and by whom, and proposing extra dimensions/requirements. These opinions were taken into consideration and the model was revised accordingly in order to be more precise and complete.

During the last step (*Model evaluation*), we evaluated the comprehensiveness of the model, validity in self-assessment and the capability of supporting the future development of a roadmap with the same experts, discussing the final version of the MM. Table 1 describes the steps according to the tasks performed and the techniques used achieved in complementing our research.

4 Proposed Digital Servitization Maturity Model

4.1 Dimensions and Requirements of Maturity Model

The identified requirements both from literature and expert interviews were summarized in four dimensions. For each dimension, the corresponding maturity criteria were defined, which describe the fields of action. Activities in these fields show the penetration of digital servitization maturity. Hence, we employed "Strategy", "Customer

Experience”, “Business Processes” and “Organization and Culture” as dimensions that serve not only as a conceptual basis but for collecting the exploratory identified requirements but also as a theoretical lens for the MM (see Table 2).

Table 2. Identified dimensions and maturity criteria in the individual steps of the study.

Dimensions	Requirements	Literature	Expert interviews
Strategy	Strategic orientation	✓	✓
	Business model	✓	(✓)
	Digital service offering	✓	(✓)
	Digital service ecosystem	(✓)	✓
Customer Experience	Customer centricity	✓	✓
	Customer trust	(✓)	✓
Business Processes	Production	✓	✓
	Marketing	(✓)	(✓)
	Human resources	(✓)	✓
Organization and Culture	Digital service business mindset and culture	(✓)	✓
	Governance and leadership	(✓)	✓
	Organization design and talent management	✓	(✓)
	Competences	✓	✓

✓ = frequent mention (✓) = occasional mention

The **Strategy** of digital servitization is embedded within the overall business strategy and focuses on how the business transforms or operates to increase its competitive advantage through digital initiatives in service. “Strategic Orientation” was identified as an important prerequisite for digital servitization and it refers to the exploitation of the overall growth strategy aiming at developing digital service offerings and innovating the company’s portfolio by keeping its heritage [26, 27]. “Business Model”, another critical requirement, refers to the different technology-enabled business models that facilitate firms to achieve a competitive advantage by providing customer knowledge-based digital service offerings during the entire product life cycle [27, 28]. In addition, “Digital Service Offering” applies to the enrichment of the existing but also the creation of totally new service offerings enriched by digital technologies that bring digital and physical systems together creating customer value and revenue streams [20]. The last requirement of this dimension is the “Digital Service Ecosystem” and makes reference to the relationship between the company and business partners (R&D organizations, technology incubators, startups), enabled by platforms, which aims at gaining access to resources such as technology intellectual property, or people to increase the organization’s ability to improve, innovate and grow, balancing security and privacy needs with the ability to flex capacity according to business demand [9, 29].

Customer Experience focuses on the necessity of considering customers’ needs and interests as the basis for developing digital service offerings. The first requirement, that we identified is the “Customer Centricity” and deals with a set of procedures and practices for assessing closer customers’ preferences and continuously evolving needs on digital service offerings, to enhance the competitive position and strengthen customer relationships [13]. Experts stressed the “Customer Trust”, which refers to how the customer’s trust is build and how the perceived risks (functional, psychological/ safety, privacy) are evaluated by them [30].

The dimension of **Business Processes** contains the way of executing and evolving a company’s operations by using digital technologies aiming at driving strategic management and enhancing service business efficiency and effectiveness. The first requirement is “Production” and indicates the way processes are executed, monitored and managed. It consists of internal processes (the way inputs are transformed to outputs, products and services are integrated through digital technologies to create value for the customers and end users), supply chain orchestration (the way the firm employs digital technologies to manage the value network of all actors and individuals that interact to deploy resources and applied competences in order to create value) and digital innovation (practices based on digital technologies that support research, design, and development of new product-service offerings) [8, 10]. “Marketing” requirement include the pricing, the process whereby a business sets the price at which it will sell its digital service offerings and value co-creation, which occurs through interactions among providers and customers by integrating resources and applying competences [31]. “Human Resources” requirement depicts to services provided by an HR department to business operations. HR operations include administrative services, recruitment, job analysis, and employee relationship management [15].

Organization and Culture dimension defines and develops an organizational culture with governance and talent processes to support progress along the digital servitization maturity curve, and the flexibly to achieve growth and innovation objectives. “Digital Service Business Mindset and Culture” describes the diffusion within the companies of a mental model that is oriented towards digital service culture: the company needs to change mental model to view digital service offering as a business logic and perspective on value creation [15]. Furthermore, “Governance and Leadership” refers to the efficient and effective decision making processes which define the expectations, systems and management of projects related to digital servitization [8]. Another significant requirement is the “Organization Design and Talent Management” and cites the transformation of the internal organizational structures by establishing dedicated team/roles/persons for the development of digital service offerings in light of new competitive pressures [15]. The final requirement is the “Competences”, which treats higher and diversified competences that employees need to develop by acquiring new knowledge and ways of working to encounter increasingly interactive tasks, take data-driven decisions, understand customer’s problem and interpret its real needs [32].

4.2 Maturity Levels

To define the digital servitization MM phases we used as main reference the MM processes of [19]. For simplicity in this study, we use three maturity stages (see Tables 3a, b and c), which were deduced from the items in each dimension.

Table 3. Maturity model for digital servitization.

Dimension	Requirement	Level 1 – Beginner	Level 2 – Experienced	Level 3 – Leader
Strategy	Strategic orientation	Limited vision of digital servitization, no documented implementation target. Strategy initiated and developed. Low investment	Incremental vision of digital servitization, not fully defined implementation target. Strategy implemented and occasionally reviewed. Investment and Innovation management established in multiple areas	Transformational vision, clearly defined implementation target. Strategy implemented and regularly reviewed. Enterprise-wide Investment and Innovation management established
	Business model	Add-on business models use DTs (ICT, IoT) to enable additional functions or adding personalized services to the existing physical products or service to facilitate service provision	Usage-based business models use DTs (IoT, cloud computing, big data) to measure the amount of product usage and allow customers to pay for or subscribe to the plan, based on their actual usage and needs (pay-per-use)	Solution-oriented business models use DTs (IoT, artificial intelligence) to enable the provision of solutions to customers. With the aid of IoT technology, providers are able to offer integrated solutions to customers' needs (subscription availability)
	Digital service offering	Low usage level of DTs is used to provide obligatory product-related services (base services), such as installation or maintenance and repair	Moderate usage level of DTs (IoT, Cloud computing, Big data, Advanced manufacturing Solutions) is used to provide intermediate services (e.g. remote monitoring)	High usage level of DTs (IoT, Big data, Advanced manufacturing solutions, Artificial Intelligence) provides value for both customer and the companies' internal processes creating novel services (advanced services)
	Digital service ecosystem	Company has partnerships with a few stakeholders; low level collaboration. No flexibility, no additional integration; limited understanding today, no future shared view	Company has partnerships with some of stakeholders; medium level of collaboration. A moderate level of flexibility, integration and understanding	Fully digitized, integrated partner ecosystem; open system built on a flexible and integrity architecture; clear shared view, today and in the future
Customer experience	Customer centricity	None customer preferences and needs are collected. Interaction between customer and company is not existent/distant. No feedbacks from the customer are collected. Impersonal customer communication	No standard approach of preferences/needs collection. The customer is integrated in the early design process in order to align the product to the customers' needs. Formal feedback is collected after technical assistance interventions	Formal procedures and rules drive customer preferences and needs, used for future strategical decision. Customer and interaction data collected through different channels. Feedbacks are discussed with the client and are explicitly considered in the continuous improvement process by creating common platforms. Intimate relationship
	Customer trust	No documentation; customer does not know when/how the service provider access the equipment; uncertain about which activities are performed on the machine. Service technician can access private/confidential information beyond the service agreement; no control	Some documentation; customer does not know when/how the service provider access the equipment; certain about which activities are performed on the machine. Service technician can access some private/confidential information beyond the service agreement; little control	Documentation; customer knows when/how the service provider access the equipment; certain about which activities are performed on the machine. Service technician cannot access private/confidential information beyond the service agreement; control
Business Processes	Production	Operation process traceability is provided partially; low level end-to-end visibility and production customization. Standard agile methods in project execution (e.g. Scrum); no clear integration and standardization. Integrated supply chain processes between company, suppliers and customers in terms of basic data sharing and communication; few	Operation process traceability is provided at production line level; medium level end-to-end visibility and production customization; integration and standardization are at a medium level. Integrated supply chain processes between company, and key strategic suppliers/customers in terms of data transfer; some software systems in use and	Operation process traceability is provided at factory level; high level end-to-end visibility and production customization; high level of process standardization. Supply chain systems are fully integrated between company, suppliers and customers which provide real-time planning; lots of software systems in use and production systems are

(*continued*)

Table 3. (*continued*)

Dimension	Requirement	Level 1 – Beginner	Level 2 – Experienced	Level 3 – Leader
		software systems in use and production systems are partially automated. No activities supporting the digital service innovation, apart from observations. Data usage in service innovation is at low level	production systems are automated at production line level. Systematic approach for digital service innovation; company is aware of the process but some activities are still incomplete or inconsistent. Data usage in service innovation is at medium level	automated in factory level. Quality management and continuous improvement activities are formalized in the procedure. Data usage in service innovation is at high level
	Marketing	A few analytics studies are conducted and data obtained from environment is not used in product pricing and dynamic pricing. The customer has little control over the contribution process and the provider offers the digital services that chooses	Analytics studies are conducted and data obtained from environment is used in product pricing and dynamic pricing. The customer has some control over the contribution process and the provider offers the digital services that customer also needs	Analytics studies are conducted and data obtained from environment is used in product pricing and dynamic pricing. The customers are tightly integrated and engaged with the provider's processes and resources. They are jointly able to discover opportunities for value creation
	Human resources	Data is used in a few areas, but company does not share real-time data with field workers. Traditional recruitment and training, e-learning is not an option	Data is used in some areas; company shares real-time data with field workers. Traditional/Digital recruitment, e-learning is an option	Data is used in lots of areas; company shares real-time data with field workers. Special training (mixed reality, internal academy) for re-qualification of the employees. Digital recruiting
Organization & Culture	Digital service mindset & culture	Low attitude towards digital servitization. Mistakes and lessons from failed projects not secretive, digital competences are not critical, the development of new digital service offerings by customers is not actively promoted. Low level of knowledge sharing and no/in limited area collaboration across company. Home office for employees for whom it makes sense	Promote attitude towards digital servitization in a medium level. Evaluate errors, identify the importance of digital competences, the development of new digital service offerings is promoted. Encouragement of knowledge sharing and structured and consistently performed cross-functional collaboration	Promote digital servitization vision. Evaluate errors to improve processes, digital competences are critical, customers suggest systematically improvements for the digital service offerings. High level of knowledge sharing and sophisticated forms of cross-company collaboration in value creation networks. Great experience on mobile working and little regulations are needed
	Governance and leadership	De-centralize decision making process. Low quality/transparency/availability and accuracy of data used for decision- making processes	Promote central decision making process. Medium quality/transparency/availability and accuracy of data used for decision- making processes	Re-centralize decision making process. High quality/transparency/availability and accuracy of data for decision- making processes
	Organization design & talent management	Organization structure is not suitable for transformation. No formal or informal roles are created. Limited interaction between departments	Organization structure is suitable for initial projects. Some roles are being created. Departments are open to cross-company collaboration	Well-structured for transformation. Formal roles responsible for strategic planning, which are well connected within business units. Departments are open to cross-company collaboration to drive improvements
	Competences	Only technology focused areas have employees with digital skills that are not allocated to specific digital servitization projects	In most areas of the business digital skills have been well developed that are allocated to specific digital servitization projects in different units	All across the business, cutting edge digital and analytical skills are prevalent and allocated to specific digital servitization projects in same units

Level 1 – Beginner is a maturity level where a company has some pilot strategy initiatives and offers base services. The usage level of digital technologies in business processes (production, marketing, HR) is low. Flexibility, integration and collaboration

with partners are at low level as well. The customer interaction is distant, while there is a low attitude towards digital servitization. The organization structure and people are not prepared enough for this transformation.

Level 2 – Experienced is a maturity level where a company is implementing digital servitization and offers intermediate services. Digital technologies are used in a moderate level in the different business processes the ecosystem is getting digitized while the collaboration is becoming closer. The customer is integrated in the design phase already and the general attitude is encouraged towards the new transformation. The organization structure is suitable for initial projects and people for specific units that have digital servitization projects have the necessary competences.

Level 3 – Leader is a maturity level where a company has implemented digital servitization, has a comprehensive vision and offers advanced services. The usage level of digital technologies is high both in the business processes and business models. There is a fully digitized, integrated partner ecosystem built on a flexible and integrity architecture. There is an intimate relationship and personalized communication with the customer while the attitude is comprehensive and promotes digital servitization. The organization structure is well structured and digital competences are prevalent in the whole company.

5 Discussion and Conclusion

Although, evidence show that manufacturing companies struggle with comprehending the impact of digital servitization and how to master it, little attention has been devoted so far in developing a tool that can be used from practitioners. This study presents the development of a new maturity model, that based on specific requirements identified in digital servitization literature and expert interviews, can be used as a management instrument to analyze the current set-up, by assessing the maturity level of strategy, business processes, customer experience, organization and culture. Three levels of maturity have been outlined, and the model constitutes the main contribution of our research, since, to the best of our knowledge, no such kind or model exists for digital servitization in manufacturing.

Coping with the challenges of digital servitization is of considerable interest to both researchers and practitioners. Initially, it provides a theoretically grounded, methodologically rigorous development of a maturity model for digital servitization in manufacturing companies. The value of the presented model, in research, resides in the combination of scientific rigor, practical relevance, and direct applicability. The tool is also directly applicable because of its extensive documentation and it describes its scope, purpose of use, and structure (maturity levels, dimensions, requirements). Even if the model has little normative power, it can favor the identification and prioritization of the improvement actions, as they emerged from literature and interviews.

The developed maturity model for digital servitization can be used by managers to inspire, establish trust, build consensus and communicate. First, managers can use the model by asking what they could learn from the others' experiences in different organizational contexts. The objective is to avoid mistakes already made by others and benefit from accumulated experiences identified in literature. The maturity model, in this way, supports managers to identify their requirements with low maturity that they need to be improved and provides them with inspiration on how to incrementally improve digital servitization. Second, the development of digital servitization requires significant high investments, for which the approval of top management is mandatory. To receive such approval, it is essential to convince decision makers that these investments are urgent and will pay off. Therefore, the model can help to create trust, that investments in digital servitization will pay off, and gain top management's support. Third, the success of fundamental business transformation depends on the existence of a strong consensus and a clearly defined and well-executed digital servitization strategy. The basis for consensus and a shared assessment of the as-is situation is a shared language and consolidation of diverse perspectives. The maturity model encompasses a number of dimensions and requirements, along with their definitions. Hence, it provides a shared language that facilitates the structure exchange of perspectives. Finally, tangible evidence of the current state of digital servitization is needed both at the corporate level but also by those who are responsible for developing this phenomenon. By capturing the maturity stages at different times, the model provides the means for continuously communicating any improvements. Consequently, the developed maturity model is a tool which enables internal awareness not only for the strengths but also the areas that need improvement. The model shows what has already been achieved and allows to track back success to understand the contributions of each individual.

Although this paper produced some interesting and useful finding, we would like to point some limitations that need to be considered when interpreting the results. The maturity model was developed to be applied in manufacturing sector. Thus, it cannot be applied across various industries. Furthermore, it is based exclusively on literature and a number of expert interviews, which makes it conceptual and for that reason, further research could involve more experts, divided into academics and practitioners, aiming at completing the requirement list considering different perspectives. We also acknowledge that even though the maturity stages have been carefully developed, based on literature and interviews, a testing and final evaluation of the tool with empirical cases are missing.

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Identification of Critical Success Factors in Crops Seed Industry

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Abstract. Changes in business environment, customers behaviour, competition and fast technological development demand the new approaches to organization management. Monitoring the effects of business processes enable and initiate retroactive actions, but identification of critical success factors should enable proactive actions and ensure the adequacy of future business process achievements. Identifying the critical success factors should not be just an end in itself, but should be accompanied by defining appropriate performance indicators that should enable monitoring of achievement from the aspect of ensuring an appropriate level in those areas of business that are recognized as critical. The aim of this paper is to identify the critical success factors in the seed industry in order to create a basis for performance management system.

Keywords: Critical success factors · Process performance · Key performance indicators · Crops seed industry

1 Introduction

Every organization seeks to achieve its goals as much as possible, while the organization's success in achieving its goals can be characterized as its performance. Past years were painted with the more intelligent usage of data to track organizational business. To use the data properly, the organization must first identify what to track and how to measure it - critical success factors and key performance indicators respectively.

Critical success factors (CSFs) represent key areas in which a manager has to have good results to achieve goals [1]. CSFs are dependent on the type of organization or project and the kind of business process (sales, research, manufacturing, etc.). To measure whether business results are good or not, organizations need to have an appropriate performance measurement system. Some examples of previous research of CSFs tracking in agriculture have dealt with the process of livestock production [2] and with the food traceability of a logistics system (from farms over to food processing and storage, distribution and sales to consumers) [3].

In the area of crop seed breeding and production, the complexity of the process and the high degree of dependence on external factors make this area difficult to manage, and at the same time very suitable for manifesting the benefits of applying the

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performance management concept. When observed from the process aspect the crop seed industry drives on several processes like the research process to develop the new varieties or seed hybrids, seed production and reproduction processes, seed processing and storage processes, and the processes of packing, sales and distribution to agri-market consumers. Since these processes can last from weeks up to a few years, consuming along with the financial and non-financial resources, it is necessary to track their performance. The development and implementation of a performance measurement system are specific and different for each organization and there is no unique one. Performance management is a constant process of performance planning, monitoring, measuring and evaluation, and continuous improvements. Key performance indicators (KPIs) consist of main indicators and their sub-indicators, which can be estimated quantitatively or qualitatively. Crop seed breeding is usually a process consisting of the growing of several plant generations in controlled environmental conditions, an inspection of research results and getting the necessary licenses to put the final product into the market. Evaluation of agricultural scientific research KPIs should not be only targeted only towards economic indicators but should enable a better understanding of process results which leads researches towards the chance to improve their performance [4]. The research presented in [5] gave a list of KPIs for agricultural scientific research. In the paper, the authors present the three levels of KPIs. At the first level are three indicators such as inputs, activities, and outputs, the second level contains six indicators concerning teams, research conditions, benefits, etc., and the third level contains twenty indicators of which three are financial (expenses, research income, and funding) and the others are non-financial. Since the research process is a long-term process which is often geographically dispersed it is also important to support the tracking of research progress with appropriate information technology to enable process efficiency monitoring [6].

Observing the processes which follow after the successful crop breeding, they are complex and involve a lot of supply chain actors. Seed production involves the production contracting, growing, inspection and sewing in the field, seed transportation and quality inspection before further processing of the for storage purposes. KPIs should enable tracking of all parameters which impact the productivity. An example of KPI tracking can be found in [7] (e.g. tracking of total fuel consumption for agricultural equipment by using sensor and geospatial data). After the seed is produced it is needed to be additionally processed in order to get cleaned of impurities or other plants and to be stored properly. Performance measurement should include here the indicators which reflect seed quality and the indicators which reflect the processing or storage parameters. Sales and distribution process demands that the seed should be properly packaged and transported to the customers (wholesale, retail store, individual customer). Process performance should include the indicators concerning sales and marketing efficiency and measurements of customer satisfaction.

Having the performance management system developed as a final goal, the objective of this paper is to identify critical success factors and define basic key performance indicators while focusing on the business processes which are previously described. The research was carried out in a large company for crops seed production. The following chapter describes the conducted empirical research methods and results.

2 Empirical Research

2.1 Data and Research Methodology

Conducting research based on psychometric and statistical methods requires planning, as the adequacy of such methods may depend on the magnitude and nature of the cause. For example, [8] points out that sample size is significant. In cases with small samples, there may be a problem of their validity and statistical significance of the model examined. Also, the distributions of smaller samples may deviate from normal, so the question arises of the sensitivity of the method to the conditions for its application, since the application of some methods assumes normal distributions of the samples.

The data collection is done by using the questionnaire technique. The use of the questionnaire was found to be largely justified, both by the nature of the research and the results of [9], which show a high correlation between objective parameters and their subjective assessment. Also, [10] indicates that there is a high correlation between subjective judgment and the actual values of financial performance indicators of a business. Most recent research into the development of performance indicators is empirical and uses the questionnaire as an instrument for measuring effects based on subjective employee judgment.

For the purpose of creating a research instrument (questionnaire) within this research, the identified processes in the company are grouped as follows:

- Research & Development,
- Production,
- Seed processing,
- Warehouse management,
- Sales and distribution, and
- Corporate level

whereby, for the sake of similarity, the process of seed production is viewed in the context of this research together in the group with the basic production process, that is, the two processes were grouped into one. In addition to these, the questionnaire also included control variables, as follows:

- Participant groups and processes related to them,
- Belonging to a group of executives,
- Representation of performance monitoring in the organization,
- Systematic monitoring of performance at the process and organization level,
- Contribution of performance monitoring systems to improving business results,
- Types of performance monitored,
- Prerequisites for better performance.

The final version of the instrument included 7 control variables, and 6 constructs of organizational and business process performance. A Likert scale was used to measure three of seven control variables. Although the Likert scale is essentially ordinal, it is usually treated in the literature as interval [11]. With this approach, comparisons of trait representation statistics (e.g. arithmetic means) for the groups studied can be made.

Designing a performance measurement system must consider internal issues and circumstances (a look at the system from the inside) and identify truly valuable performance metrics for the organization. The availability of standard indicators from external experts (as part of performance measurement systems) may be helpful, but uncritically retrieving them may prove to be a very poor solution. That is why the questionnaire was designed on the basis of open-ended questions, i.e. the respondents were asked to propose for each of the six constructs their own opinion on the preconditions for successful realization of the business process, as well as to identify indicators that reflect the success of the implementation of the previously defined processes in the best way. Also, one of the reasons for using open-ended questions was to explore the level of awareness and knowledge about critical success factors and indicators of respondents.

2.2 Results

This research is conducted in a large crops seed production company. Data is collected from 236 respondents, employed in 17 different sectors/departments of the company, participated in this research, which makes a stratified representative sample from the employed population of 637 or 37%. Out of the total number of respondents, 73 are scientists, 48 are expert associates (bachelor and master degrees), 66 are technicians and laboratory assistants, 17 are salesmen and retail employees, 24 are promoters, 2 are employed in marketing. Only 6 respondents did not specify a group to which they belong in the company. Also, from the total number of respondents, 37 employees were assigned to the management positions of the company. This indicates that the percentage of all groups of employees in the survey is uniform, which gives methodological validity to the testing process in terms of statistical processing of data and drawing conclusions based on reliable information. The collected data is analyzed using basic statistical analysis of frequencies.

On the question about presence of business performance monitoring at the company – Fig. 1, 43% of the total number of respondents who answered this question (233 respondents) think that monitoring is at a satisfactory level, 36% think that monitoring is good or excellent, which indicates that the majority of the employees think that the performances of the company are being measured and monitored.

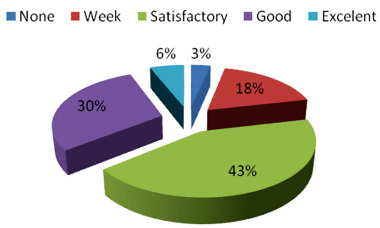

Fig. 1. Presence of business performance monitoring in the company.

Of the total number of respondents who answered on the question about organized and planned business performance monitoring in the company (230), 63% believe that performance monitoring at the company is planned and organized only in some segments of the company, which indicates the need to develop systematic performance measurement and monitoring system in all defined processes as well as at the corporate level, that is, the need to develop a unified integrated system for performance measurement and evaluation at the company (Fig. 2).

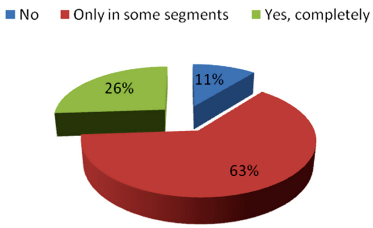

Fig. 2. Systematic business performance monitoring in the company.

The fact that 48% of the total number of respondents (232) who answered question about contribution of performance monitoring systems to improving business results, believe that the system for monitoring and measuring performance may contribute to the improvement of business results, indicates that there is a lack of awareness and knowledge of the respondents about the importance and the contribution of developed performance monitoring system (Fig. 3).

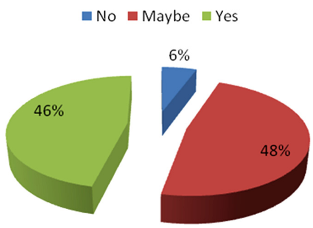

Fig. 3. Contribution of performance monitoring systems to improving business results in the company.

The next control variable refers to the types of performance that are monitored in the company in terms of whether the performance measurement system relies solely on financial performance or whether other performance indicators are monitored. Most of those who answered this question believe that either there is only an analysis of financial results (18%) or other performance indicators (52%) are included but not enough. This indicates that there is a need to develop a unique and comprehensive system of measuring and evaluating the performance of the company (Fig. 4).

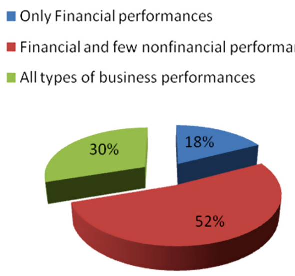

Fig. 4. Types of business performances in the company.

The last question, in the part of the questionnaire with control variables, was to determine the opinion of the employees on what could contribute to the better performance of the organization. Within this question, 7 predefined answers were offered, with the possibility for respondents to submit their own proposals on their own initiative. The results showed that the largest number of respondents (172) identified employee motivation as one of the most important prerequisites for achieving better performance. According to the results of the research, the next important prerequisite is better organization of the process and clearer vision of the organization (an average of 100 respondents). Approximately the same number of respondents (average 60 respondents) believes that better quality staff, more pronounced market orientation and a different structure and more innovative approach of employees can contribute to better results.

The objective of the second part of questionnaire was to identify a set of critical success factors and indicators for their monitoring. The set of indicators that were recognized as the most relevant in terms of performance monitoring at the level of the company, or at the level of its main business processes, was based on information derived from the conducted survey, using open-ended questions. The resulting set of critical success factors and indicators is shown in Tables 1 and 2.

Table 1. Identified critical success factors and indicators.

Processes	Critical success factors	Indicators
Corporate level	Profitability; Management; Human resources; Equipment; Brand image;	ROA, ROE; Direct costs per plant species; Clear mission and objectives; Motivation and expertise; Equipment costs; Customer satisfaction;
Research & development	Genetic resources; Scientific cooperation; Equipment; Staff; Soil;	New genotypes; New joint projects; Staff mobility; Availability and functionality of equipment; Competence of researchers; Availability and capacity of soil for research;

Table 2. Identified critical success factors and indicators.

Processes	Critical success factors	Indicators
Production	Raw material base; Varieties and hybrids; Soil; Subcontractors; Equipment; Human resources; Planning and organization;	Quantity of seed of higher categories; Genetic purity of crops; Average yield and quality per Ha – by plant species and categories; Availability and quality of soil for production; Isolation Distances for Seed Crops; Technical equipment of subcontractors; Availability and functionality of equipment for production; Equipment maintenance costs; Availability of production stuff; System for production planning and control;
Seed processing	Raw material base; Seed processing; Storage conditions in seed processing; Equipment; Human resources; Planning and organization;	Quality of raw material; Overall Capacity for seed processing; Quantity and quality of processed seed/waste percentage; Temp./Humid./Purity; Availability and functionality of equipment for seed processing; Capacity utilization; Availability of stuff; System for seed processing planning and control;
Warehouse management	Storage conditions; Storage capacity; Human resources; Equipment; Planning and organization;	Temp./Humid./Pest; Inventory turnover ratio; Average storage occupancy; Average age of seeds in stock; Availability of stuff; Availability and functionality of equipment for storage; System for inventory planning and control; Delivery efficiency;
Sales and distribution	Price competitiveness; Customer satisfaction; Human resources; Marketing;	Product Competitiveness Ratio; Average number of complaints (quality/yield); Availability of qualified stuff; Number of new customers; Sales efficiency ratio; Market share; Collection of accounts receivable; Revenue per plant species; Share of licenses revenue;

3 Conclusion

Considering that there is still not enough connection between the process approach and organizational performance in the seed industry, this paper represents the first step in the preparation of the organization for the implementation of the performance management system.

Performance measurement systems are dynamic systems whose content needs to be systematically updated. Therefore, the system presented here, that is, a set of critical success factors and indicators, must be treated as an initial version of the system, which will eventually need to be modified, expanded or narrowed as needed.

The optimal content of the system, both in terms of quantity and quality of indicators, is a variable category, as is the organization itself and its environment. The downside of a too modestly designed performance measurement and evaluation system is that it does not provide enough information to successfully manage performance, while an overly conceptualized system can be said to engage more resources than necessary, distracting the essentials with excess detail.

In addition to constantly reflecting on the most appropriate set of performance monitoring indicators, an organization that wants to operationally implement its performance measurement and evaluation system must necessarily face extra effort. This effort concerns a more detailed description of performance metrics than the one given in the tables above, and the permanent definition of targets as desired metric values in the near or far future. The table above provides a rough illustration of what organizations should define for each performance indicator.

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Identifying Lean Enterprise Model Enabler Practices for Lean Office

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Abstract. Concerning to its application in service industries, the methodology Lean Office presents certain complexity level, due to some fundamental characteristics in the services area. In this context, this article is inherent to the implementation of lean training, based on the enabling practices proposed by the Lean Enterprise Model that proposes 12 primary practices and 61 enabling. This paper aims to identify practices for implementing Lean Office by performing a systematic review of the literature, identifying the most cited theoretical practices and submitting these practices to the analysis of experts in Lean Office. The process results in a list of 28 practices and the evaluation of these practices was carried out by means of a survey with 34 Brazilian researchers with experience and publications in Lean Office. The results were analyzed by means of cluster and ANOVA resulting in 19 training practices recommended for training for Lean Office implementation and prioritized in a list of seven main practices.

Keywords: Lean office · Training practices · Primary practices

1 Introduction

In the recent decades, the Lean philosophy has been widely disseminated and applied in different sectors and segments of the economy, without being tied to its classic application, Lean Manufacturing.

From 50% to 80% of the workforce in the West works in offices and for this reason, there is a growing interest in research on the impact of lean implementation in administrative environments, especially in terms of productivity performance [1]. Authors [2] have written that all costs incurred to meet a client's request, whether manufacturing a part or providing a service, involve administrative functions from 60% to 80%.

Lean Office applications began to be reported in the 1970s in service industries aiming at the quality, efficiency, and productivity of their processes [3]. It complements the author that in this area the fundamental characteristics of intangibility, simultaneity and heterogeneity, make their understanding more complex.

The needs of knowledge provision through training are identified in the implementation systems of Lean Office proposed by various authors [2, 4–8]. This research

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focuses on the capabilities demanded by the Lean Office. For organizations to implement lean, it is necessary to train the employees. Lean Enterprise Model – LEM [9] is a model developed at MIT. The model presents 12 primary practices and 61 enabling practices (see Table 1).

Table 1. Primary practices and their unique practices of LEM trainers.

Primary practices	Enabling practices
Identify and optimize enterprise flow	(a) Establish models and/or simulations to permit understanding and evaluation of the flow process (b) Reduce the number of flow paths (c) Minimize the number of flow paths (d) Reduce setup times (e) Implement process owner inspection throughout the value chain (f) Strive for single piece flow (g) Minimize space utilized and distance travelled by personnel and material (h) Synchronize production and delivery throughout the value chain (i) Maintain equipment to minimize unplanned stoppages
Assure seamless information flow	(a) Make processes and flows visible to all stakeholders (b) Establish open and timely communications, among all stakeholders (c) Link database for key functions throughout the value chain (d) Minimize documentation while ensuring necessary data traceability and availability
Optimize capability and utilization of people	(a) Establish career and skill development programs for each employee (b) Ensure maintenance, certification and upgrading of critical skills (c) Analyze workforce capabilities and needs to provide for balance of breadth and depth of skills/knowledge (d) Broaden jobs to facilitate the development of a flexible workforce
Make decisions at lowest possible level	(a) Establish multidisciplinary teams organized around processes and products (b) Delegate or share responsibility for decisions throughout the value chain (c) Empower people to make decisions at the point of work (d) Minimize hand-offs and approvals within and between line and support activities (e) Provide environment and well-defined processes for expedited decision making

(*continued*)

Table 1. (*continued*)

Primary practices	Enabling practices
Implement integrated product and process development	(a) Use systems engineering approach in product design and development (b) Establish clear sets of requirements and allocate these to affected elements of the product and process (c) Definitive risk management (d) Incorporate design for manufacturing, test, maintenance and disposal in all engineering phases (e) Design in capability for potential growth & adaptability (f) Establish effective integrated product teams (g) Involve all stakeholders early in the requirements definition, design and development process (h) Use the "software factory" process (i) Implement design to cost process (j) Maintain continuity of planning throughout the product development process
Develop relationships based on mutual trust and commitment	(a) Build stable and cooperative relationships internally and externally (b) Establish labor management partnerships (c) Strive for continued employment or employability of the workforce (d) Provide for mutual sharing of benefits from implementation of lean practices (e) Establish common objectives among all stakeholders
Continuously focus on the customer	(a) Provide for continuous information flow and feedback with stakeholders (b) Optimize the contract process to be flexible to learning and changing requirements (c) Create and maintain relationships with customer in requirements generation, product design, development and solution-based problem solving
Promote lean leadership at all levels	(a) Flow-down lean principles, practices and metrics to all organizational levels (b) Instill individual ownership throughout the workforce in all products and services that are provided (c) Assure consistency of enterprise strategy with lean principles and practices (d) Involve union leadership in promoting and implementing lean practices

(*continued*)

Table 1. (*continued*)

Primary practices	Enabling practices
Maintain challenge of existing processes	(a) Establish structured processes for generating, evaluating and implementing improvements at all levels (b) Fix problems systematically using data and root cause analysis (c) Utilize cost accounting/management systems to establish the discrete cost of individual parts and activities (d) Set jointly stablished targets for continuous improvement at all levels and in all of the product live cycle
Nature a learning environment	(a) Capture, communicate and apply experience generated learning (b) Performance benchmarking (c) Provide for interchange of knowledge from and within the supplier network
Ensure process capability and maturation	(a) Define and control processes throughout the value (b) Establish cost beneficial variability reduction practices in all phases of product life cycle (c) Establish make/buy as a strategic decision
Establish make/buy as a strategic decision	(a) Level demand to enable continuous flow (b) Use multi-year contracting wherever possible (c) Minimize cycle-time to limit susceptibility to externally imposed changes (d) Establish incremental product performance objectives where possible (e) Program high risk developments off critical paths and/or provide alternatives

Lean Office is a methodology that focuses on business improvement through the elimination of the waste in business processes [10]. New approaches include the Lean Office, which aims to reduce the occurrence of waste in administrative processes [11]. Due to the lack of resources, a prioritization is needed, so the research question arises: what are the instructive practices that are essential to implement the lean office?

2 Objectives

This article aims to identify the most used Lean Enterprise Model Practices in the Lean Office.

3 Methods

Figure 1 summarizes the research methodology. The research method was a survey based on a literature review that identified 31 articles about Lean Office, followed by a systematic analysis that prioritized the 28 most cited training practices. Then they were transcribed for the survey. The population was selected through curriculum lattes analysis, which identified 147 researchers. From these researchers, the ones who have publications and/or works in events were chosen, resulting in 52 researchers. These researchers received the survey through e-mail, giving a response rate of 68% to the survey. Of the respondents, 91% had experience in implementing Lean Office, and the lowest value of Crombach's Alpha was 0.82 while the highest was 0.84.

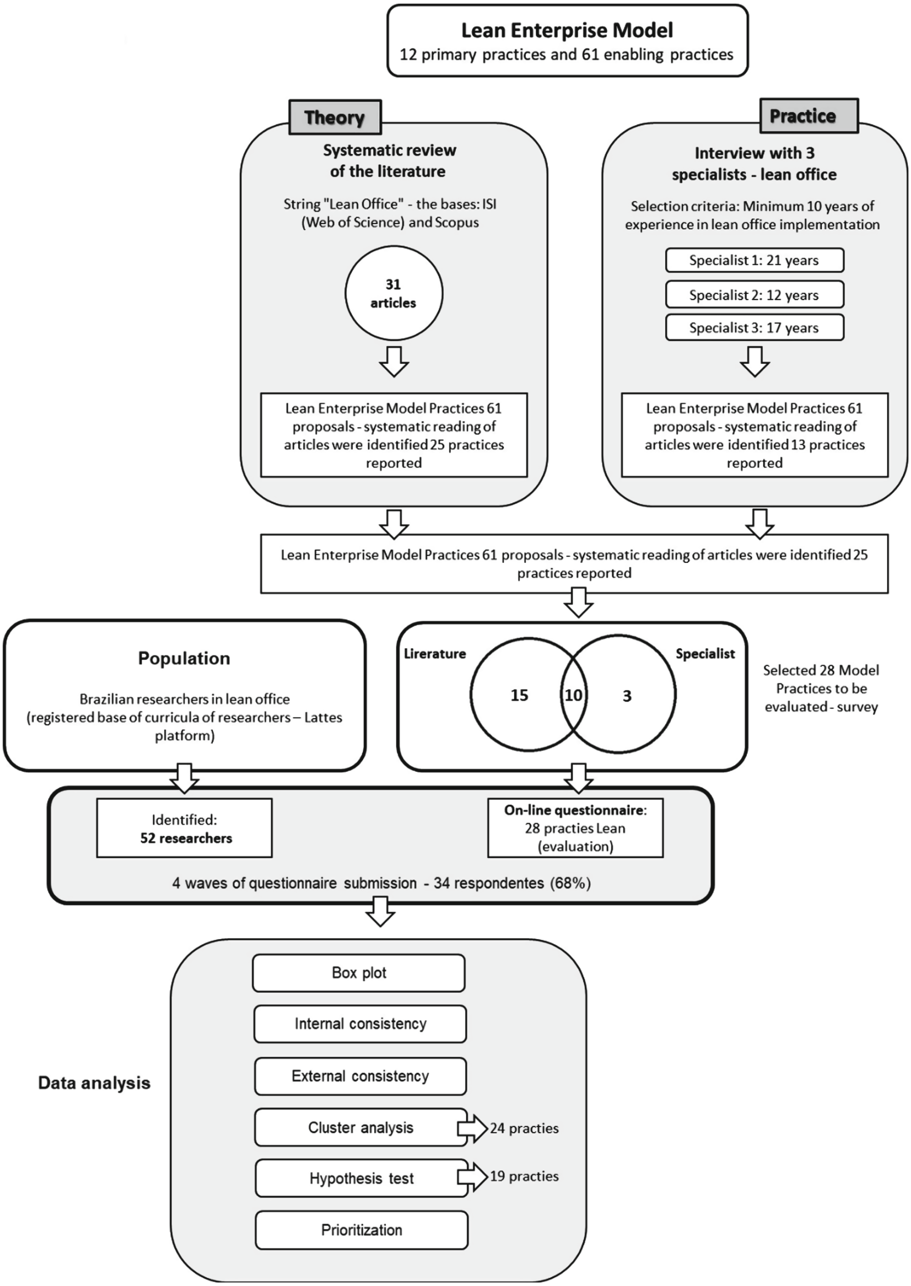

Fig. 1. Summarizes the research methodology.

Figure 2 presents the enabling practices (the priority ones are written in red and the others in blue).

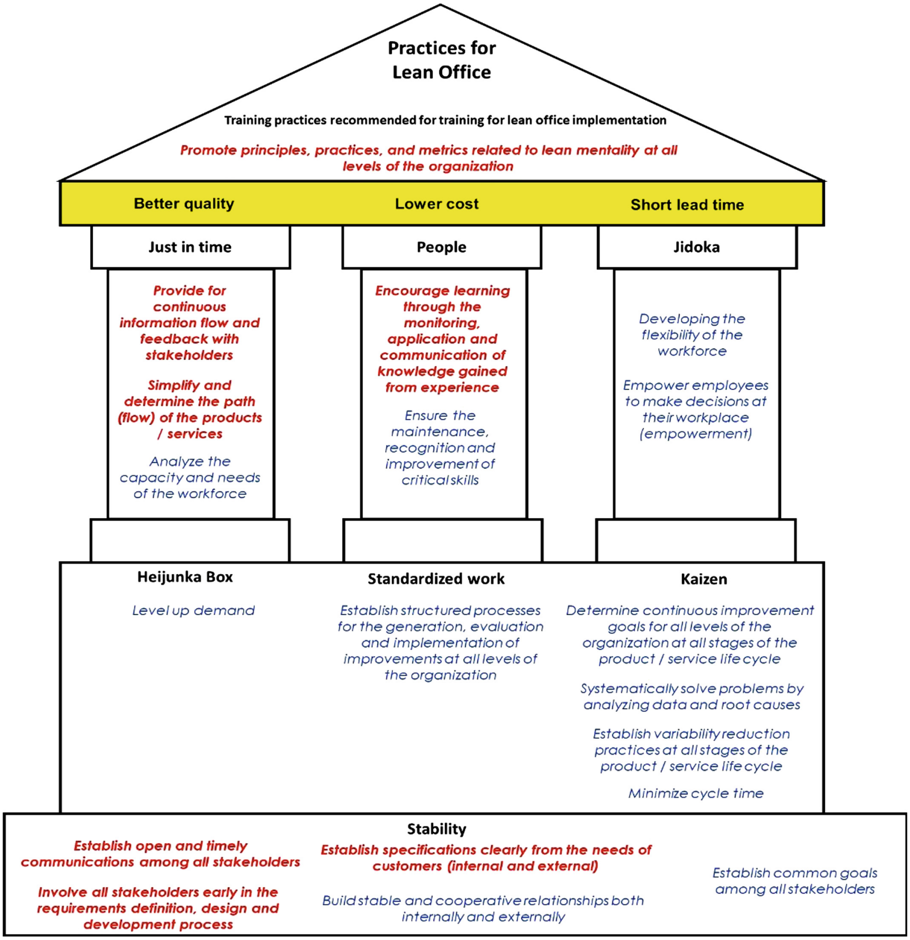

Fig. 2. Result practices lean office model.

4 Results

The clusters were calculated by the Ward method. The ones that presented similarity of more than 75% were analyzed and grouped, culminating in 19 capacitive practices and resulting in three principles: simplify and determine the way (flow) of the products; establish an effective communication channel between all of the stakeholders and; disseminate principles, practices and metrics related to lean mentality at all levels of the organization. With the results obtained, we proposed to implement the Lean Office using the training practices grouped in a summarized way based on the Lean Manufacturing model.

5 Conclusion

The present research has reached the objective of identifying which are the main training practices needed to be more reliable and achieve satisfactory results. Of the 61 initial training practices proposed by LEM, 28 were identified as the ones with the highest occurrence in the literature, and were subsequently evaluated and grouped into 24 practices. Then the ones with the highest averages within the same construct stood out, obtaining 19 capacitive practices as the most used in Lean Office, grouped to contribute to the implementation. The following are the seven prioritized training practices: flow-down lean principles, practices and metrics to all organizational levels; provide for continuous information flow and feedback with stakeholders; simplify and determine the path (flow) of the products/services; establish open and timely communications among all stakeholders; involve all stakeholders early in the requirements definition, design and development process; establish specifications clearly from the needs of customers (internal and external); encourage learning through the monitoring, application and communication of knowledge gained from experience.

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Digitalization: A Literature Review and Research Agenda

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Abstract. Given the noticeable and quick progress of digitalization it is well accepted that digital practices are changing business landscapes. However, while this concept is being labelled in the literature it is also often used indistinctively. To avoid misconceptions, we propose to clarify the concept by providing an overview of the existing theory. This research is one of the first attempts to define the "digitalization" term, and to make a distinction between similar ones. The authors have conducted a systematic review of the existing literature, by identifying and synthesizing the existing body of knowledge. While going digital, firms are expecting to enhance their competitive advantage by offering services throughout virtual channels and operationalize its operations management. Furthermore, the literature suggested the development of new digital technologies along with automation and artificial intelligence is enabling a new wave of smart companies, a topic that deserves to be studied in the future.

Keywords: Systematic literature review · Automation · Artificial intelligence · Operations management

1 Introduction

Digitalization has been identified as the most significant technological trend that is changing both, society and business [1, 2]. Nowadays, firms are constantly under pressure to use digital technologies and to adapt their business models to this new reality [3]. However, although going digital evokes many benefits, it also requires investments and associated costs [4]. Given the noticeable progress of digital technologies [5], the question is how digitalization is being employed by practitioners and into what extent this progress is being followed by scholars and academics. Therefore,

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our main goal is to illustrate the current state-of-the-art and to provide a better understanding of the digitalization term. Interestingly, there are several articles in the literature on digital transformation, but few on digitalization. One of the first literature reviews on digital transformation were notably conducted by Henriette et al. [6], and followed similar research, such as Gebayew et al. [7], Reis et al. [8], Vukšić et al. [9] and Vial [10]. It is well-known that digital transformation term was coined by business professionals and later studied by academics. On the other hand, we also know that the large knowledge gap is currently present at the governmental level, which accounts for only 1% of world research [8]. In response to the changing expectations, governments are currently changing their mode of operation to improve public service delivery, while public administrators themselves are defining digital transformation in their own day-to-day practices [11]. Thus, in that regard, academics such as Mergel et al. [11] are providing empirical-based definitions of digital transformation retrieved from expert interviews, rather than literature reviews. With regard to digitalization, we could find few literature reviews, one focus on the organizational effects of digitalization by Kuusisto [12] and another research by Parida et al. [13], which developed a framework that communicates and sets the direction for future research by linking digitalization, business model innovation, and sustainability in industrial settings.

This article is structured as follows. Section 2 presents the methodological process, discussing how the systematic review was structured. Section 3 describes the analysis and general discussion of the selected articles. Section 4 concludes the paper, by presenting contributions to theory and practice, as well as the guidelines for future research.

2 Methodology

In order to achieve the stated objective, a systematic literature review was employed in order to clarify the digitalization concept, to provide an overview of the existing theory and to suggest guidelines for future research. This method is of particular value due to the uncertainty about what the evidence says about this topic [14], being the right tool to study the phenomenon.

On March 5th, 2019, a search was conducted using Elsevier's Scopus citation database of peer-reviewed literature. The initial search criterion was based on the word "digitalization" in the article titles. To improve our review process and to justify why we chose a certain type of articles and not others, we applied several filters to exclude irrelevant papers and save time [15]. The initial search revealed 1,441 documents, which included journal articles in the English language to enable interpretation. The inclusion criteria focused on management and social sciences, given they are the most promising ones of theoretical research, due to the existence of extensive empirical evidence. The final systematic literature review included 121 articles. Table 1 presents an overview of the review process.

Table 1. Systematic review process.

Elsevier's Scopus database		Documents
Search term "Digitalization"	All fields	13,194
	Title-Abstract-Keywords	7,954
	Article title	1,441
Language	English	1,018
Source type	Journal	572
Document type	Article	442
Major subject area	Social sciences; Business, management and accounting; and Economics, econometrics and finances	121

We analysed the data through the *content analysis* technique, which is widely used to detail the proportion or percentage of a text dedicated to a determined subject, and that allowed to make evaluative comparisons of materials with established goals [16]. Content analysis can be briefly defined as the systematic, objective, quantitative analysis of message characteristics – it included both human-coded analysis and computer-aided text analysis [17]. Using a computer-assisted qualitative data analysis software NVivo 11 – QSR International [18], we examined the data by generating codes and clustering the text into hierarchized categories and subcategories to identify patters and establish new relations within the literature. After coding the 121 articles in order to coin a consistent definition of "digitalization" we are now presenting the results of the systematic review in the next section.

3 Findings

We have noticed that Nordic European countries are investing on the integration of information and communication technologies (ICT) and digitalization processes [1] in new or existing business models (Fig. 1). While, at the same time, these countries are studying its implications to the business landscape [19], several cases are illustrating the current Nordic investment on digitalization, e.g., manufacturing companies are pursuing servitization strategies, which are increasingly relying on developing digitalization capabilities to interact and co-create value to their customers [20].

Drawing on the results of this research, we found that the development of digital technologies exists along with advancements in artificial intelligence (AI) and automation, which are enabling a new wave of service delivery systems [21–23] and manufacturing innovations [24]. On the other hand, digitalization and servitization of manufacturing processes are moving companies to find competitive advantages through innovative digital business models [25]. Moreover, the literature best identifies supplementary technologies that are identified as facilitator and do have a broader effect on digitalization, examples are: the use of mobile devices that are changing consumer practices and organizational behaviours [19, 26].

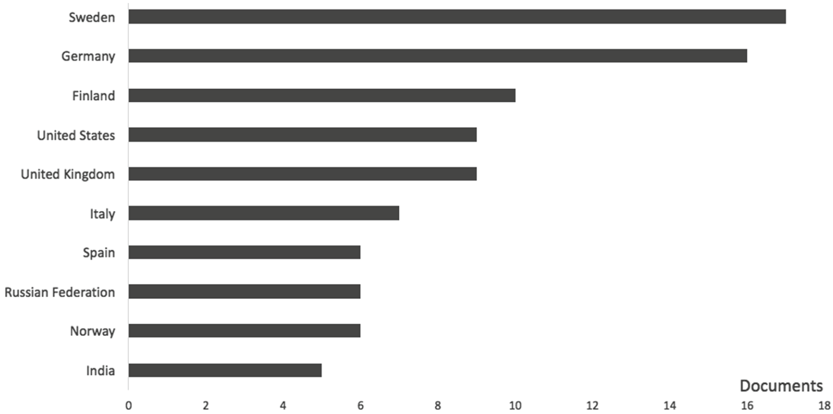

Fig. 1. Documents by country or territory (Top 10).

Interestingly, few articles distinguish between digitalization, digitization, and digitation, which are being sometimes used indistinctly in the literature [8, 27] or, at least, there seems to be quite some confusion regarding the usage of terms [28]. Common themes associated to the aforementioned concepts are digital innovation, digital disruption, digital convergence and digital transformation, which are the abilities of different companies to compete when digitalization alters the dynamics of core technologies and core markets shifts [29]. Srai and Lorentz [30] also argues that much of the literature on digitalization appears to be ambiguous in terms of the exact definition of the term, probably due to the elusiveness of the concept. Only a couple of articles, which are interested in making such distinction, were identified. Notable examples are presented by Clerck [28], where digitalization is presented as "the use of digital technologies and of data in order to create revenue, improve business, replace/transform business processes and create an environment for digital business, whereby digital information is at the core", and Gobble [22] which identifies the term as "digital technologies and probably digitized information, to create the harvest value in new ways". Srai and Lorentz [30] evidences that past contributions mixed e.g. digitalization and digitization, where digitization is the material process of converting analogue streams of information in digital bits [31], thus, digitalization refers to the technology of digitalising information. Ringenson et al. [32] support those definitions and find them useful for highlighting the difference between the technological conditions necessary for digitally related social change (digitization) and the actual change (digitalization). The limited research regarding the usage of terms, evidenced that this is an area to be explored and suggests future research on the topic.

We analysed each definition and then presented the scholar debate around the term, which is summarized in Table 2.

Table 2. Digitalization definitions.

Author(s)	Definition(s)
Maxwell and McCain [33]	Digital technology takes information and breaks it down into its smallest components. By transforming an analogue signal into discrete pieces, digitalization makes it possible to manipulate information, text, graphics, software code, audio, and video in ways never before thought of, thus its informating, transforming capabilities
Hagberg et al. [26]	Digitalization is one of the most significant on-going transformation of contemporary society and encompasses many elements of business and everyday life. Digitalization refers both to a transformation from "analogue" to "digital" (e.g. a shift from cash to electronic payments) and to the facilitation of new forms of value creation (e.g. Accessibility, availability, and transparency) (citing Amit and Zott [34])
Clerck [28]	Digitalization is defined as the use of digital technologies and of data in order to create revenue, improve business, replace/transform business processes and create an environment for digital business, whereby digital information is at the core
Lenka et al. [20]	The industrial management literature defines the digitalization as the phenomenon of intelligent connected machines that information and digital technologies power (citing Lerch and Gotsch [35] and Parida et al. [36])
Machekhina [37]	Digitalization means transformation of all information types (text, sound, visuals, video and other data from various sources) into the digital language
Parviainen et al. [2]	The action or process of digitizing; the conversion of analogue data (esp. in later use images, video, and text) into digital form
Thorseng and Griot [38]	The transformation of existing socio-technical structures that were previously mediated by non-digital artefacts or relationships into ones that are mediated by digitized artefacts and relationships with newly embedded digital capabilities (citing Yoo et al. [39])
Valenduc and Vendramin [40]	The term "digitalisation" is not the irruption of a new revolution, but the pervasive synergy of digital innovations in the whole economy and society (citing Perez [41])
Crittenden et al. [23]	Digitalization creates new forms of interaction between companies and customers through channels (citing Hansen et al. [42])
Devereux and Vella [43]	Digitalization is the process of spreading of a general purpose technology. The last similar phenomenon was electrification. Digitalization of products and services shortens distances between people and things. It increases mobility. It makes network effects decisive. It allows the use of specific data to such an extent that it permits the satisfaction of individual customer needs – be it consumers or businesses. It opens up ample opportunities for innovation, investment, and the creation of new businesses and jobs. Going forward it will be one of the main drivers of sustainable growth (citing Gaspar et al. [44])

(*continued*)

Table 2. (*continued*)

Author(s)	Definition(s)
Eling and Lehmann [27]	The integration of the analogue and digital worlds with new technologies that enhance customer interactions, data availability and business process
Gobble [22]	Digitalization refers to the use of digital technology, and probably digitized information, to create and harvest value in new ways
Morley et al. [45]	Digitalization is the growing application of ICT across the economy "encompassing a range of digital technologies, concepts and trends such as artificial intelligence, the "Internet of Things" (IoT) and the Fourth Industrial Revolution" (citing IEA [46])
Ringenson et al. [32]	Digitalization is about social life's restructuring around digital communication and media infrastructures (citing [31])
Gebre-Mariam and Bygstad [47]	Digitalization refers to the development and implementation of ICT systems and concomitant organizational change, it involves the transformation of socio-technical structures formerly mediated by non-digital artefacts into ones mediated by digitized artefacts (citing Yoo et al. [48])
Srai and Lorentz [30]	Digitalization is defined as the way many domains of social life are restructured around digital communication and media infrastructures. In simple terms, digitalization may be defined as the use of digital technologies

Summarizing the Table 2; the first focused definition was presented by Maxwell and MacCain [33], who considered digitalization as the transformation of analogue signals into digital pieces. The aforementioned description was therefore supported by Hagberg et al. [26], Parviainen et al. [2] and Eling and Lehmann [27]. Whereas Machekhina [37] described digitalization in a broader way, characterizing it as all information types to the digital language. Should be noted that digitalization is the most significant on-going transformation of contemporary society and encompasses several domains of daily life, such as: the social [30, 32], the economic [40], and the organizational domain [27, 47], in order to create and harvest value [22]. In their article, Eling and Lehmann [27] also presented a very similar debate about the concept of digitalization, with the difference that, in the end, they present a middle ground conceptualization, between the broad and the narrow. Likewise, in our view: *digitalization is the phenomenon of transforming analogue data into digital language (i.e. digitization), which, in turn, can improve business relationships between customer and companies, bringing added value to the whole economy and society*.

The above definition is somewhat broader and brings back all the domains that were previously identified in the literature – social, economic and organizational. Therefore, it is not surprising to verify that the major subject areas[1] (Table 1) are tied together with the minor subject areas (Fig. 2): (1) business, management and accounting (30%); (2) social sciences (26%); (3) engineering (10%), and (4) economics, econometrics and finances (8%). During the last two decades, new technological developments such as, the Internet, and smartphones, have profoundly impacted every part of economic, political and social life [49]. The integration of digital devices reorganized the activities of business organization; thus by adopting business process digitalization, companies have started to gain market and operational efficiency [50].

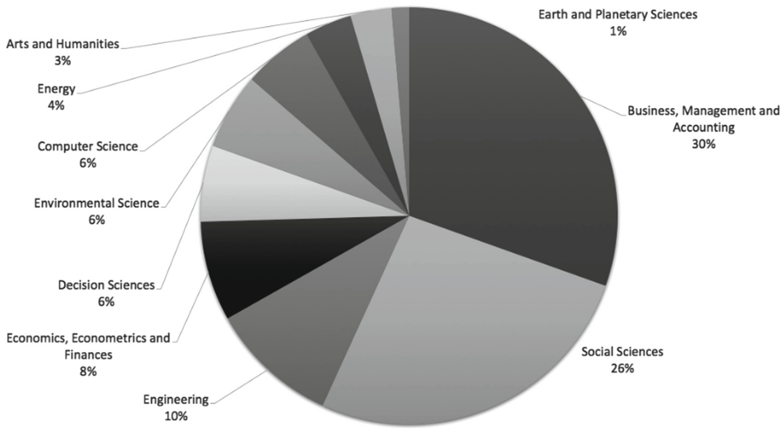

Fig. 2. Documents by subject area.

According to Fig. 2, we could observe that the engineering area has had a great preponderance on the digitalization landscape (10%), as it is influencing, for example: (1) the improvement of manufacturing processes – industrial engineers [30, 40]; (2) the building of applications – systems engineers [52]; (3) the developments of intelligent machines and artificial intelligence technologies – electrical, mechanical and robotics engineers [27].

We have also explored the journal distribution, which refers to the largest number of publications in the digitalization scope (Fig. 3). We also cross-checked the journal distribution with Scimago[2] Journal Ranking (SJR indicator), which measures the journal's impact, influence and prestige that is measured from Q1 (best indexed journals) until Q4 (lowest indexed journals).

[1] Scopus classified the documents under four broad subject clusters (life sciences, physical sciences, health sciences and social sciences & humanities), which are further divided into 27 major subject areas and 300 + minor subject areas [51].

[2] https://www.scimagojr.com.

Fig. 3. Documents distribution by journal (Top 10).

The journals with highest percentage of publication were: The German journal of ZWF Zeitschrift für Wirtschaftlichen Fabrikbetrieb, which is mainly addressed to companies' executives and specialists' in production and service engineering domains; the Swiss journal of Sustainability and the Romanian Journal Quality – Access to Success, which are cross-disciplinary, scholarly and open access journals. Although the ones with better quotation were the British Journals Transfer, Research Technology Management, and the Journal of Retailing and Consumer Services. As mentioned above, the highest scientific journal emphasized practice-based research, which is a clear indication that research is largely driven by practitioners; followed by academics, particularly with respect to publications in major journals i.e. between quartiles 1 and 2.

The bars in Fig. 4 illustrate the dispersion of each research approach. Although the Fig. 4 does not present all the research methodologies and methods, we have considered the generic ones with more incidences, giving just a few examples: mixed methodologies included multimethod research or mixed method research; and empirical research included case studies or focus group.

Figure 4 shows that there is a higher incidence of empirical studies when compared to the conceptual ones, which shows that there is still room to study the phenomenon from a conceptual point of view, so future research should focus more on defining the theoretical foundations of the field. We could also verify that most part of the empirical research were qualitative case studies, which according to Yin [53] have no generalization perspectives, only theoretical, and therefore it would be useful to invest on quantitative research methods to allow generalization. There is also a great lack of mixed studies and therefore it would be more valuable to draw more attention in that regard. Mixed studies allow researchers or a team of researchers to combine elements of qualitative and quantitative research approaches for a broader purpose of breadth and depth of understanding and corroboration [54]. Moreover, there is a level of agreement that mixed studies are superior in comparison with single methods [55, 56], as are less prone to errors or biased conclusions [57].

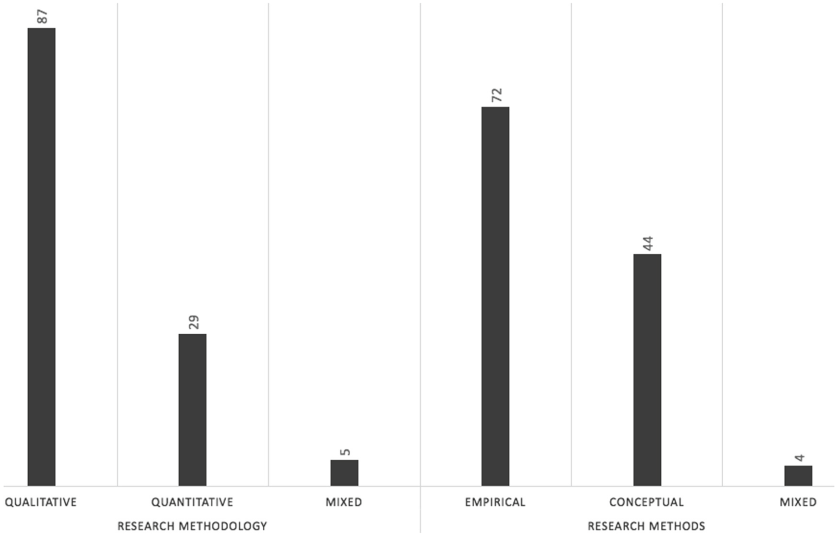

Fig. 4. Major research approaches.

Although the quality of publications increased, i.e. in the first two months of 2019, approximately 70% of publications were Q1, the number of publications also increased progressively over the years (Fig. 5). The document distribution increased mainly due the transition of digital technologies from computer science to the service and manufacturing industry, thus the digital transformation is re-shaping the industrial processes: e.g. industry 4.0, industrial artificial intelligence or internet of things.

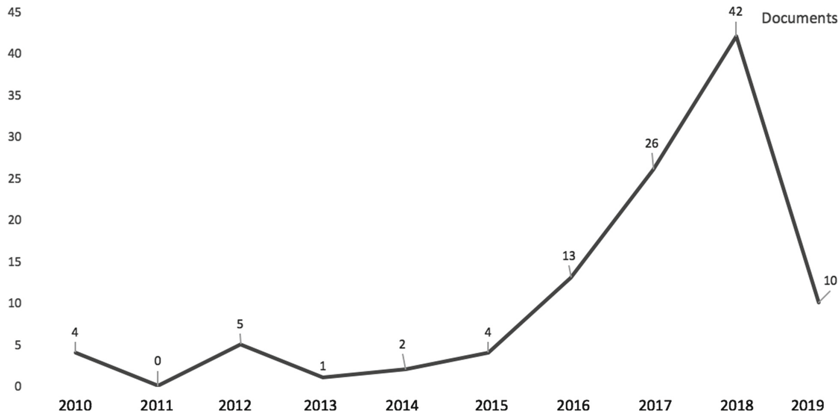

Fig. 5. Documents distribution by year (10 years' period).

The digital era is not only driving innovation into the industry sector, as it seems to being influencing developments in the public sector as well [58]. Moreover, Reis et al. [8] argue the government digitalization is one of the promising themes, with more prospects for future development. A perspective that has already been verified in the first two months of 2019, with a slight increase of studies related to public education [23, 59] and public health services [47, 51] when compared with the same period in 2018. In the next section we present the conclusions, where is included the contributions to theory and practice, as well as the guidelines for future research.

4 Conclusions

This study draws on evidences that are paving the way on how new technologies are assisting customers and companies to create value. This article provides cutting-edge results: on the one hand, the developments achieved in the service industry are being made in combination with synergies between digital services and other new technologies, such as AI or IoT; on the manufacturing domain, companies are also pursuing new venues in finding competitive advantages by applying innovative digital practices on their industrial process (e.g. servitization strategies).

Moreover, this study contributes to the digitalization literature, by providing a clear understanding of its foundations in regard to the advancements achieved in the last few years. To strengthen the aforementioned argument, several authors [26, 60] have concluded that additional debate on the digitalization agenda is needed, to further develop a deeper understanding on how digital initiatives are changing existing business models.

This article has some limitations: firstly, the way we choose the search term influences which publications were included in the review, while choosing the term "digitalization" many contributions using synonyms were excluded from this work [61], on the other hand, we must accept that in conducting systematic reviews there is a hierarchy of evidence and that what can be empirically stated about the world is derived from studies in which design is explicit and rigorous [62]; secondly, we only include articles in English, excluding all works in other languages, although we recognize that excluded articles may have different results, we decided to give priority an accurate interpretation of the articles, thus avoiding any kind of misunderstanding; finally, we also know that most systematic reviews use more than one database to be more comprehensive in choosing articles, but for this article we decided to prioritize transparency and easy reproducibility of results.

Future research should aim at a broader understanding of the digitalization phenomenon, therefore our research can be enriched by the analysis of related topics, such as digital disruption, digital convergence or digital divide. Such attempts may focus on presenting a clear definition of the conceptual field, as well as a brief bibliometric analysis of each term. Researchers should also draw on the theoretical foundations of the field of digitalization, identifying existing theories or developing new ones in order to theoretically support novel empirical research. The literature review has also presented other perspectives that have received little attention to date, and which are well highlighted by Martín-Peña et al. [25], such as the challenges and success factors in the transformation from traditional to digital business models [63] and the analysis of strategic implications [64], just to mention some.

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A Theoretical Analysis of the Barriers of Implementing Green Supply Chain Management

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Abstract. Sustainability became a topic of great importance of this and the future decades. Due to this fact, organizations became aware of environmental issues and the relevance in adopting them as a competitive advantage. This study aims to analyse the main barriers that organizations face to implement methods and make the maintenance of the Green Supply Chain Management (GSCM). The study shows that to have an effective GSCM implementation, it is of great relevance know and overcome such barriers.

Keywords: Green supply chain management · Barriers · Implementing

1 Introduction

In fact, environmental issues have become determinant concerning to the competitive advantage and cost-cutting. According to [1] in the last decade there has been a great intensification of the competition and globalization in a way that the Supply Chain Management has gained prominence among organizations making companies, gradually, set up a bigger dependence on the Supply Chain Management to deal with the expectations of the consumers and with the technological progress.

Therefore, with the environmental awareness development and with the protection and better resource management the organizations must take the sustainability subject as a priority. This way the organizations must implement green practices embracing its whole Supply Chain. According to [2], all the Supply Chain members are connected through the material flow, information and capital. So, all the members of this Chain are responsible for the install and keep the sustainable practices and not only the focal companies.

According to [3], the Green Supply Chain Management (GSCM) may be defined as an inter-disciplinary area that has, in recent years, developed and become relevant not only in the industry but also in the academic field. [4] says that it is about a traditional Supply Chain integrated to environmental principal or concerns into organizational purchasing decision and long-term relationships with suppliers. Thereby a strategy change of the Supply Chain was quite important for the rising of the GSCM, so it could develop as a rising field and apart from the traditional Supply Chain, related to an environmental integration of the Supply Chain traditional concepts [5].

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The GSCM tries to limit de waste concerning the industrial processes in a way to preserve energy and other resources. It also tries to prevent leakage of hazardous waste into the environment [6]. This concept has been, more and more, incorporated to the industry becoming a way to the organizations to work according to the demand of the environmental rules to improve the performance of the productive processes and their products [7] and to reduce the environmental impacts due to industrial activities. There are several reasons that may make an organization adopt the GSCM, because besides reducing the environmental impact, it may also have a positive financial return to the organization that adopts these practices [8].

Although having economic and social benefits gotten through the GSCM implementation, most of the organizations show themselves reluctant in adopting these practices due the fact that during the implementation they see themselves before several challenges and problems to get, effectively, the results wanted [5]. Some obstacles may be observed and prevented through the early stage of the GSCM implementation. The companies must be prepared to eradicate these obstacles, acknowledging that it isn't possible to remove them in a simultaneous way [9]. Having this in mind it is of great relevance to identify the obstacles during the implementation in a way to solve these problems [10] and to make the sustainable practices maintenance through all the Supply Chain. The effective industrial implementation plays an important role in competitive advantage, gaining it or keeping it. So, this study keeps the target on obstacle analysis that occurs more frequently during the implementation of GSCM practices.

2 Methods

The methodology used in the beginning of this study consists on making a theoretical research through a literature review that approaches the Green Supply Chain Management subject focusing in case studies. This literature review has the purpose to allow the researcher to have a better knowledgement about the obstacle found by organizations of multiple industrial shares, in several countries, each one with its own challenge and practices adopted to solve problems.

This study was taken from 02.01.2015 to 02.05, selecting articles through Engineering Village data bases, using the "Green supply chain management" arranged with the words "maintenance", "implement", "barriers" and "challenges", observing a total of 722 articles, and using 61 of them. These articles were selected due to the fact that they were the best to match the research aims, in other words, the ones chosen are adequate and convenient to the obstacles and challenges found by the organizations to the GSCM implement.

As of the selection of the articles, a literature analysis was made with emphasis on case studies. So, after reading and analysing a list was produced, with the purpose of making easy the case studies shown, getting the main obstacles or challenges found by organizations through the implementation period and GSCM practice maintenance.

Once this article analysis is done and, therefore, using the obtained article data, it was possible to number the frequency and later, to make a graphical analysis, showing which are the most common obstacles found by the organizations through several stages of the sustainable practice implementation through the whole Supply Chain.

3 Results

Aiming to have a global interpretation, the data was evaluated in a numerical form, developing a graph with the barriers obtained by the analysis, comparing the prime barriers and the frequency they show up, as presented in the Fig. 1.

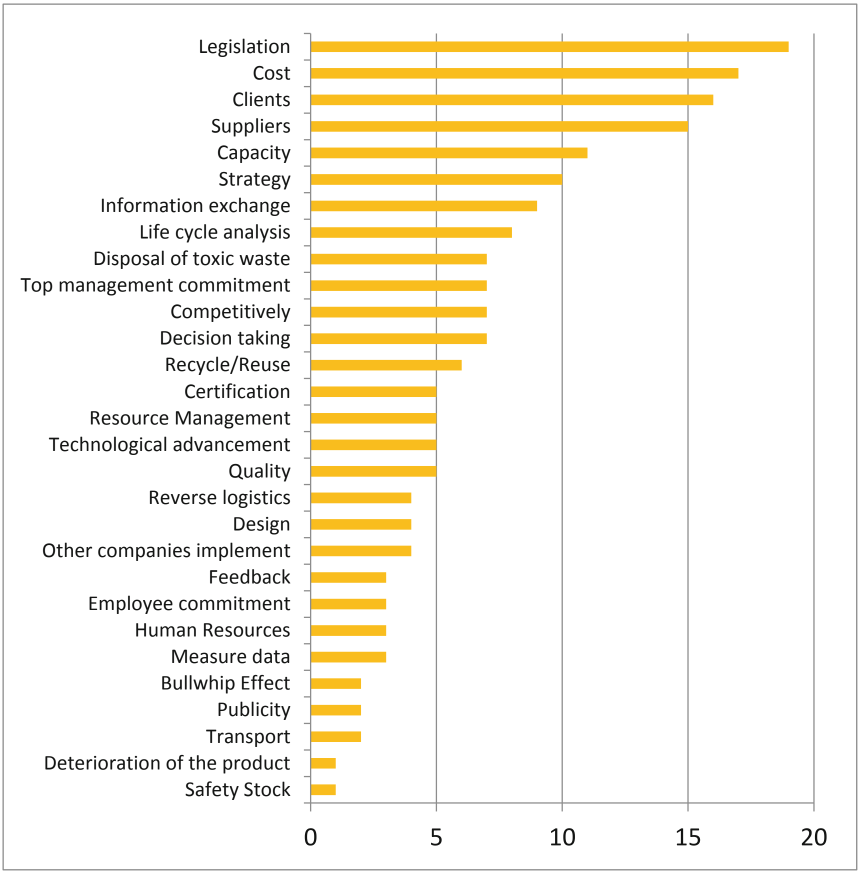

Fig. 1. Graphical presentation with the main barriers.

Through the analysis, it might be observed that the most frequent barriers are: legislation, costs, problems related to suppliers, problems related to clients, productive capacity and the strategy adopted by the organization.

By means of reading the select articles, the barrier "legislation" was the most frequent occurrence. Due to the fact that government has the power to establish the environmental laws to the whole industry, legislation might stimulate or not stimulate the adoption of environmental innovation [11]. The organizations are not acceding the environmental policies by the fact of needing a great demand of green products, by costs, taxes and principally, by government that doesn't support those organizations which invest in this area.

Another crucial barrier to organizations to adopt green practices is the cost. This is one of the most discussed topics by companies around the world and it is utilized as a way to measure the organization performance, so, this is a factor of great pressure and influences the GSCM if compared with the traditional SCM [12].

According to [13] companies which are seeking to implement sustainable practices must conciliate the cost reduction and simultaneously, reduce the environmental impacts, increase the profits, the supply chain efficiency as well as the market share. Although, great part of those organizations believe that they are not winning in competitiveness by adopting good environmental practices, because the cost of greening the product and the process can't be passed to the client and the initial investment to adequate the process and the design is very high.

The problems related to the clients rise as a relevant barrier due to the fact that, costumers are the base and the essence of any market, so organizations seek to attend their needs and satisfy them in any way. Although the environmental awareness is presenting a significant growth each day, the main obstacle to the companies, related to clients, is the fact that they don't have, indeed, a great demand for green products. As it was showed before, the cost of greening the product is very high and that consequently makes those products more expensive than the common products. If there isn't a significant demand which chooses green products instead of others, the company which made a great investment to change its process to adequate the green policies, must have a great loss.

Each company, in a supply chain, must be responsible for the social and the environmental performance of their suppliers [2]. Therefore, the problems related to suppliers are truly relevant so green practices might develop in a supply chain, due to the environmental planning and for sharing the information with each other, obtaining a positive performance [14], this fact might make easy the coordination of activities and change the process in a way that satisfies the costumers. About the "productive capacity" barrier, we might mention the problems related to the lack of financial investments to equipment and others, which limit the production of the companies. Also, a few levels of scale economy related to the production of green products contribute to the increasing of the cost, restricting de production, reducing the flexibility of the process and as a consequence, reducing profits and the satisfaction of the clients.

The environmental awareness of the clients, as claimed previously, are gradually increasing, which makes the organizations that choose implementing GSCM practices to have a better social image in the market. The strategic planning provides a framework which helps in the organization with decision taking and helps in the evaluation of the performance, evidencing significant errors or risks to the implementation that might arise [15].

4 Conclusion

Due to the complexity of the Green Supply Chain Management, to implement this concept becomes, to the companies, an arduous task. Several barriers present during the implementation and also, to the maintenance of it, make companies discredit the GSCM and conceal the competitive advantage of adopting those practices. Although, the companies are being pressed, both by government and society, to implement sustainable practices through all the productive process. Thus, it is noted the relevance of studies related to the removal or minimization the negative effects caused by the barriers inherent to the implementation of GSCM.

As presenting those barriers, it's possible to observe that the plausible solutions ate linked. The most suggested practices may initially show the, purpose of changes in the legislation due to the fact that the laws are considered weak and companies that really engage to implant sustainable practices are beyond the request, so it can make the cost increases in a significant way and even losing competitivity. Another important proposal is that the government offer benefits to those companies which decide to implement GSCM practices, in other words, improvements. So, those companies might have a differential advantage, like tax exemptions, which consequently reduce the product price and encourage other companies to adopt those practices.

It is of huge vital importance to spread the green concept among the population, through governmental acts or through the companies themselves. The consumers are not aware sometimes of what a green product brings or what its certifications mean, and consequently they choose a cheaper product. To persuade the consumer that choosing a green product is to choose a better product that follows environmental laws will improve the competitiveness of the company.

Despite the benefits, many suppliers are not willing to change the process due to the environmental requirements. So, the main responsibility belongs to the focal companies, to develop the supplier about the environmental specifications necessary to the product. So, exchanging information, the supplier may reduce or eliminate de environmental impacts inherent to the productive process. The productive capacity is directly related to the technological development and companies' investments, so it's necessary to increase scale production, which is the main factor that limits the production. Consequently, organizations must overcome the challenges, with special attention to each one and finally become so competitive as the other companies which are already in the market.

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"Industry 4.0" Digital Strategy, and the Challenges for Adoption the Technologies Led by Cyber-Physical Systems

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Abstract. The Brazilian's manufacturing sector suffered a downturn due its recent economic crisis, reaching a negative growth rate of 8.48% in 2015. A proposed solution for improving performance in the manufacturing sector, and consequently developing several economies, such as Brazil, is the adoption of the digital strategy known as Industry 4.0. Since 2011, when this strategy was presented during Hannover Messe, in Germany, it is being considered as fourth industrial revolution, as a result of the developing new digital technologies and principles of implementation. However, to deployment of Industry 4.0, the manufacturing will face a number of challenges, such as related to technical, strategical and organizational contexts. The most frequent challenges are sorted by technical issues and demand for systems in CPS (Cyber-Physical Systems) technology. To benefit the manufacturing sector, the challenge of adoption CPS technologies, on real cases should be analyzed. The aim of this article is to present an international literature review about the challenges of Industry 4.0 on manufacturing sector. The literature does not present yet a broad study for identifying the challenges in this sector. As result, was discovered that there is a gap in the literature in the identification of systems solutions, simulated and or applied in the real context, which meet the requirements of CPSs, due to the low level of maturity of this technology. Developing algorithms of CPS and the related technologies of Industry 4.0, beside meet the new production demand is the fundamental challenge in the search for a digital and efficient industry.

Keywords: Manufacturing strategy · Digital technology · Industry 4.0 · Challenges

1 Introduction

The fourth industrial revolution which has had attention through pioneer Germany strategy called Industry 4.0, new digital technologies associated with principles of employment are proposed to achieve manufacturing benefits such as customization, manufacturing flexibility as well improvement of financial performance and development. According to this revolution, is necessary to fit a strategy that help better results for manufacturing sector and, consequently, for general economy at countries in development, such as Brazil, and especially to this country which has crossing a deep

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economic crisis. Despite of reached better results after the negative growth of 8.48% in 2015, the manufacturing sector still in recovering with a low average of growth of 1.5% in the last two year after crisis according to Geographical and Statistics Brazilian Institute [1], what reinforce the need of solutions from the Industry 4.0 and its concepts for manufacturing sector. However, it is important to highlight that the adoption of the strategy is not so simple and triggers a series of challenges according Schwab [2]. For adopting new technologies and apply principles, achieving great benefits, first is important understand what are these main challenges.

Industry 4.0 and its challenges are between the main topics discussed in this decade. Since 2011, articles by researchers in worldwide have been published in order to understand the phenomenon, find solutions and propose examples of adoption, such as [3], which has analyzed the design of the CPSs systems in the manufacturing sector and published a systematic review describing all steps of adoption this technology. Most of the studies on I4.0 challenges address literature reviews, theoretical studies, and modelling and simulation, but not any has focus on describing all the challenges found of the literature. Xu and Mohamed [4, 5] review the challenges, but there is not a deep discussion and understanding about the trends of the subject. The author [6], addresses broadly the challenges, but only focused in an emerging country and its issues. The aim of this article is to present an updated review of the international literature about the challenges of Industry 4.0 in manufacturing sector, showing the general challenges, the research trends and the identification of possible literature gaps as well suggestion for the development of future studies concerned about this subject. Using a specific perspective, presented in the method, with the most frequent records of international articles, in an attempt to find a research trend, was identified and presented set of specific challenges. Section 2 discusses manufacturing strategy, being the basic concept for I4.0 and the main concept technologies. The methodology is presented in Sect. 3, followed by the results in Sect. 4. The discussions are in Sect. 5 and the final considerations in Sect. 6.

2 Theoretical Background

The conceptual approaches of process technology in manufacturing sector have their origin in the production strategy being a fundamental element in the literature, but its maturity in relation to the main technologies, has been concentrated in this decade on industry 4.0, in the approach of its technologies and its principles.

2.1 Manufacturing Strategy

The technologies used as manufacturing strategy to benefit the operations in the last decade were those related to industrial automation, during the third industrial revolution. These technologies were deep discussed on concepts of manufacturing strategy and operation management. Skinner [7] brought the competitive vision to the exploitation of production resources, identifying the need for an alignment of the manufacturing strategy with the competitive strategy. His work was the first to classify process technology on structural decisions as plant and equipment. Subsequently, these concepts were much expanded.

According to Hayes et al. [8], process technology on structural decisions is responsible for the strategy that determines the level of technologies and how much industrial automation should be adopted for the operations. Industrial automation encompasses a number of technologies that have been developed from information and communication technologies (ICT). The authors also present the importance of ICT in the adoption of known technologies through the concept of advanced manufacturing technology (AMTs). The following Table 1 gives a summary of the main concepts of decisions categories in manufacturing strategy according to [8].

Table 1. Decisions categories in manufacturing strategy.

Structured decisions
- Capacity – amount, type, time
- Supply chain and vertical integration – direction, extension, balance
- Facilities – size, localization, specialization
- Information and process technology – automation and level, interconnectivity, led or follow
Infrastructure systems and policies
- Allocation of resources and capital budget systems
- Human resource system – selection, skills, compensation, employee safety
- Activity plan and control system – aggregate plan, planning, control or stock and or reserves
- Quality systems – prevention, monitoring, intervention and elimination
- Measurement and reward system – measure, bonus, promotions policy
- Process development product and process – leader or follower, project team organization
- Organization – centralized or decentralized, which decisions should be delegated, the role of support groups

One strategy focused on technology, with support of structural decisions in information and technology, aims to renovate the industrial processes, through decisions which seek the competitive advantages of the company, renovating the obsolete technologies in use and thus promoting the competitive priorities, such as, production of goods and services with lower costs, higher quality, greater accuracy and reliability in delivery, and greater flexibility in products. Moreover, this general view is current in the context of Industry 4.0 and decisions about adopt its digital technologies, really must be taken in order to achieve better results in a new and dynamic market.

2.2 Industry 4.0

The term Industry 4.0 (I4.0) represents for Germany its strategy of adopting digital technologies, and at the same time for Germany and to the world, the fourth industrial revolution. According to Kang et al. [9], the term was initially launched in 2011 at Hannover Messe, the German and international fair for process technologies and technological equipment. The I4.0 is a broad strategy, being not only a strategy of manufacturing sector, but also can be employed in a diversified field as smart cities, autonomous vehicle, smart grids, and so on.

For manufacturing sector one aspects of I4.0 must be clearer: on the adoption of I4.0 strategy, new process technologies must be employed along with one important aspect, the principles of adoption the concept as a whole. Only with the attention to the principles, will be possible for a factory to become, for example a smart factory, which also is one of the principles. For Ghobakhloo [10], industry 4.0 might be in near future, yet, most design principles and technologies that enable I4.0 have already been used in practice, and they have been an active area of research for almost a decade. Table 2 shows some of technologies found on literature.

Table 2. Technologies of Industry 4.0 approached on literature.

Technologies	Authors	Research methodology	Contributions
Internet of things	Xu et al. (2018)	Literature review	Article about general aspects of I4.0
Cyber physical systems	Ribeiro & Bjorkman (2018)	Literature review/conceptual model	Study about the transitioning from the actual industrial automation to cyber physical systems
Artificial intelligence	Wan et al. (2018b)	Literature review/conceptual model	Study about the awareness and the intelligence in new way of transporting materials in manufacturing operations
Cyber security	Yue et al. (2015)	Literature review/conceptual model	Article which addressed a new architecture based on CPS
Cloud computing	Zhong et al. (2017)	Literature review/conceptual model	Article which presents main concepts and applications of technologies including cloud computing
Big data	Chen et al. (2017)	Conceptual model/simulation	Article which presents main applications of big data in a smart manufacturing
Additive manufacturing	Chen e Lin (2017)	Literature review	Study which presents a broad aspect about the additive manufacturing
Virtualization	Tao & Zhang (2017)	Literature review/conceptual model	Article that shows concepts about digital twin, which means a virtualization of manufacturing process
Virtual reality	Gorecky et al. (2017)	Literature review/conceptual model	Article which presents ways of use the virtual reality as a tool of operational training
Augmented reality	Roy et al. (2016)	Math model/simulation	Study about the use of tools as augmented reality for a smart maintenance concept

Industry 4.0 initiatives can influence whole business system via transforming the means the products are designed, produced, delivered and discarded [6]. However, complete integration of the processes in a vertical way until the corporate management, and in a horizontal way from the supply chain until the participation of the final consumers on the process of entire life cycle of products is other important principle of I4.0. Moreover, for its implementation, technologies with wireless networks, high-speed networks, cloud computing, systems virtualization, among others technologies are the key for the success to the adoption of I4.0.

The international literature presents the principles in publications in [5, 10–12], and Table 2 presents some examples of technologies of the strategy I4.0 approached in the literature and its authors.

The literature about industry 4.0 has increasingly with the need of understand the concepts and also with the creation of other strategies by the countries as China, USA, South Korea and Brazil. Brazil created your own strategy in 2017 called "Internet of Thing: a strategy plan to Brazil", what has prioritizing areas as mobility and manufacturing, but is not enough to guarantee that the technologies will be adopted and create benefits to the manufacturing sector and development to the entire economy.

3 Research Methodology

A structured literature review was conducted according the proposal [13, 14] to identify the scientific publications that present the challenges of I4.0 in the international literature. The relevant terms in this search were defined and the research was conducted using the keywords "industry 4.0" and "challenges" through "Scopus" database. The parameter used was search by title, keywords and abstract. Thus, a total of eight hundred and thirty eight (838) documents were obtained between the years of 2013 and 2018. Articles of conference, chapter of books, books, articles in review and articles in review of conference were excluded, using only the scientific articles in the analysis. Then obtained two hundred and sixty nine (269) articles verified until August 2019. A total of one hundred and seventy seven (177) articles that present at least one challenge from the industry 4.0 were selected by reading 75% of the articles and reading the titles and summaries of the other articles that did not receive full access.

Articles were recorded into a data spreadsheet, and then categorized with the following variables: method, challenges, solutions, benefits, associated principles and technologies. Also included were title, author, country of publication, periodical, corresponding disciplines, method and quantity of citations. After conclude the database, was made a bibliometric analysis and also presented the challenges extracted from these articles sorted.

Due to the large volume of articles as a result of the search in the "Scopus" database, arose 177 articles for analysis, a specific perspective to find a trend on the search was used, through the following variables associated with the challenges, as follow: the dimension, the category of challenges and the technology. First was used the variable "dimension" to identify what are the most frequent records, and then, was used the "category of challenges" and in the end, what was the "technology" most frequent. Thus, the results are that the "technical" dimension in the "demand for systems" category and "Cyber Physical Systems" technology were the most frequent records.

After analysing the articles from this perspective, an overview of the content is presented, ending with gaps and future research, as shown in Fig. 1.

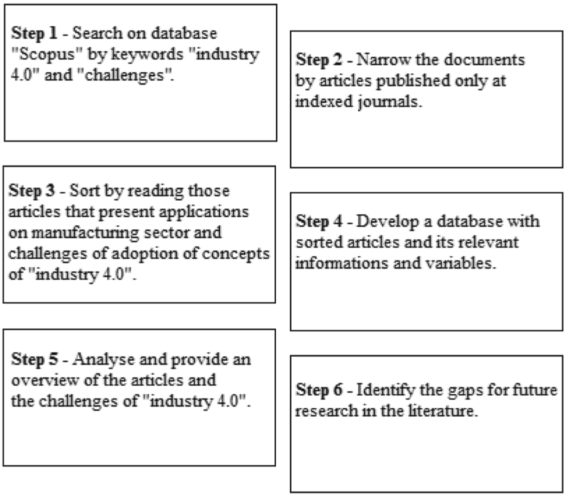

Fig. 1. Research steps.

4 Results

First of all, this research found more than a hundred general challenges, being the most frequent challenges, issues related to data and information security, human skills qualifying, investments capacity and data and information integrity. An important challenge of the technology CPS is development of reconfigurable and auto organizable mechanisms responsible to take decisions about the reorganizations of new routes of a product in manufacturing. This article presents the general challenges and, later presents the challenges of the CPSs system in more detailed way in the section discussion.

4.1 Bibliometric Analysis

For the bibliometric analysis, the 177 articles sorted that present at least one challenge on adoption of the I4.0 are analyzed. A strong growth trend in publishing from 2017 is perceived, but since 2013 and 2014 when I4.0 was widely disseminated by the German government, its challenges began to be researched, as shown in Fig. 2.

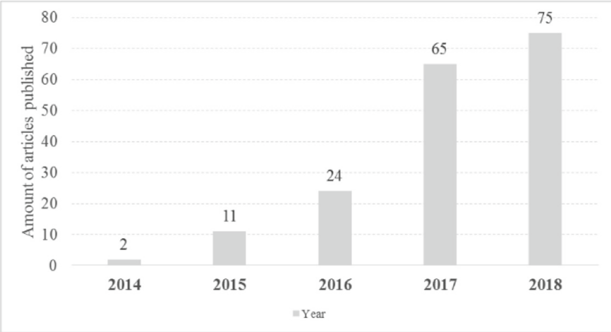

Fig. 2. Growing publication trend on industry 4.0 challenges.

A publishing [15] about the German strategy I4.0 has been one of the main references of research about this concept. Since then, an increase amount of articles has been published, not just to identify the challenges, but also in order to find others aspects and subjects of study about the I4.0. Because Germany had the pioneering strategy of the fourth industrial revolution, they also have more publishing than any other country as a result perceived in this sample.

4.2 Challenges of International Literature

Four hundred and thirty-nine (439) distinct challenges were found in four (4) dimensions (Technological, Organizational, Strategic and Legal), in one hundred and seven and seven (177) articles. On 16 (sixteen) articles the challenges were not related because only by reading their abstract it was not possible to identify them, only being possible to understand that there was an approach to the challenges of I4.0. Table 3 presents 18.91% of all challenges encountered, representing the top 10 challenges.

Table 3. The top 10 ranked general challenges of Industry 4.0 most frequent in literature.

Challenges	Frequency	Frequency (%)
Data security and integrity	34	4,16%
Qualification of human skills	21	2,57%
Information security and ownership	17	2,08%
Capacity of investments	16	1,96%
Human skills development	14	1,71%
Lack of information and communication technology infrastructure	13	1,59%
Network scalability	13	1,59%
Integration of new technologies into existing technologies	12	1,47%
Product customizations	11	1,34%
Unclear investment benefits	11	1,34%

The strategy I4.0 will transform the way how the things are thought and designed. 10. Ghobakhloo [10] tries to understand the future of the manufacturing sector, and conclude that: "*Yet, it cannot be ignored that there are many challenges associated with the fourth industrial revolution, examples of which are financial capability, data security issues, maintaining the integrity of the production process, IT maturity and knowledge competencies. The promise of Industry 4.0 is real, but for companies that are mature enough to embrace it, and have devised a comprehensive transition strategy*".

Related to the trend found about the I4.0 literature, is possible indicate that CPSs technology is among the most frequent in the classification of system demand challenges. According to Glück [16], basic directions of CPS projects are lacking because they establish a solid relationship in large obscure engineering systems. On Table 4 the challenges sorted after selection done by dimension, challenge classification and technology are presented.

Table 4. Challenges of CPS technology about Industry 4.0.

Development of reconfigurable and self-organizing mechanisms
Ability to self-assess system under normal and disturbed conditions
Management heterogeneous data with performance
Semantic ability to explore a dataset
Simulation process with limited coverage in CPS system operation
Systems architecture for CPS data integration
Integrating heterogeneous data into CPSs using ontological methods
System instability in data analysis
Parallel communications in complex production resource architectures
Resource interactions on functions sharing
Schedule modeling in production system
Monitoring system standardization
Verification and validation of systems in automatic transactions
Development of CPS variability assessment systems
Information passed on complex architectures of production resources
Different time characteristics between systems

After clearing what are those challenges of Industry 4.0 witch follow a trend, being them related to CPSs technology, some of them will be discussed in the next section.

5 Discussion

The authors [5, 16, 17] reported the challenge "development of reconfigurable and self-organized mechanisms". Moreover, Wan et al. [17] proposes a method of reconfiguring resource based on ontological functions that analyze a specific behavior of data. Among the benefits suggested, management of operations resource data is enabled. About the challenge "management heterogeneous data with performance", [18, 19] published a conceptual work, and compared network and computing technologies in the cloud. Yue et al. [18] suggests the use of different algorithms for data analysis and

Mueller et al. [19] suggests the use of a system with a model of operations synchronous semi-autonomous and integrated.

Ribeiro and Hochwallner [3] and Jiang et al. [20] approach the challenge "ability to self-assess system under normal and disturbed conditions", as a result of stabilization and improvement in the operational performance of the CPSs systems. The authors [20] suggest a platform with integrated collaborative features. Ribeiro and Hochwallner propose a requirement for the development of CPSs systems, called by the authors as *diagnosability*, with the benefit of autonomous failure detection and tracking of the causes of production defects.

Ribeiro and Hochwallner [3] and Ribeiro and Björkman [15] address the challenge "semantic ability to explore a dataset". The approach of [3] suggests that CPSs systems should be developed at levels to achieve better capacities and different CPS requirements. In addition, Ribeiro and Björkman propose a hierarchical solution with dynamic adjustment in hierarchical state control, decentralizing the analysis capabilities. The authors conclude that the demand for systems that evaluate hierarchical production information at the level of collaboration between CPSs, by dynamically determining activities, a minimum interface between systems and equipment is required.

6 Conclusion

In this research was presented an international literature review to identify the main challenges of Industry 4.0 and then identify an existing trend in research according to identified challenges. Issues related to systems security, human skills and investments and so on, are the main challenges of I4.0. However, was possible to identify that the technical dimension, the classification of demand for systems and CPS technology, are the most frequent results for each of these variables, suggesting a trend in researches. Thus, the technical challenges for CPS systems development identified can be used as a reference for further research aimed at approaching and addressing these challenges.

A limitation of this research is the speed of new publications in the same parameter used in the Scopus database, so it was decided to use only publications until 2018, because even the year not yet completed, the number of publications in 2019 is higher than 2018, being impossible to analyze the new publications. For future research, one valuable way could be empirical studies on the CPS system, because still there is a gap in the literature in this regard. A research using other keyword instead of "challenge", the shift to "barriers" can be another option. As well as another specific technology could be studied in order to identify its challenges.

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Descriptive Evaluation in Public Healthcare Services

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Abstract. Customer satisfaction and quality is highly important for organizational survival. So measure and evaluate the quality offered by service providers is important while research purpose as well as to companies which intend to improve their services. Regarding to service quality and services management in healthcare sector is observed that this sector has attracted significant research attention in recent years. Thus, this paper aim to describe and analyse the customers' expectations and perceptions levels related to the public healthcare service as well as identify the most important attributes of these services from customer´s views. To achieve the results, a questionnaire was applied to 320 users of the public healthcare service in Aparecida de Goiânia city, Goiás state, Brazil. A Likert scale of 5 points was used to measure expectations and perceptions of the public healthcare service´s users. The quantitative data were treated statistically, especially referent the customers' expectations and perceptions levels. It was obtained parameters inherent to descriptive statistic, particularly measures of central tendency and dispersion. After that, it was identified the gaps between users' expectations and perception levels to each attribute. The Cronbach's Alpha coefficient was calculated in order to estimate the scale reliability. The data referent to the importance level, to each attribute/construct, was calculated based on customers´ opinions. One can conclude that in general the customers are unsatisfied with the public healthcare service, mainly referent the attending/responsivity construct and that the most important constructs are attending/responsivity and reliability.

Keywords: Satisfaction · Customers · Public · Healthcare services

1 Introduction

Health services has been the subject of much discussion and controversy at global level, especially when there is focus on its quality performance. [1] highlight that in developed and under development countries, the health service area shows up the fastest growth rate if compared with other service fields, mainly because all countries are struggling to deal with the growth demands for health facilities, in terms of human and material resources.

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Considering the relevance of the sector, the quality of service rendering becomes an important object of study. Efforts has been made to evaluate the quality of services provided by several sectors of the economy, with the health sector being one of the most researched, although the literature is still timid [2].

In a general context, for organizational management, quality represents providing clients and users with services that are covered with aspects and attributes that meet, and why not surprise, customers in meeting their needs and desires [3].

Performing an analysis under the perception of the quality of the public service from the point of view of the user is of fundamental importance in order to include them in the improvement of management processes, where it is possible to recognize their needs, meet and exceed their expectations and, above all, to guarantee the sustainability of public policies [4]. Add that this statement agrees with the idea about the nature of scientific work, which should serve to analyze a phenomenon seeking to explain and reveal the relations they maintain with others, in a real way and beyond appearances.

So quality is no longer seen as a differentiation factor among market competitors, not even in the public sector, but rather, it has become a necessary basic condition to remain in the market. In this sense, [5] points out that in the public sector, the challenge for public administration is how to transform bureaucratic structures that are hierarchical and that tend to a process of isolation in flexible and entrepreneurial organizations.

In order to improve the public health in the Brazilian context, the Brazilian government provides a public service focused on health care, which is the focus of this study. In this perspective, [6] point out that public health services in developing countries may be precarious, because of the great struggle over increasing demand and resource depletion. So, to guarantee the quality of services in these contexts, the use of evaluation has become essential. Identifying the perceptions of the users of the services received and the perceptions of the offered service providers, it is possible to evaluate effectively the quality of the service studied.

Based on these considerations, the objective of the present empirical study is, therefore, to describe and analyze the levels of expectations and perceptions of the customer/users of public health services (Basic Health Units - BHUs) of Aparecida de Goiânia (metropolitan region of Goiânia), as well as identifying the most important attributes of these services from the customers' opinions. Customer satisfaction is obtained important highlight from the difference between expectations and perceptions customers´ levels.

2 Method

Related to the data collection process, we highlight that primary data were collected, of a quantitative and qualitative nature. These data were obtained from a non-probabilistic sample of 306 customers from different Basic Health Units (BHU) in Aparecida de Goiânia city, Goiás state of Brazil. These data were collected from January to March of 2019. Regarding to scale, it was developed and validated in the papers by [7] and [8], and it is showed in Appendix. The scale was developed in four phases until to obtain de final version. In this sense it is important to highlight that the scale was created from bibliographic references, especially from the work developed by [9].

Considering the relevance of the sector, the quality of service rendering becomes the quantitative data was treated statistically, especially regarding to customers' expectations and levels of perception. Parameters inherent to descriptive statistics was obtained, particularly measures of central tendency and dispersion, such as mean age, standard deviation and coefficient of variation. After it, the gaps of each attribute from the difference between the customer expectations and the perception levels were calculated. The results are shown in Table 1.

Table 1. Mean, standard deviation, coefficient of variation and gaps.

Attribute	Mean score		Gap	Standard deviation		Coefficient of variation (%)	
	Expectation	Perception		Expectation	Perception	Expectation	Perception
1	4,79	2,77	2,01	0,50	1,25	10,40%	45,18%
2	4,73	2,74	1,99	0,56	1,26	11,91%	45,95%
3	4,56	3,23	1,33	0,65	1,31	14,15%	40,44%
4	4,44	3,54	0,90	0,82	1,22	18,37%	34,60%
5	4,63	3,50	1,13	0,64	1,28	13,71%	36,64%
6	4,78	2,99	1,79	0,47	1,38	9,93%	46,16%
7	4,75	3,25	1,50	0,49	1,36	10,23%	41,97%
8	4,72	3,36	1,36	0,57	1,32	12,11%	39,43%
9	4,80	3,40	1,40	0,46	1,33	9,64%	39,13%
10	4,65	3,38	1,27	0,62	1,40	13,33%	41,39%
11	4,69	3,42	1,27	0,54	1,35	11,41%	39,61%
12	4,69	3,56	1,13	0,55	1,36	11,79%	38,37%
13	4,87	2,97	1,91	2,93	1,35	60,12%	45,41%
14	4,66	2,89	1,77	0,65	1,32	13,94%	45,65%
15	4,89	3,69	1,20	2,92	3,19	59,78%	86,57%
16	4,75	3,49	1,26	0,53	1,28	11,16%	36,78%
17	4,78	3,62	1,16	0,45	1,22	9,49%	33,79%
18	4,28	2,79	1,48	0,94	1,40	21,94%	50,11%
19	4,33	3,31	1,02	0,89	1,27	20,45%	38,35%
20	4,39	3,14	1,25	0,82	1,35	18,74%	42,79%
21	4,42	3,07	1,35	0,84	1,35	19,04%	43,81%

The Cronbach's Alpha coefficient was calculated to estimate the reliability of the scale. Finally, the data was processed referring to the level of importance of the attributes and constructs obtained from the customers' opinions. In this sense, the relative importance of each construct was estimated, as shown in Table 2. Therefore, a comparative analyzes between the levels of importance of the construct and the performance referents each one based on the perception levels was performed.

Table 2. Relative weighting and relative importance.

Construct	Relative weighting	Relative importance (%)	Performance
Responsivity	869	31,54%	3,26
Reliability	752	27,30%	3,19
Empathy	221	8,01%	2,37
Safety	299	10,86%	2,16
Tangibility	614	22,29%	3,37
Total	2755	100,00%	–

To calculate relative importance, a "weighting" for each level of importance was define. For example:

- First most important: weighting 5
- Second most important: weighting 3
- Third most important: weighting 1

From the weights, the relative weight was obtained for each construct using the customers' choices. For example, if the Responsivity construct was chosen 108 times as the most important (weighting 5), 84 times as the second most important (weighting 3) and 77 times as the third most important (weighting 1), the weighting relative to the Tangibility construct is calculated as:

$$(108 \times 5) + (84 \times 3) + (77 \times 1) = 869$$

This procedure was applied for each construct of the study. Thereafter, the total of the relative weights, in this case, 2755 were measured. Finally, the relative importance for each construct was calculated. For example, for the Service construct the relative importance is calculated as:

$$869 \div 2755 = 0.315(31.5\%)$$

3 Results and Discussions

3.1 Descriptive Analyses and Scale Reliability

The purpose of this study is to measure and evaluate the satisfaction of the health service provided by BHUs in Aparecida de Goiânia city. From this perspective, [10] report that customer satisfaction is based on previous expectations of this customers. [11] corroborate this idea, at the time he declares that the quality of the service is the result of the comparison between expectations and customer perception about the service actually received. In addition, [12] complement that the quality of the service depends of the comparison of the expectations of clients with their perceptions of performance.

Table 1 shows the values related to expectation, perception, mean, standard deviation and coefficient of variation of each assessed attribute offered by the BHUs evaluated. The description of all attributes are included in Appendix. The Gap, the difference between the mean levels of expectation and perception for each attribute, is also measured and presented.

First, it is possible to perceive that for all attributes the level of expectation is higher than the level of perception. Table 1 shows this fact which reveals that customers, in general, feel dissatisfied with the health services provided by the BHUs under study. It can be observed that the most expressive gap is 2.01 points, regarding to question 1 ("The hospital must have preserved and modern equipment"), referring to the Tangibility construct. The second and third largest gaps refer, respectively, to questions 2 ("The hospital must have a quantity of equipment that provides a satisfactory service") and 13 ("The hospital must have a minimum amount of qualified teams and qualified to provide satisfactory car"). Question 2 is also included in the Tangibility construct, in turn, question 13 is part of the Reponsivity construct. This denotes that for these attributes there are the main dissatisfactions of these clients.

On the other hand, the three smallest gaps relate to attributes 4 ("The hospital staff must have well-tended appearance and attire, according to the characteristics of the work environment"), 6 ("In the hospital, the team should give individualized attention to the patient"), and the attributes 5 ("The reports and other documents delivered to the patient should be easy to understand") and 12 ("In the hospital, the team must be polite and courteous to their patients"). Attributes 4 and 5 are represented by the Tangibility construct, attribute 6 makes up the Reliability construct, and attribute 12 is included in the Responsivity construct. Thus, it can be considered that for these attributes there are the lowest levels of dissatisfaction for these clients.

Regarding to the values of expectations, it can be pointed out that the three most expressive values are respectively the attributes 15 ("In the hospital, the behavior of the team must convey confidence to the patients"), 13 ("The hospital must have a minimum quantity of qualified and trained teams to provide satisfactory care") and 9 ("The hospital should present reports, documents and information about the patient without errors"). The attributes 9 represent the Reliability construct, while the attributes 13 and 15 integrate the Responsivity and Safety constructs respectively. From this perspective, it is worth stressing that high values regarding expectations represent significant importance for customers. Thus, attributes 15, 13 and 9 are relevant to these clients and, therefore, actions should be prioritized precisely to achieve the best performances within the health service of the BHUs under study.

Table 1 also shows the parameters relative to the coefficient of variation (CV). As exposed by [13] the result of CV, given in percentage value, corresponds to the ratio between standard deviation and mean, being a statistical parameter used mainly in researches aimed at the quality of precision in experiments. According to [14], in field experiments, if the coefficient of variation is less than 10% is said that the same is low, if it is between ten and 20% is said to be median, already between 20:30 percent is considered high, and above 30% is declared as very high.

[15] complements that if CV presents lower values, it means that the data set is more homogeneous. CV can be considered low when it is less than or equal to 25%. However, this pattern may differ according to the data to be analyzed. It is risky to classify a coefficient of variation as low, median or high. But [15] asserts that this can be useful at times when two variables or two groups are impossible to establish comparisons.

Based on Table 1, it can be observed that the values for the coefficient of variation (CV) are relatively low for the attributes related to the expectation of the health service user of the hospitals analyzed. However, these coefficients of variation become elevated when the attributes relative to the perception of the user are evaluated.

The coefficient of variation for the expectation of the attributes is on average 18.17%, the mean coefficient of variation for the perception of the attributes is 43.43%. Thus, based solely on the mean, there is a low to moderate coefficient of variation for the attributes relative to expectation, but this coefficient of variation would be considered high when the evaluation was on the attributes related to perception. Based in the information from Table 1, in relation to the values of expectations, the majority of the attributes presented a moderate coefficient of variation, with values between 10% and 20%. However, most of the coefficients of variation of the attributes of perception are expressive because they are greater than 35%. Nevertheless, the perceptions, in terms of coefficient of variation values, were more homogeneous than the expectations of the clients.

Finally, in relation to reliability analysis, Cronbach's alpha was calculated. The value found was equal to 0.904. The result points out that the reliability of the scale is excellent. [16] declares that the smallest value to be considered for the Cronbach's alpha should be 0.60; because the more reduced the value for this weaker parameter is considered the consistency of the data.

3.2 Comparative Analyses Between Importance Levels and Performance

Continuing with the statistical analysis, there is the relative weighting and the relative importance inherent to each construct, as shown in Table 2.

As shown in Table 2, it can be seen that the construct that presents the greatest relative importance, Service, presents a performance of 3.26, considered high in view that is the second largest among all constructs. The performance relative to the second construct with the highest relative importance, Reliability, also presents the second highest performance among all constructs, 3.19. The third highest relative importance relates to the Tangibility construct, but its performance is the largest among all constructs with a score of 3.37.

This analysis obtained from Table 2 shows that the constructs with the greatest relative importance tend to have better performance, and the inverse also tends to be true, that is, constructs with lower relative importance generally present reduced performance. It means that there is coherence between importance and performance. In terms of importance, level regarding to constructs the finds obtained from Table 2 show similar results when we compare to the finds referent the expectations levels because in both case the most important constructs are Responsivity and Reliability.

4 Conclusion

The purpose of this paper is describe and analyze the of public health services (Basic Health Units - BHUs) of Aparecida de Goiânia (metropolitan region of Goiânia), as well as identifying the most important attributes of these services from the customers' opinions.

In this sense one can conclude that in general the users are unsatisfied with the public health services (Basic Health Units - BHUs) of Aparecida de Goiânia, referent mainly to Tangibility and Responsivity constructs. One can conclude also that the most important attributes are linked to Responsivity and Reliability constructs. It means that these dimensions are the most relevant to customers. It means that the public managers have to priority these aspects in order to promote better services to customers.

Regarding to coefficient of variation it was observed that the values referent the perceptions are more heterogeneous than expectations' values. In terms of scale reliability analysis the value found (Cronbach's parameter) shows that the reliability of the scale is acceptable and consistent.

Finally, we have stablished comparative analyses between importance levels and performance. In this sense we perceived that there is coherence between importance and performance. And we observed that the customers consider the most important constructs are Responsivity and Reliability.

Appendix

Survey on the perception of users about the quality of services provided in the health area

User.

This questionnaire comes from a research that is being carried out to evaluate the quality of health services in the city of Aparecida de Goiânia, based on the "perception" of users of such services. This research is linked to the Production Engineering course of the Faculty of Science and Technology of Campus Aparecida de Goiânia, Federal University of Goiás.

Part1 – General data

1. **Has any disabilities?**

   ( ) Yes ( ) No

2. **Genre:**

( ) Female

( ) Male

3. **Age:**

( ) up to 18 years

( ) 19 to 35 years

( ) 36 to 50 years

( ) 51 to 60 years

( ) Over 60 years

4. **Frequency of use health service?**

( ) Daily

( ) Weekly

( ) Monthly

( ) Yearly

( ) Rarely

5. **What is your degree of education?**

( ) First degree incomplete (basic education)

( ) Incomplete high school (high school)

( ) Complete high school (high school)

( ) Incomplete higher education

( ) Complete higher education

6. **What type of service is used?**

() Public (SUS)

() Private (UNIMED, IPASGO, BRADESCO...)

7. **What is the name of the hospital/organization that you used the health services evaluated?**

____

Part 2 – Expectations

User,

This part of the questionnaire is part of a survey to be carried out on "**expectations**" of usersof health in the city of Aparecida de Goiânia/GO. That way, in this step, it is a rating of "**1 to 5**" in which:

1 No importance	2 Little importance	3 Moderate importance	4 Important	5 Very important

TANGIBILITY	
1. The hospital must have modern and well-maintained equipment	
2. The hospital must have an amount of equipment that provides satisfactory care	
3. The physical facilities of the hospital must be pleasant and well signaled	
4. Hospital staff should be well-groomed in appearance and attire, according to the characteristics of t the work environment	
5. Reports and other documents delivered to the patient should be easy to understand	
RELIABILITY	
6. The hospital must carry out its activities on time	
7. The hospital must show sincere interest in solving the patient's problems	
8. The hospital should perform the services and procedures correctly, not causing rework	
9. The hospital must present reports, documents and patient information without error	
RESPONSIVITY	
10. In the hospital, the team must inform patients accurately when services will be performed	
11. In the hospital, the team should promptly attend to their patients.	
12. At the hospital, staff should be polite and courteous to their patients.	
13. The hospital must have a minimum number of qualified and qualified staff to provide satisfactory care	
14. The hospital must have a minimum number of technicians for the operation of examination equipment	
SAFETY	
15. In the hospital, team behavior should convey confidence to patients	
16. Hospital patients should feel secure in using their services	
17. In the hospital, staff should have adequate knowledge to answer patients' questions	
18. The hospital must have an entrance and exit control of persons	
EMPATHY	
19. In the hospital, the team should give individual attention to the patient	
20. The hospital should operate at appropriate times for its patients.	
21. The hospital should prioritize the patient's interests	

Parte 3 – Perceptions

User,

This part of the questionnaire is part of a survey to be carried out on "**perceptions**" of users of health in the city of Aparecida de Goiânia/GO. That way, in this step, it is a rating of "**1 to 5**" in which:

1	2	3	4	5
Very Dissatisfied	Dissatisfied	Indifferent	Satisfied	Very Satisfied

TANGIBILITY	
1. The hospital must have modern and well-maintained equipment	
2. The hospital must have an amount of equipment that provides satisfactory care	
3. The physical facilities of the hospital must be pleasant and well signaled	
4. Hospital staff should be well-groomed in appearance and attire, according to the characteristics of the work environment	
5. Reports and other documents delivered to the patient should be easy to understand	
RELIABILITY	
6. The hospital must carry out its activities on time	
7. The hospital must show sincere interest in solving the patient's problems	
8. The hospital should perform the services and procedures correctly, not causing rework	
9. The hospital must present reports, documents and patient information without error	
RESPONSIVITY	
10. In the hospital, the team must inform patients accurately when services will be performed	
11. In the hospital, the team should promptly attend to their patients.	
12. At the hospital, staff should be polite and courteous to their patients.	
13. The hospital must have a minimum number of qualified and qualified staff to provide satisfactory care	
14. The hospital must have a minimum number of technicians for the operation of examination equipment	
SAFETY	
15. In the hospital, team behavior should convey confidence to patients	
16. Hospital patients should feel secure in using their services	
17. In the hospital, staff should have adequate knowledge to answer patients' questions	
18. The hospital must have an entrance and exit control of persons	
EMPATHY	
19. In the hospital, the team should give individual attention to the patient	
20. The hospital should operate at appropriate times for its patients.	
21. The hospital should prioritize the patient's interests	

What is your level satisfaction with the public transport service?

1 – Very Dissatisfied ______________________________ 5 – Very Satisfied

We ask that choose three most important attributes conform your perception:

1º: ______________________________

2º: ______________________________

3º: ______________________________

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Food Delivery Using Cargo-Bikes with IoT

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Abstract. In order to reduce noise and limit air pollution, there is a trend of limiting or prohibiting entry by motor vehicles in urban areas. This has a major impact on the delivery of food in urban zones with classic delivery vehicles (trucks, vans, cars, etc.). The cargo bikes can carry loads of up to 100 kg in large front-mounted boxes that are suitable to transport goods and they are perfectly suited for inner-city transportation, because they are quiet, emission-free, and less disturbing for the citizens. In this paper a proposed solution for a system for food delivery using cargo-bikes with IoT is described. This system consists of test application for mobile phones for users, sensory units placed in packets of fresh food products or in bikes cargo compartments and server application with a database. The users of the system are all participants in the chain of distribution of fresh food products: producers and sellers of fresh food products, deliverers of fresh food products and consumers of fresh food products. Developed system was tested and results gathered in test period from system users are represented in this paper.

Keywords: Cargo-bike · Internet of Things · Delivery

1 Introduction

Today society is facing a number of challenges related to globalization, urbanization and limitation of natural resources. One of the areas where all three challenges pay important role is transport. A challenge to the transport arises from the limited storage capability of non-fossil energy sources on mobile platforms and from the fact that the worldwide trend of urbanization leads to a concentration of traffic and transport in urban areas. This is accompanied by negative impacts on life quality in areas with a high traffic density.

The way of life is also changing. People are working longer hours, spend more time to travel from home to work and backward thus having less time to cook meals. Society is also facing demographic changes leading to ageing societies which require essential goods related to: procurement of food, pharmaceuticals, health services and transport. In fact older people tend to travel less than younger age in contrast to the requirements of older citizens for an instantaneous and continues access to essential goods.

One solution that can help today's society in procurement of food in urban conditions with transport limitations is usage of cargo-bikes for food delivery. The cargo bike, once a common mode of transport, played a minor role in the last decades of

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motorization. However, the cargo bike is perfectly suited for inner-city transportation. It is quiet, emission-free, and less disturbing for the citizens [1]. This low-carbon transportation innovation can contribute to reducing greenhouse gas emissions. Cities, should promote low-carbon transportation and reduce automobile use [2]. Urban areas with high population densities and diverse land-use supports lower modes of transportation as locations can be quickly and easily accessed [3].

According to some of researches, 40–50% of all car journeys are less than 5 km [4]. For short distances like these, available alternative is the cargo-bike, also known as transport bicycle, box bike, long john, or bakfiets [5]. Cargo bicycles come in various shapes and sizes, and from a variety of manufacturers, sometimes with electric assist capacity. They can carry loads of up to 100 kg in large front-mounted boxes that are suitable to transport goods (see Fig. 1). Research has shown that these bike types may have advantages for the transport of goods but also children in that they may be more visible, and therefore safer from collisions, than a pull-behind bicycle trailer [6–8]. The latest innovation, the electric cargo-bike, could become an even more competitive alternative to cars [7].

Fig. 1. Examples of cargo-bikes [9, 10].

There are different ways to promote using cargo-bikes instead of car. For example Berlin, which ban on car-courier services within the city centre in favour of cargo bikes [11, 12]. These cargo bike focused studies are also paralleled by recent work which suggests that mode choice and travel behaviour is not based solely on origin-destination or financial market factors, but also on social, behavioural and cultural norms [13–15].

2 Proposed Solution

The basis of the proposed solution of the system for delivery of fresh food products in urban zones using cargo-bikes consists of users, sensory units placed in packets of fresh food products or in bikes cargo compartments, server application with a database. The Fig. 2 shows the block diagram of the proposed solution of the system for system for delivery of fresh food products in urban zones using cargo-bikes with IoT.

The users of the system are all participants in the chain of distribution of fresh food products: producers and sellers of fresh food products, deliverers of fresh food products and consumers of fresh food products (households, hotels, restaurants, etc.).

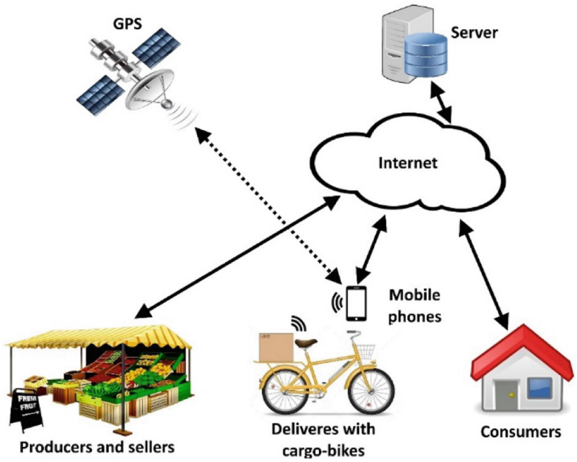

Fig. 2. Block diagram of the proposed solution for system for delivery of fresh food products in urban zones using cargo-bikes and IoT.

Sensory units placed in packets with fresh food products or in bikes cargo compartments allow monitoring of the conditions in which fresh food products are transported (air temperature and humidity, vibrations, etc.). The collected data can be used: to alert users if fresh food products are transported under inappropriate conditions (for example air temperature and humidity outside of optimal limits), to assess the states of the transported fresh food products, and to make a decision whether fresh food products are still safe for consumption.

The server application is linked to a database that contains user data (their names, their roles in the system, locations for pick-ups and deliveries of fresh food packets) and enables their interconnection. Through server application producers and sellers of fresh food products, after forming packets with fresh food products, can create a requests deliveries for packets with fresh food products. Created requests for deliveries of packets with fresh food products can be forwarded to the desired deliverers or may be placed on the delivery requests list. Deliverers can see all the current requests in the delivery requests list and select the packets whose deliveries they will perform. Consumers of fresh food products can have an insight into the status of the packets with fresh food products: whether their package is formed, whether the delivery is in progress, conditions of transport of fresh food products collected by sensory units.

In order to facilitate and speed up the work there is a dedicated application for mobile phones, through which users can log on to the system, create requests for deliveries, and have insights on the data for each packets with fresh food products that is related to them. In addition, the ability to localize a mobile phone through a global positioning system (GPS), mobile phone application serves to provide additional information and facilitate the operation of system users by displaying it on the mobile phone screen, such as locations for pick-ups and deliveries of packets with fresh food products on maps. The global positioning system can also be used to guide the deliverer from the current location where it is to the pick-up place of the packets with fresh food products, and then to guide the deliverer to the consumer of the fresh food products. With the location information of the deliverer's mobile phone, the system can determine whether the deliverer has come to the place of pick-up and delivery of the packets of with fresh food products, and the deliverer and the consumer of fresh food products can have an insight into the estimated time of delivery of the packets with fresh food products, etc.

In order to enable the longest possible operation of the sensor units, the ability of a mobile phone to communicate via the Internet is used, i.e. a sensor unit, that is placed in a packets with a fresh food products or in bike cargo compartments, uses a mobile phone as a gateway, i.e. the measured data on the current transport conditions is forwarded to the application on the mobile phone of the deliverer, and then these data, along with the current location data, are forwarded to the server application. This allows the sensor unit to be of small dimensions and has a very long interval of operation.

3 Experimental System

The experimental system was set up in order to demonstrate the functionality of the proposed solution of the system for delivery of fresh food products in urban zones using cargo-bikes. The server application is executed on a server computer and is implemented in C # programming language and Microsoft Visual Studio 2017 development environment. This application is linked to the MySQL database that contains test user data. Data on the measured transport conditions (air temperature and humidity and vibrations) for each packets with fresh food products are also entered into this database. The test application for mobile phones has been implemented for smartphones with an Android operating system using the Android Studio development environment.

The server application receives user requests, i.e. requests from producers and sellers of fresh food products for the deliveries of packets with fresh food products. All requests for deliveries are placed on the delivery requests list and becomes visible to the deliverers. Since the product's sensitivity to transport conditions is different from product to product (degradation of the quality of food products in some products are faster at higher temperatures), the producer and seller of fresh food products defines the sensitivities for the entire packets with fresh food products based on the most critical product in the packets. In experimental system it is possible to define three levels of product sensitivity to transport conditions: low sensitivity, medium sensitivity and high sensitivity. The experiments were carried out on a small number of test users so that the list of current delivery requests was sorted only on the defined packets sensitivity to the delivery conditions. If, in the meantime, a new delivery request appears, depending on the defined packets sensitivity, the packets are sorted according to the sensitivity and deliverers are notified that there is a new request for delivery via a test application on the mobile phone. When deliverer access to the current delivery requests list, all requests are sorted based on packet sensitivity to transport conditions, on the distance to the pick-up place and the distance to the place of delivery (see Fig. 3).

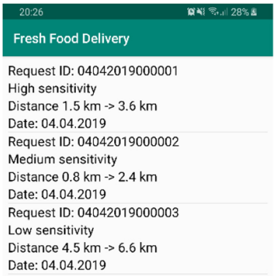

Fig. 3. Part of the test application on a mobile phone that displays the current delivery requests to the deliverer.

By choosing the request in delivery requests list, location of the pick-up place and location of the delivery place are shown on navigation map in test application on mobile phone (see Fig. 4a). Figure 4b shows a part of the test application for guiding the user to the packet delivery place.

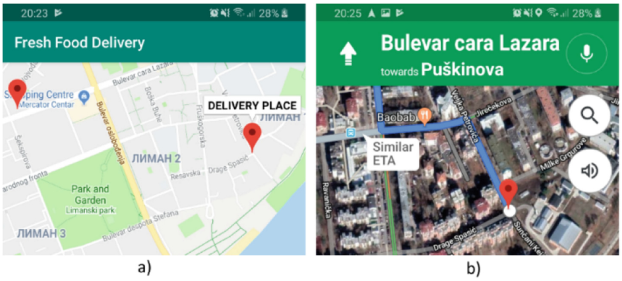

Fig. 4. Part of the test application on a mobile phone that displays locations on map and navigation to the delivery place.

In the event of a change in the delivery requests list, notifications will be sent to system users via the test application on the mobile phone. Examples of notifications are shown in Fig. 5.

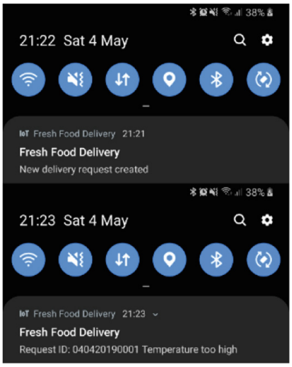

Fig. 5. Examples of notifications shown on mobile phone.

In order to monitor the conditions of transport of fresh food products in the packet, a sensor unit is developed. Sensor unit consists of microcontroller ATmega328P (manufacturer Atmel), Wi-Fi module ESP8266 (manufacturer Espressif Systems), sensor for measuring air temperature and humidity BME280 (manufacturer Bosch Sensortech), accelerometer ADXL362 (manufacturer Analog Devices). For the power supply of the sensor unit, the lithium-ion battery NCR18500A (manufacturer Panasonic) with a nominal voltage of 3.6 V and a rated capacity of 1900 mAh was used. The developed sensor unit shown in the Fig. 6.

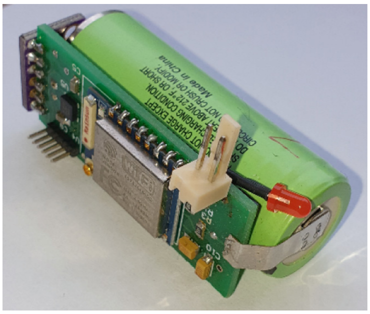

Fig. 6. A developed sensor unit for monitoring the transport conditions of packets with fresh food products.

The BME280 sensors measure the air temperature and humidity inside packets of fresh food products or inside bike cargo compartment. The ADXL362 accelerometer is used for measuring vibrations and shocks during transportation so that, in case of strong vibrations and shocks, users of the system are alarmed that damage or potential damage to food products occurred (damage to fruit and vegetables, egg shell breakage, etc.). In the event of damage or potential damage to fresh foods in the packets, consumers of food products should review the packets in detail and use the damaged products as soon as possible or return them to the producers and sellers of fresh food products through the reclamation procedure. The Wi-Fi module ESP8266 is used to communicate with the server application via a local Wi-Fi network within the packet pick-up place or via a Wi-Fi network created on the mobile phone during packet transport. The microcontroller ATmega328P controls the operation of the sensors unit and connects all components into one whole. By sending commands microcontroller ATmega328P read data from the air temperature and humidity sensor as well as the accelerometer. By sending AT commands to the Wi-Fi module, microcontroller ATmega328P establish communication and transmit data to the server application. During operation, the microcontroller also reads the battery voltage on analogue input. If the battery voltage falls below 3.4 V, the microcontroller switches off the operation of the sensor unit to protect the battery from a deep discharge. During the testing developed sensor units, a battery of 1900 mAh capacity provided a satisfactory autonomy for the operation of the sensor unit. By sending data within an interval of one minute, the autonomy of about 15 days was achieved. By sending data within an interval of five minutes, the autonomy of about 35 days was achieved.

The server application records all activities related to creation of requests for delivery, performing of the delivery (which users are related to delivery, date and time of packet pick-up, date and time of packet delivery, packet paths, transport conditions (air temperature and humidity, vibrations, shocks), etc.), which makes it possible to track the history of data and generate different reports.

After trial period of 2 months, information about developed system for food delivery using cargo-bikes with IoT was gathered from: users of test application for mobile phones, data base of server application, and survey that was done with system users. Users of test application for mobile phones stated that the concept of the system was satisfactory and it helped them in planning daily routine. According to data from database and comments from sellers and buyers it was determined that there were about 12% of undelivered goods/packets. There was small number of packets delivery delay which led to sellers and buyers dissatisfaction of service and potential food spoilage. Also it was determined that there ware packets for which the sensitivity to transport conditions where not correctly selected which led to food spoilage (some of the products were defrosted).

4 Conclusion

In this paper, a system for food delivery using cargo-bikes with IoT is described. The described system is intended for all users who participate in the chain of production, sales, distribution and use of fresh food products (producers and sellers of fresh food products, deliverers of fresh food products and consumers of fresh food products). The proposed solution for system for food delivery using cargo-bikes with IoT offered all users an insight into historical data for each delivered packets with fresh food products (which users are related to the packet, date and time of delivery, transport conditions, etc.), which increases security and mutual trust between system users. Based on initial testing, the proposed solution for a system for food delivery using cargo-bikes with IoT gave satisfactory results. Some of the problems were also detected, so in the next phase it is planned to slightly change the system in order to lover number of: undelivered goods/packets, packets delivery delay and to define more levels of sensitivity to transport condition, so the quantity of spoiled food will be reduced.

For the future work, it is planned to expand the proposed solution for a system for food delivery using cargo-bikes with IoT with the additional functionalities. One functionality would be the implementation of an efficient way of storing a large amount of data, especially storage of data on package transport conditions, for faster and easier processing of a large amount of data. Another functionality would be the implementation of more complex algorithms for sorting the list of delivery requests. It is also planned to introduce a system of mutual evaluation of users which could influence the sorting and display of the list of requested deliveries to certain users of the system. In addition to the implementation of additional functionality, more detailed testing of the proposed system for food delivery using cargo-bikes with IoT is planned.

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Development of a New Model for Performance Measurement Based on the Tool for Action Plan Selection

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Abstract. With the aim to present a new method for improving industrial company performances, this study will present a new model for performance measurement and management using Tool for Action Plan Selection (TAPS). As a software tool, TAPS assist managers to define goals, measure Key Performance Indicators (KPIs) and create strategic decisions. The new model defines the main functional areas of an industrial company as four sectors with KPIs are measured by sector managers and are giving general management information about their influence on the defined objective. Non-parametric statistical analysis with Wilcoxon rang test showed the difference between assessment for functional areas of general managers and average scores of KPIs for functional areas of sector managers. The research is conducted within eight international industrial companies and the results give information about the most important KPIs. The results of this research are can be used as guidelines and support for the management of international industrial companies in the process of strategic decisions making.

Keywords: TAPS · Performance · KPIs · Measurement · Management

1 Introduction

Many Researchers analyze the relationship between Strategy and Management, as well as their influence on companies performances [1]. Performance measurement deliver reliable information for supporting managers in decision-making [2]. Performance of industrial companies can be improved by reviewing how well processes work and by making adjustments in order to make them operate more efficiently and effectively [3].

Performance management can be defined as a continuous process of identifying, measuring, and developing the performance and aligning it with strategic objectives of industrial companies [4]. Managers need information about strategies and action plans to be presented in a meaningful format [5] with appropriate visual representation, which is provided by an efficient structure for expressing data [6].

Tool for Action Plan Selection (TAPS) will be presented in this research, as a program which provides modelling outputs, as well as measurements of performance in four core sectors of industrial companies. Within every sector the most influential KPIs

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will be defined and analysed based on the assessment of their impact made by the management of industrial companies, which was researched by survey.

2 Theoretical Background

Organizational effectiveness has always measured how successful organizations achieve their missions through their core strategies [7]. Some researches focus on internal organizational factors when defining criteria of performance, such as organizational goals or the procedures for accomplishing these goals [8]. In order to develop performance metrics, we begin grouping the organization's resource - gathering and resource – disbursing activities into five clusters: inputs, activities, outputs, outcomes, and impacts [9].

The performance measurement models evolved from a cybernetic view, where performance measurement was based mainly on financial measures and considered a component of planning and control cycle, and they grew to a holistic view based on multiple nonfinancial measures, where performance measurement acts as an independent process integrated in a broader set of activities [10]. Performance measurement is thus implicitly linked to the notion of diagnostic control systems, described as formal feedback systems used to monitor organizational outcomes and correct deviations from the present standards of performance [11].

Key performance indicator (KPI) is a number or values which can be compared against an internal target, or an external "benchmarking" target to give an indication of performance. That value can relate to data collected or calculated from any process or activity [12]. An essential requirement for tracking achievement of set goals is a suitable choice of KPIs for assessment of production performance [13].

TAPS software will be used in this research as a tool which helps managers in creating action plans. It is based on relation between defined KPIs and their influence on defined objectives of Industrial Companies. Action plans creation requires making structural decisions (technology, capacity etc.) and infrastructural decisions (performance measurement, organization, etc.), so managers need to analyse many KPIs before creating action plans [14].

3 Objectives and Hypotheses

Research objectives can be defined as follows:

- Objective 1: Creating a model with the main sectors and KPIs within each sector which could be analysed with the aim to create strategies for industrial companies.
- Objective 2: Analysing defined KPIs and their influence on defined objective of industrial companies - efficient production with minimum costs.

Hypotheses in accordance with the aim of the research can be defined as follows:

- Hypothesis 1: There is a possibility for creating a model for assessing quantities of defined KPIs as critical factors in the decision-making process that influence defined goals of industrial companies.

– Hypothesis 2: Relations and values of KPIs can be analysed with the aim to ensure better management decisions.
– Hypothesis 3: General Managers of industrial companies do not have enough information about all important KPIs and there can be more possibilities for organizing effective production with minimum cost than it was assessed by the general management.

4 Methodology

The research will be conducted with the creation of the model based on input-process-output-outcome model [15] which will be analysed by creating the new model includes defining goal, four functional areas and sixty KPIs. The model will be analysed conducting a survey based on Likert-type scale with data processing of the results in program TAPS and statistical analysis.

The proposed method based on Connectance Model is developed for production management system which contains over 200 variables and shows their correlations which are displayed in a network diagram [16, 17]. Analysing effects of changes in input variables on the values of output variables managers could easier make strategic decision with the aim to reach the companies objective.

The Burbidge original model has been further developed as a tool for addressing the issues of identifying the range of action plans – TAPS, which assist managers in making strategic decisions and assessing factory performance drivers. The tool is implemented using Microsoft's Visual Basic 6.0 programming language and has four main modules [18]:

1. Database for storing the variable information
2. Graphic user interface for displaying the variable information in a connectance diagram
3. Analysis using functions for analysing any variable and
4. Evaluation which supports managers in prioritising action plans.

Statistical analysis will be made using Wilcoxon signed ranks test for testing the difference between assessment for functional area of general managers and average scores of KPIs of functional areas of sector managers.

5 Example

TAPS program was used for analysing the impact of defined KPIs in industrial companies, but until now has not been used for quantitative analysis of the impact of KPIs on objectives of industrial companies which are defined in this paper, as well as using the method for TAPS implementation which will be presented in this research.

The survey was conducted on a sample that includes eight international industrial companies that organize production in different countries and also in the Republic of Serbia in different branches such as Pharmaceutical, Automotive, Ceramic Production, Oil and Gas Industry, Cosmetics Production, Production of Household Appliances, Conductors Production and Port of Novi Sad. The study surveyed senior management who analysed the overall ability for Efficient production with minimum total cost and middle management, who analysed the influence of defined KPIs on Efficient production with minimum total cost of the whole company in four sectors: Marketing and Sales, Logistics and Manufacturing, Finance and Accounting and Human Resources. The survey included questions for senior management to assess the impact of each sector on the defined objective and questions for sector managers to assess the impact of each of the fifteen defined KPIs per sector on the defined objective.

On the graphic representations of the KPIs in TAPS program Efficient production with minimum costs will be marked as 1 with four perspectives: Marketing and Sales will be marked as 11, Logistics and Manufacturing as 12, Finance and Accounting as 13 and Human Resources as 14. KPIs within the perspectives will be marked with number of perspective connected with the number of the KPI within the perspective, and there can be defined sixty KPIs [19–21].

6 TAPS Applied for Analysis in Industrial Companies

The analysis was done for all eight companies, but as an example the result of the survey conducted in the eighth company that worked with the TAPS is shown in Fig. 1, and the analysis results of other companies will be shown in the full analysis.

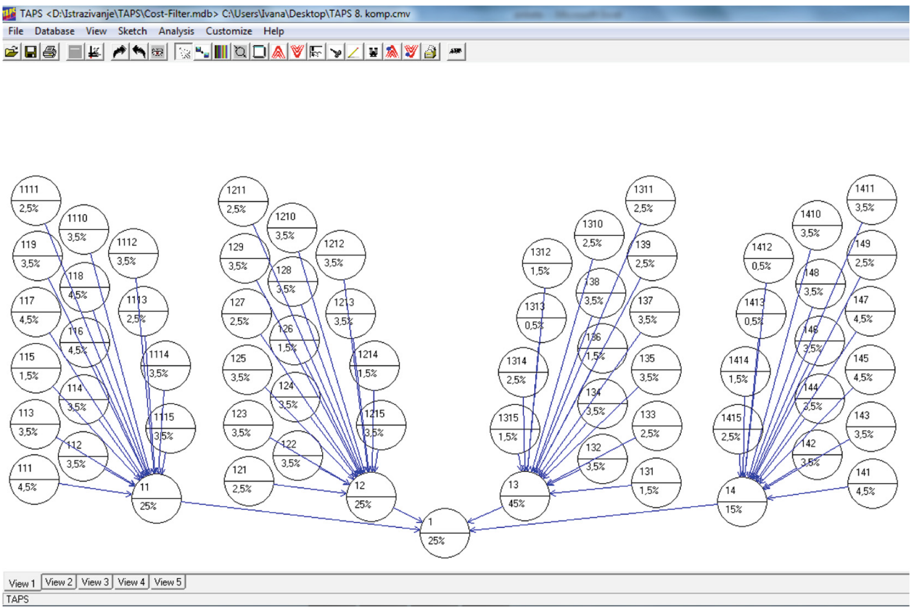

Fig. 1. Graphical presentation of KPIs in the TAPS program for the eighth industrial company.

In Table 1 are shown the results of the most influential KPIs in the eighth industrial company:

Table 1. The most influential KPIs in the eighth industrial company.

IP	1	11	12	13	14	111, 116, 117, 118	122, 123, 124, 125, 128, 129, 1210, 1212, 1213, 1215	132, 134, 135, 137, 138	141, 145, 147
8	25%	25%	25%	45%	15%	4,5%	3,5%	3,5%	4,5%

The most influential KPIs of the: sector 11 have impact: 0,25*0,25*0,045 = 0,0028125, sector 12 have impact: 0,25*0,25*0,035 = 0,0021875, sector 13 have impact: 0,25*0,45*0,035 = 0,0039375, sector 14 have impact: 0,25*0,15*0,045 = 0,0016875.

In the eighth Industrial company the most influential KPIs belong to sector 13, their influence is 0,0039375, and they are following KPIs:

132 - Inventory turnover ratio
134 - Profit per product
135 - Net income
137 - Low level of investment
138 - Liquidity index

Analysis of the most influential KPIs in eight industrial companies (IC):

1.IC: 0,0013125; 2.IC: 0,0023625; 3.IC: 0,0013125; 4.IC: 0,0010125; 5.IC: 0,0055125; 5.IC: 0,0010125, 6.IC: 0,0016825; 7. IC: 0,0039375.

Comparing the most influential KPIs in eight industrial companies, it can be concluded:

- The most influential KPIs in four industrial companies: 123 - Overall efficiency of technological systems, 126 - Low transport costs
- The most influential KPIs in three industrial companies: 124 - Preparatory - final time
- The most influential KPIs in two industrial companies: 113 - Index of number of new customers during the period, 116 - Time from investment to cash collection, 1110

Recognition of the company's brands on the market, 121 - Ratio of realized orders and deliveries, 125 - Quality of transport, 129 - Reliability of logistical support, 134 - Profit per product, 135 - Net income, 141 - The efficiency of employees, 142 - Professional expertise of employees, 143 - Motivation of employees, 1410 - Competent external partners, 1412 - Patents and licenses.

7 Non-parametric Statistical Analysis

The survey was conducted through interviews of general management about possibilities for organizing efficient production with minimal costs and middle management as sector managers to assess fifteen KPIs within each sector, so it opens opportunities for Non-parametric statistical analyses. Non-parametric statistical analysis was conducted with the aim to analyse assessment from General managers of eight industrial companies for four defined functional areas -sectors and the average scores of KPIs assessed by Sector managers.

7.1 Testing the Difference Between the General Managers Assessment of Sectors and Average Scores of KPIs of Functional Areas from Sector Managers

In order to investigate the existence of a statistically significant difference between the general managers Assessment of sectors and Average scores of KPIs of functional areas from sector managers, Wilcoxon signed-rank test was used. This test is a non-parametric alternative to the t-test for dependent samples. It is designed to test hypotheses about the location (median) of population distribution. Given that these are two ways of measuring the same phenomenon, it was analysed whether these two measures differ. The Wilcoxon Signed Ranks Test often involves the use of matched pairs. The test computes the differences between the two variables for all cases and classifies the differences as positive, negative, or tied [22]. Table 2 shows the descriptive KPIs for Assessment for sector of general managers and Average scores of KPIs of functional areas from sector managers as the results of Wilcoxon rank test.

Table 2. Wilcoxon rang test: testing the difference between the Assessment for sector of general managers and Average scores of KPIs of sector from sector managers.

	N	Mean	Std. deviation	Percentiles			Z	Asymp. sig. (2-tailed)
				25th	50th (median)	75th		
Assessment for sector of general managers (all sectors together)	32	2.3750	1.09985	1.2500	2.0000	3.0000	−3.899	.000
Average scores of KPIs of sector from sector managers (all sectors together)	32	3.4675	.49955	3.1650	3.5650	3.7825		

Wilcoxon rank test shows that the Assessment for sector of general managers is significantly different compared to the Average scores of KPIs of functional areas from sector managers. Ratings for the functional area of general managers (median = 2.00) were significantly lower compared to the average estimates of KPIs of functional area from sector managers (median = 3.56). It can be concluded that analysing KPIs within each functional area gives general management the result that there are more possibilities for organizing effective production with minimum costs.

7.2 Testing the Difference Between the General Management Assessment of Functional Areas and Average Scores of KPIs of Functional Areas from Sector Managers Separately for Functional Areas

In order to investigate the existence of a statistically significant difference between the Assessment for functional area of general managers and Average scores of KPIs of functional area from sector managers the Wilcoxon signed-rank test was also used, but so that there are observed reviews separately for each sector. Descriptive evaluation of KPIs for each sector separately, as well as the results of Wilcoxon rank test are shown in Table 3.

Table 3. Wilcoxon rang test: testing the difference between the Assessment for functional area of general managers and Average scores of KPIs of the functional area from sector managers.

	N	Mean	Std. deviation	Percentiles			Z	Asymp. sig. (2-tailed)
				25th	50th (median)	75th		
Assessment for functional area of general managers for sector MS	8	2.3750	.91613	1.2500	3.0000	3.0000	−1.690	.091
Average scores of KPIs of functional area from sector managers for sector MS	8	3.3838	.69412	3.1000	3.5350	3.9325		
Assessment for functional area of general managers for functional area LP	8	2.6250	1.06066	2.0000	2.5000	3.7500	−2.103	.035
Average scores of KPIs of functional area from sector managers for sector LP	8	3.7337	.24065	3.6000	3.6350	3.8350		
Assessment for functional area of general managers for functional area FA	8	2.0000	1.60357	1.0000	1.0000	3.5000	−1.960	.050
Average scores of KPIs of functional area from sector managers for sector FA	8	3.2788	.37384	3.0175	3.2100	3.6200		
Assessment for functional area of general managers for functional area HR	8	2.5000	.75593	2.0000	2.0000	3.0000	−2.366	.018
Average scores of KPIs of functional area from sector managers for sector HR	8	3.4763	.54222	3.1000	3.5000	4.0025		

Analysing the differences for each functional area separately, a statistically significant difference between the ratings for general managers Assessment of functional areas and Average scores of KPIs of functional area from sector managers are obtained for the functional areas LP (Logistics and Production) and HR (Human Resources). On the border of statistical significance are the results for the FA (Finance and Accounting) functional area, while differences were not obtained for the MS (Marketing and Sales), estimates do not differ for MS. Ratings for the functional areas from general managers are for all factors lower than the average scores of KPIs of sector managers, but as for functional areas LP and HR these differences were statistically significant, so it can be concluded that in these two functional areas indicators gives result there are more possibilities for organizing effective production with minimum cost than it was assessed from general management.

8 Findings

The results obtained in this research include information and knowledge of the most influential KPIs within each of the defined four main functional areas within the industrial companies on achievement defined objective – effective production with minimum costs. The most influential KPIs show managers the most critical factors for achieving defined objective, and statistical analysis shows that using the new model for KPIs measurement General Managers could make better strategic decisions.

9 Contribution

The new model for KPIs analysing can be applied in all industrial companies for performance measurement and decision-making. The program that was used for analysing KPIs has not been applied for performance management in a way that it was applied in this study and based on the conducted survey the most influential KPIs on defined objectives are found and used for strategy creation.

10 Conclusion

Considering that in the results of four industrial companies the show that on the organization of efficient production with minimum costs the greatest impact have Overall efficiency of technological systems and Low transport costs, it leads to the conclusion that the Overall efficiency of technological systems is the basis for efficient production and that savings in transportation affects cost reduction most.

Transportation costs can be reduced by various methods, but the most effective method is organising industrial production in the area close to suppliers and customers. This fact is important for creation of global strategies, whereby international industrial companies could organise production in locations that among other benefits also reduce transportation costs. Based on the research and different methods, defined hypotheses are proven as follows:

– Hypothesis 1: In the conducted research it has been proven that there is a possibility for creating a model with defined objective of industrial companies and four main sectors with KPIs as critical factors in the decision-making process that influence on the objective defined.
– Hypothesis 2: The research has confirmed the assumption that measuring the values of KPIs can be analysed with the aim to ensure better management decisions and that can be applied in industrial companies.
– Hypothesis 3: Non-parametric statistical analysis with Wilcoxon signed ranks test gives result there are more possibilities for organizing effective production with minimum costs than it was assessed from general management.

Research results present the new model for analysing KPIs suitable for International industrial companies which operate worldwide. Using this model General Managers could have information about all important KPIs on defined objective which is necessary for strategic decisions and better company performance.

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SFM for Supporting Performance Measurement and Management

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Abstract. The aim of the research is to present Shop Floor Management (SFM) convenient for supporting measurement and management of Key Performance Indicators (KPIs). SFM is a closed loop process to observe the problems on site and supports the consistent development of processes and procedures including problem solving to attack sporadic and chronicle issues. The benefit of SFM relies not on the presence of tools but rather on their consistent, process-driven application. SFM is a structured approach with the aim to link the management level with operative processes and employees where visualization takes an important role. This research helps in understanding practical usage of SFM and analysis of KPIs that could be implemented. The empirical part of the study is based on Research from 10 shop floors in the same industry based in Central and Eastern Europe in order to investigate correlations between KPI measurement and scores on the level of implementation and Managerial responsibility.

Keywords: SFM · Performance · Management

1 Introduction

Competitive business environment challenges organization to have vision, objectives and to make optimal steps to go toward them. Importance of strong link between vision and everyday objectives is inevitable. Shop Floor Management (SFM) with pragmatic principles supports everyday measurement and management of Key Performance Indicators (KPIs), including problem solving to attack sporadic and chronicle issues. Relevant initial factor is to provide strategy deployment and prioritization to all levels. Communication and people empowerment are essential for further steps.

According to the current business surroundings, there is a need for more research in that field including implementation of SFM in practice.

2 Theoretical Background

Organizations that use methods for measuring performance have the ability to achieve competitive advantages [1]. KPIs are set of measures focused on the aspects of the organizational performance that are most critical for success of the organization [2].

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KPIs are used for performance measuring, as well to reflect the critical factors of organizational success [3]. KPIs could also be defined as variables that provide a meaningful, concise, general picture of the organizational performance and its processes [4].

The introduction of new management practices is an important issue for organizations which want to upgrade their productivity, improve the quality of customer offerings and retain competitiveness [5, 6]. Among these practices, Lean Manufacturing is often regarded as the most important strategy for manufacturing firms desiring to achieve world-class performance [7, 8].

SFM can be defined as a closed loop process to observe the problems on site. Since SFM emerges from the context of Lean Production, it has links to many other components of Lean Principles like Visual Management, Performance Management, Leadership Systems, Continuous Improvement Process and Systematic Problem Solving [9]. Implementation of Lean Methods on the shop floor contains six main areas: Empowering every single employee, Presence of leading personnel on the shop floor, Using various concepts of visualization, Introducing new organization forms like mini-factories, Fostering the application of improvement and problem solving processes and Facilitating competency development on the shop floor [10].

3 Objectives and Hypotheses

The main objective is presentation of SFM for supporting measurement and management of KPIs. Objectives can be also defined as researching influence of KPIs on company performance, production planning and control. Hypothesis in accordance with the aim and subject of the research can be defined as follows:

- H1: With a high degree of certainty can be argued that SFM is convenient for supporting measurement and management of KPIs and
- H2: Correlations between measurements of defined KPIs and scores on the level of implementation could be investigated.

4 Methodology

Great performance management system is more than just colourful set of reports, or the tracking the right metrics, it is also the right approach to manage dynamics of performance. The people who operate the process must be able to see critical measures of performance so they can take the right steps to make high performance. The benefit of SFM relies not on presence of tools but rather on their consistent, process-driven application [11].

Frontline managers are directly responsible for managing the vast majority of a company's employees and, therefore, have exceptional leverage on company performance [12]. The leading personnel should be recognized at the shop floor, which enhances motivation of the workforce and facilitates the problem solving process [13].

5 Research

Research is done in 10 shop floors in same industry with same production and similar headcount (450–500). The KPIs measured are: Stage of implementation of shop floor management, Level of responsibilities of first line managers, Number of KPIs followed and routine to follow/take action, Number of lean tools used, Correlation between first two variables and percentage of defects eradicated, Correlation between first two variables and 5 key drivers improvement over the last three years and Correlation between first two variables and number of lean tools used.

6 Findings

In the first part of practical research, Level of implementation has been used as independent variable, and it was analysed in correlation with variables: Managerial responsibilities of SF Managers, Routines implemented, Basic tools implemented, Intermediate tools implemented, Advanced tools implemented, Safety results, Financial results, Continuous improvement results and Total results. Correlation was checked using Spearman rank of correlation and nonparametric test of high power (see Table 1).

Table 1. Correlation between the variables determined by Spearman's rank correlation.

		Stage
Shop floor Managers managerial responsibilities	ρ_S	.762*
	P	.010
	N	10
Routines implemented	ρ_S	.961**
	P	.000
	N	10
Basic tools applied	ρ_S	.730*
	P	.017
	N	10
Medium tools applied	ρ_S	.959**
	P	.000
	N	10
Advanced tools applied	ρ_S	.747*
	P	.013
	N	10
Safety results	ρ_S	−.535
	P	.111
	N	10

(*continued*)

Table 1. (*continued*)

		Stage
Continuous improvement results	ρ_S	.932**
	P	.000
	N	10
Financial results	ρ_S	−.103
	P	.776
	N	10
Kpi	ρ_S	.767**
	P	.010
	N	10

*. Correlation is significant at the level of 0.05 (2-way).
**. Correlation is significant at the level of reliability of 0.01 (2-way).

It was found that: with a higher level of implementation increase: number of managerial responsibilities of SF managers ($\rho S = .762$, $p < 0.05$), number of implemented routine ($\rho S = .961$, $p < 0.01$), number of implemented basic tools ($\rho S = .730$, $p < 0.05$), number of implemented medium tools ($\rho S = .959$, $p < 0.01$) and number of implemented advanced tools ($\rho S = .747$, $p < 0.05$).

Regarding correlation with basic results, results are following (see Table 1). It was found that: with a higher level of implementation, total results are improved ($\rho S = .767$, $p < 0.05$), safety results are improved ($\rho S = -.535$, $p > 0.05$), continuous improvement results are improved ($\rho S = .932$, $p < 0.01$) and financial results are improved ($\rho S = .762$, $p > 0.05$).

In the second part, number of managerial responsibilities of Shop floor managers, is used as independent variable, and as depended: Routines implemented, basic tools implemented, Intermediate tools implemented, Advanced tools implemented, Safety results, Financial results, Continuous improvement results and Total results. Spearman correlation rang showed that with the increasing number of responsibilities of SF manager increases the number of implemented routines ($\rho S = .760$, $p < 0.05$), number of implemented basic tools ($\rho S = .762$, $p < 0.05$), number of implemented routines medium tools ($\rho S = .767$, $p < 0.05$), number of implemented routines advanced tools ($\rho S = .770$, $p < 0.01$).

It was not found that with a higher managerial responsibilities of SF managers, safety results are improved ($\rho S = -.143$, $p > 0.05$) and financial results are improved ($\rho S = .762$, $p > 0.05$). It was found that with a higher managerial responsibilities SF managers, continuous improvement results are improved ($\rho S = .660$, $p < 0.05$) and total results are improved ($\rho S = .661$, $p < 0.05$). Correlations between the variables determined by Spearman's rank correlation are presented in Tables 2 and 3.

Table 2. Correlation between the variables determined by Spearman's rank correlation.

		Level	Responsibility	Routines	Basic. tools	Med. tools	Ad.tools	Safet	Improv	Financ	Kpi
Level	ρ_S	1.000	.762*	.961**	.730*	.959**	.747*	−.535	.932**	−.103	.767**
	p	.	.010	.000	.017	.000	.013	.111	.000	.776	.010
	N	10	10	10	10	10	10	10	10	10	10
Responsibility	ρ_S	.762*	1.000	.760*	.762*	.770**	.740*	−.143	.660*	.224	.661*
	p	.010	.	.011	.010	.009	.014	.694	.038	.535	.038
	N	10	10	10	10	10	10	10	10	10	10
Routines	ρ_S	.961**		1.000	.770**	.923**	.700*	−.408	.928**	.085	.850**
	p	.000		.	.009	.000	.024	.242	.000	.814	.002
	N	10		10	10	10	10	10	10	10	10
Basic.tools	ρ_S	.730*		.770**	1.000	.771**	.705*	−.287	.537	.051	.577
	p	.017		.009	.	.009	.023	.422	.109	.889	.081
	N	10		10	10	10	10	10	10	10	10
Med.tools	ρ_S	.959**		.923**	.771**	1.000	.824**	−.629	.851**	−.012	.735*
	p	.000		.000	.009	.	.003	.052	.002	.973	.016
	N	10		10	10	10	10	10	10	10	10
Ad.tools	ρ_S	.747*		.700*	.705*	.824**	1.000	−.624	.556	.004	.464
	p	.013		.024	.023	.003	.	.054	.095	.992	.176
	N	10		10	10	10	10	10	10	10	10

*. Correlation is significant at the level of 0.05 (2-way).
**. Correlation is significant at the level of reliability of from 0.01 (2-way).

Table 3. Correlation between the variables determined by Spearman's rank correlation.

		Level	Responsibility	Routines	Basic. tools	Med. tools	Ad.tools	Safet	Improv	Financ	Kpi
Safet	ρ_S	−.535		−.408	−.287	−.629	−.624	1.000	−.375	.314	−.181
	p	.111		.242	.422	.052	.054	.	.285	.378	.617
	N	10		10	10	10	10	10	10	10	10
Improv	ρ_S	.932**		.928**	.537	.851**	.556	−.375	1.000	.061	.881**
	p	.000		.000	.109	.002	.095	.285	.	.867	.001
	N	10		10	10	10	10	10	10	10	10
Financ	ρ_S	−.103		.085	.051	−.012	.004	.314	.061	1.000	.482
	p	.776		.814	.889	.973	.992	.378	.867	.	.159
	N	10		10	10	10	10	10	10	10	10
Kpi	ρ_S	.767**		.850**	.577	.735*	.464	−.181	.881**	.482	1.000
	p	.010		.002	.081	.016	.176	.617	.001	.159	.
	N	10		10	10	10	10	10	10	10	10

*. Correlation is significant at the level of 0.05 (2-way).
**. Correlation is significant at the level of reliability of from 0.01 (2-way).

As a third part, factories have been clustered, using hierarchical cluster analysis. This method is average distance (average linkage) as a rule of association (amalgamation rule) and Euclidean distance as a measure of the distance. Factories can be grouped according to all indicators into three clusters as follows: The first cluster consists of factory 2, 8 and 10 (named Worse), the second cluster consists of plant 4, 7 and 9 (named Medium), and the third cluster consists of plant 1, 3, 5 and 6 (named Better).

According to Dendrogram it seems that groups of Medium and Better are more similar with measured characteristics (Fig. 1).

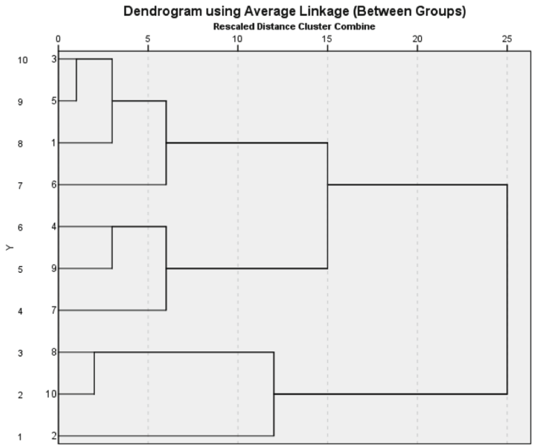

Fig. 1. Dendrogram showing the sequence of association factories.

Comparison of three clusters is done with Kruskal-Wallis test (Table 4). It was found that they are different in: Level of implementation ($\chi2(df = 2) = 8.481$, $p < .05$), Managerial responsibility ($\chi2(df = 2) = 6.792$, $p < .05$), Implemented routines ($\chi2(df = 2) = 8.647$, $p < .05$), Medium tools applied ($\chi2(df = 2) = 8.321$, $p < .05$), Continuous improvement results ($\chi2(df = 2) = 7.699$, $p < .05$) and KPI results ($\chi2(df = 2) = 6.018$, $p < .05$).

Table 4. Kruskal Wallis test.

	χ^2(df)	df	P
Level of implementation	8.481	2	.014
Managerial responsibility	6.792	2	.033
Routines implemented	8.647	2	.013
Basic tools applied	5.024	2	.081
Medium tools applied	8.321	2	.016
Advanced tools applied	5.625	2	.060
Safety results	1.844	2	.398
Continuous improvement	7.699	2	.021
Financial results	.479	2	.787
Kpi results	6.018	2	.049

Comparisons of each cluster with each another, post-hoc tests, were performed by Mann-Whitney test, and it was found (Table 5):

– Level of implementation - there are three different groups, so the highest score had better cluster, and the lowest worse cluster;
– Managerial responsibility of SF Managers - there is a difference between better and worse cluster as well as between better and medium cluster, and in both comparisons better cluster were better;
– Routines implemented - there are three different groups, so the highest score had better cluster, and the lowest worse cluster;
– Medium tools applied - there are three different groups, so the highest score had better cluster, and the lowest worse cluster;
– Continuous improvement results - there are three different groups, so the highest score had better cluster, and the lowest worse cluster;
– KPI results - there is a difference between better and worse cluster as well as between better and medium cluster, and in both comparisons better cluster was better.

Table 5. Post hoc tests for differences between clusters defined with Mann-Whitney test.

Compared clusters	Worse-medium			Worse-better			Medium-better		
	MWU	Z	P	MWU	Z	p	MWU	Z	p
Level of implementation	.000	−2.121	.034	.000	−2.223	.026	.000	−2.291	.022
Responsibility of SFM	4.500	.000	1.000	.000	−2.223	.026	.000	−2.201	.028
Routines implemented	.000	−2.023	.043	.000	−2.366	.018	.000	−2.366	.018
Medium tools applied	.000	−2.121	.034	.000	−2.223	.026	.000	−2.160	.031
Cont. improvem. results	.000	−1.964	.050	.000	−2.121	.034	.500	−1.962	.050
KPI results	1.000	−1.528	.127	.000	−2.121	.034	2.000	−1.414	.157

Legend: MWU Mann-Whitney U statistic

As forth, it has been used Friedman test to analyze the factories with higher level of implementation and higher managerial responsibility of SF Managers who have better general progress. Friedman test is used for repeated measures whether progress in some dimensions of the overall sample is observed.

The answers to these questions are provided firstly by Friedman test: The improvement in safety result is not observed ($\chi2(df = 2) = 4.957$, $p > .05$); The progress in Continuous improvement results is not observed ($\chi2(df = 2) = 1.636$, $p > .05$); The improvement in financial results is observed ($\chi2(df = 2) = 6.741$, $p < .05$); There was no progress in Continuous improvement results, in Medium cluster results in 2015 were slightly better, and among factories in Better cluster are the highest improvements from year to year. In terms of financial status the results are slightly unclear. The most critical results observed in 2015 (Fig. 2).

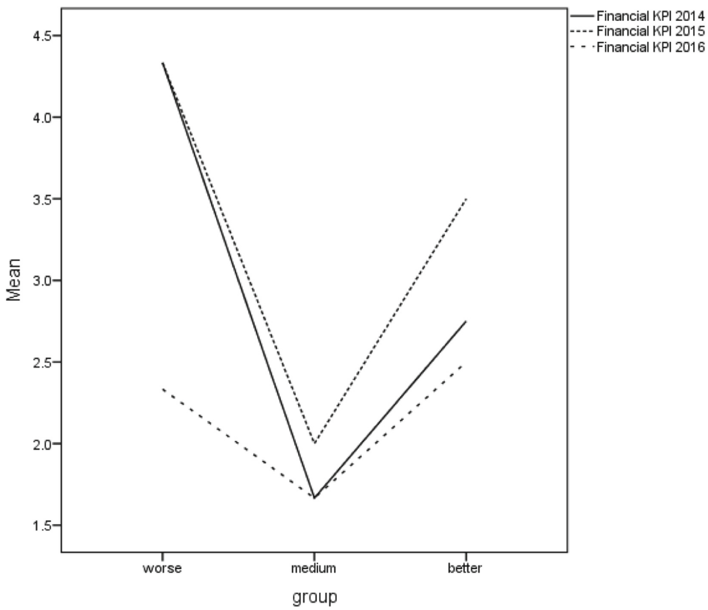

Fig. 2. Comparison of clusters on Financial results by year.

Correlations between KPI measurements and scores on the level of implementation (stage) and Managerial responsibility of SF managers (responsibility) as it is presented in Tables 6 and 7, show that they are associated with improvement. Relation between Level of implementation and Continuous improvement results oscillated, it was stronger in 2014 but fell in 2015 and increased in 2016. With responsibility it was linked only by Continuous improvement results in 2014.

Table 6. Correlation between KPI measurement and Stage and Responsibility.

		Stage	Responsibility
Safety KPI 2014	ρ_S	−.369	−.036
	p	.294	.921
	N	10	10
Safety KPI 2015	ρ_S	−.199	.122
	p	.581	.738
	N	10	10
Safety KPI 2016	ρ_S	−.298	−.473
	p	.402	.168
	N	10	10

Table 7. Correlation between KPI measurement and Stage and Responsibility.

		Stage	Responsibility
Continuous improvement KPI 2014	ρ_S	.897**	.758*
	p	.000	.011
	N	10	10
Continuous improvement KPI 2015	ρ_S	.784**	.382
	p	.007	.276
	N	10	10
Continuous improvement KPI 2016	ρ_S	.910**	.580
	p	.000	.079
	N	10	10
Financial KPI 2014	ρ_S	−.111	.311
	p	.760	.381
	N	10	10
Financial KPI 2015	ρ_S	−.117	.260
	p	.747	.468
	N	10	10
Financial KPI 2016	ρ_S	.073	.253
	p	.842	.480
	N	10	10

7 Conclusion

SFM supports the consistent development of processes and procedures. It offers different advantages in production planning including faster information flow, transparent overview of all relevant data, direct support of management, cost reduction, shorter reaction times to deviations, sustainable and structured problem solving, optimal use of resources as well as efficient communication, planning and control.

In this research the focus was on investigating SFM that gives organizations benefit to analyze correlations between KPIs measurements and scores on the level of implementation and Managerial responsibility. Using SFM, organizations will benefit from more stable processes and aligned decision making rather than reactive problem solving.

Based on the research and use of various methods, hypotheses are proven as follows:

– H1: It has been proven that with a high degree of certainty SFM is convenient for supporting measurement and management of KPIs and
– H2: There is evidence that correlations between measurements of defined KPIs and scores on the level of implementation could be investigated.

In addition to maintaining existing standards, SFM has to provide a consistent approach and methodology to facilitate sustainable efficiency improvement.

According to the research it can be concluded that there is an influence of defined KPIs to company performance. The Paper has limitations since it is based on the sample with defined KPIs and methods. Because of those reasons, further research SFM should be more implemented in a bigger sample for performance measuring, defining different KPIs and including different statistical methods.

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An Iterative Cyclic Algorithm for Designing Vaccine Distribution Networks in Low and Middle-Income Countries

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Abstract. The World Health Organization – Expanded Programme on Immunization (WHO-EPI) was developed to ensure that all children have access to common childhood vaccinations. Unfortunately, because of inefficient distribution networks and cost constraints, millions of children in many low and middle-income countries still go without being vaccinated. In this paper, we formulate a mathematical programming model for the design of a typical WHO-EPI network with the goal of minimizing costs while providing the opportunity for universal coverage. Since it is only possible to solve small versions of the model optimally, we describe an iterative heuristic that cycles between solving restrictions of the original problem and show that it can find very good solutions in reasonable time for larger problems that are not directly solvable.

Keywords: Vaccines · Network design · Mixed integer programming · Heuristics

1 Introduction

Infectious diseases are one of the main causes of mortality in low and middle-income countries, and over the years it has been repeatedly proven that one of the best strategies to protect against many diseases is an effective program of childhood vaccination. Over the years many diseases such as polio and small pox have been virtually eliminated and the incidences of many others like measles, rubella, tetanus, pertussis, and diphtheria have been vastly reduced. A World Health Organization (WHO) report on immunization [1] indicates that immunization is one of the most cost-effective investments and results in 2 to 3 million deaths being averted each year.

The first major initiative to provide universal access to all important vaccines for children was the Expanded Programme on Immunization (EPI), which was established in 1974 [2]. The second major initiative in this regard was the Global Alliance for Vaccines and Immunization, or Gavi as it is better known, which was formed in 2000 [3]. The main focus of Gavi was on the poorest countries, mainly in sub-Saharan Africa and Asia, where the vaccination rates were the lowest. It is estimated that EPI and Gavi have been responsible for saving millions of lives worldwide and for almost completely eliminating diseases like polio and measles [4].

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While immunization rates have been rising steadily over the years, coverage is still only around 85% (and even lower in many countries) and it is estimated that another 1.5 million deaths per year could be avoided if global vaccination coverage could improve further. For example, in the most recent year for which data is available almost 20 million children under the age of one worldwide did not receive the recommended three doses of DTP-3 vaccine that protects against diphtheria-tetanus-pertussis [5]. Coverage rates are generally quite high in developed countries, but many low and middle-income countries still suffer from inadequate coverage and present vast opportunities for improvement [6]. There are many reasons why vaccination rates are low in poorer countries. These include limited health budgets and resources, weak or unreliable infrastructure, poorly designed distribution chains, a lack of scientific healthcare management, inadequate or faulty equipment, lack of transportation resources, poor monitoring and supervision, inadequate access to facilities, and even religious reasons [7]. In general, the primary challenge is not so much in obtaining the vaccines as it is in ensuring that these are shipped, stored and delivered to the recipients at the end of the distribution chain in a cost-efficient fashion. A major consideration for the distribution system is that vaccines require narrowly defined temperatures of between 2 and 8 °C during storage and transportation, i.e., we must deal with a so-called "cold" chain.

In most low and middle-income countries, vaccines are usually distributed via a hierarchical legacy medical network determined by political boundaries and history. These networks also have a rigid structure that is replicated in most of these countries. In particular, there has been virtually no attempt to design vaccine distribution networks with flexible structures and operational characteristics tailored to the demographic, geographical and other features of a specific country. The goal of the work presented in this paper is to introduce a mathematical model for redesigning the EPI vaccine distribution network in any country. The model adheres to established WHO guidelines and also emphasizes the operational simplicity that is important in low and middle-income countries that often lack management abilities required for more sophisticated systems. We illustrate how our model can be used by using data that is derived from several different countries.

2 Problem Development

A typical vaccines distribution network uses a four-tier hierarchical architecture such as the one shown in Fig. 1. Vaccines are purchased or obtained through donations from international organizations and shipped by air once or twice a year. They are then stored in a *national* distribution center in a large city (usually the capital) in the nation where it is to be distributed. Quarterly shipments of vaccines in the required amounts are then made to *regional* distribution centers (typically, fewer than 10), usually via specialized vehicles like temperature-controlled cold trucks. The regional centers then transport vaccines to *district* centers (typically, 40 to 80) that fall under their domain. This is usually done every month using 4×4 trucks with cold storage boxes or vaccine containers. The last node in the distribution chain is a *clinic* or health center (typically, several hundred of these) where infants and children come and receive vaccinations. A clinic obtains its required amounts of vaccines from the district center to which it is assigned. This usually happens once a month using locally available means of transportation such as cars, trucks, motorcycles, bicycles, etc. that move the vaccines in a vaccine carrier/cooler for storage in refrigerators at the clinic.

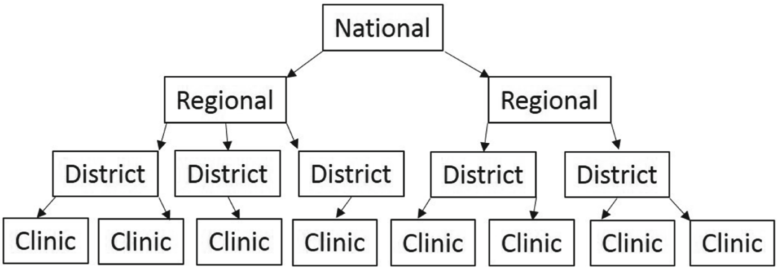

Fig. 1. A typical four-tier vaccine distribution network.

While there might be one more or one fewer intermediate level in some places, almost all countries distribute vaccines from the central store to individual clinics using a network that is very similar to the one just described. However, there is no compelling reason as to why the network should have this strict hierarchical structure everywhere. For instance, it might make more sense for a district to be supplied by another district, or for a clinic to be supplied directly by a regional center or for a district to be supplied by the national center. Replenishment frequencies at districts and regions could also be more flexible as long as they are not too complicated for the logistics expertise at hand.

To develop an optimal network design with more flexible operational policies, we combine the district and regional centers into the same pool and simply refer to them as hubs. Thus, our overall problem is to design a network that will move vaccines from the central store to individual clinics around the country through a system of intermediate hubs, while minimizing the overall cost of transportation, facilities and storage across the network. In line with WHO guidelines, the constraints of this optimization problem must ensure that there is *opportunity* for 100% of all demand for the area served by a clinic to be satisfied, while using recommended replenishment frequencies, picking from approved storage devices [8] and available transportation modes, and meeting constraints on both storage and transportation capacity. The decisions consist of hub allocations for each clinic, all hub-to-hub and national store-to-hub connections, vaccine flows along these connections, and the types of storage and transportation devices to be used at each selected location and along each selected connection. In our problem formulation we only consider the total volume of vaccines shipped; these volumes are determined by the space requirements for the individual vaccines in the country's vaccine regimen as determined from available data. Each open facility has an associated annual operational cost. With a view to operational simplicity, which is critical in low and middle-income countries, we assume that each facility is supplied by a single node, and uses a single type of approved storage device. Each hub is supplied either by the national center or by another hub and has a flexible vaccine stock replenishment policy with either a monthly or a quarterly replenishment frequency (as per WHO guidelines). Clinics are supplied every month by a hub (or possibly by the national center if it is closer than any hub). Finally, we assume that there is a 25% safety buffer at each location as per WHO guidelines so that the total required storage volume is inflated by a factor of 1.25.

Variants of this network design problems have been addressed by the operations research community, as the p-median problem and the facility location problem (see [9–11]). However, none of the prior work considers multiple, discrete choices of storage and transportation devices and replenishment frequencies, as is the case here. As far as vaccine distribution networks, Chen et al. [12] were the first to develop a planning model. The goal was to maximize coverage under current network capacity with an extension that allowed capacity expansion. However, this work does not address the network design; rather it looks at operations in an existing network. Some relatively recent work by one of the authors of this paper and his colleagues [13] was the first to introduce a model to completely redesign the vaccine distribution network. The model we present below is based on this model but refines it considerably by dispensing with several assumptions made by the former such as coordinated deliveries to hubs using vehicle loops, fixed storage devices, rigid replenishment schedules and the option of multiple vehicle trips for a single delivery. We introduce this model next.

2.1 Model Formulation

Consider a network with possible *h*ub locations in index set H, and *c*linics locations in index set C; let the index 0 to refer to the national store. Let the transportation *m*odes and WHO-qualified storage *d*evices available be indexed by index sets M and D, respectively. We use $f = 1$ to denote a monthly replenishment policy with $n_1 = 12$ annual replenishments and $f = 2$ to denote a quarterly replenishment policy with $n_2 = 4$ annual replenishments. Finally, define the set A of feasible arcs in the network, i.e., $[i - j] \in A$ if a direct flow is possible from location i to location j. Our inputs include the following parameters and costs:

a_i – volume associated with the annual demand at clinic $i \in C$,
V_m – maximum volume that can be stored in vehicle associated with transportation mode $m \in M$,
S_d – maximum volume that can be stored in storage device $d \in D$,
T_{ijm} – roundtrip transportation cost from location i to location j using transportation mode m,
F_{id} – facility cost per year at location i when it uses storage device d.

The primary decisions that we need to make are (a) which hub locations to open, along with the storage device and replenishment frequency to use at each open location, and (b) which location i to use for supplying vaccine to any location j that represents a clinic or an open hub, along with the associated transportation mode. We therefore define the following decision variables and formulate the mixed integer programming model that follows:

Y_{ijmf} – 1 if vaccines flow along $[i-j]$ using transport mode m and replenishment frequency f; 0 otherwise,
Z_{idf} – 1 if hub location $i \in H$ is open with device d and replenishment frequency f; 0 otherwise,
X_{ij} – volume of the annual vaccine flow along arc $[i-j]$.

2.2 Program 1

$$\textit{Minimize} \;\; \sum\nolimits_i \sum\nolimits_d F_{id}\left(\sum\nolimits_f Z_{idf}\right) + \sum\nolimits_{[i-j]\in A} \sum\nolimits_m T_{ijm}\left(\sum\nolimits_f n_f Y_{ijmf}\right) \tag{1}$$

s.t.

$$\sum\nolimits_{i\in\{0\}\cup H} \sum\nolimits_m Y_{ijm1} = 1, \; \forall j \in C \tag{2}$$

$$\sum\nolimits_{i\in\{0\}\cup H} \sum\nolimits_m \sum\nolimits_{f\in F} Y_{ijm1} \le 1, \; \forall j \in H \tag{3}$$

$$\sum\nolimits_d \sum\nolimits_f Z_{idf} \le 1, \; \forall i \in H \tag{4}$$

$$\sum\nolimits_d Z_{jdf} - \sum\nolimits_{i\in\{0\}\cup H} \sum\nolimits_m Y_{ijmf} = 0, \; \forall j \in H, \; f = 1, 2 \tag{5}$$

$$\sum\nolimits_{i\in\{0\}\cup H} X_{ij} = a_j, \; \forall j \in C \tag{6}$$

$$\sum\nolimits_{i\in\{0\}\cup H} X_{ij} - \sum\nolimits_{k\in H\cup C} X_{jk} = 0, \; \forall j \in H \tag{7}$$

$$\sum\nolimits_m V_m\left(\sum\nolimits_f n_f Y_{ijmf}\right) \ge X_{ij}, \; \forall [i-j] \in A \tag{8}$$

$$\sum\nolimits_d S_d\left(\sum\nolimits_f n_f Z_{jdf}\right) \ge 1.25 \sum\nolimits_{i\in\{0\}\cup H} X_{ij}, \; \forall j \in H \tag{9}$$

$$X_{ij} \ge 0, \; Y_{ijmf} \in \{0, 1\}, \; Z_{idf} \in \{0, 1\} \tag{10}$$

The objective (1) minimizes the sum of the annual facility costs across all facilities that are open and annual round-trip transportation costs across all arcs in the network that are selected. Constraints (2) ensure that every clinic is replenished monthly by a single hub (or the national store) with an associated transport device, while constraints (3) ensure that any open hub is supplied by a single source with an associated transport device and replenishment frequency. Constraints (4) ensure that any open hub has a single type of storage device and uses a single replenishment frequency. Constraints (5) ensure that if a hub is not open there is no flow into it, constraints (6) state that the total annual inflow into a clinic is equal to its annual demand and constraints (7) are flow balance equations for the hubs. Constraints (8) ensure that in any arc along which there is a flow, a transportation mode with sufficient capacity for that flow is selected. Constraints (9) ensure that in each open facility there is storage device with enough capacity to store the vaccines required within each replenishment interval (including the 25% buffer that the WHO requires). Note that n_f is either 4 or 12 and in (8) and (9) the RHS is effectively divided by n_f for the selected frequency.

2.3 Computational Limits with Program 1

We first explored the solution of Program 1 for a number of problems using a standard off-the-shelf mixed integer programming solver (IBM ILOG CPLEX 12.6) on a 3.20 GHz processor with 8 GB of memory. Problems of various sizes were generated using data that were derived from information we could access for four different countries in sub-Saharan Africa. While all of these countries currently have a similar four-tiered distribution architecture, they had significantly different demographic characteristics (size, population density, etc.) and also differed in the number of potential hub locations. In general, the effort required for a problem depends mainly on the total number of nodes as well as potential hub locations; however, it also depends on the population distribution and the costs. There was no clear means to specify the limits to what is solvable. Our numerical tests are described in more detail in Sect. 4, but as a gross generalization, only problems with under about 200–250 nodes and 15–20 potential hub locations can be solved in reasonable time. A key fact that makes Program 1 hard to solve is that it has a large number of 0–1 decision variables. For a typical small to mid-size 100-node problem with 15 candidate hubs, the number of binary decision variables is close to 10,000. This clearly calls for heuristics or other approaches.

3 An Iterative Cyclic Algorithm

We describe an easy-to-implement MIP-based heuristic that solves a sequence of MIP problems, each of which is a restricted version of Program 1 that is relatively easy to solve. These restrictions are with respect to either the replenishment frequencies used at hubs or the total number of hubs that are open. The method is motivated by initial experiments where we tested the MIP when some variables are fixed, thereby reducing the number of decision variables. First, we formulated a restricted version by fixing all replenishments at hubs to be done either once a month or once a quarter. These restricted versions yielded solutions in a very short amount of time and with values under 1% larger the true optimum for smaller problems. Next, we formulated an alternative restriction where we fixed the total number of hubs to be open. Once again, fixing a portion of the network structure generally yielded solutions much more quickly (although as we force more hubs to be open the time does start to increase).

Based on these observations, our algorithm starts by solving a restricted version of Program 1 with an initial vector of fixed replenishment frequencies at the hubs, to obtain a locally optimal set of open locations under this frequency vector. The algorithm then fixes these open hub locations and solves another restricted version of

Program 1 (with other hubs kept closed) to find the corresponding optimal frequencies. The procedure iterates until we cannot improve the solution. Before describing the algorithm, let us denote:

ε – a suitably small constant,
$\boldsymbol{f}$ – a vector of order $|H|$ indicating the replenishment frequency at hubs; if the i-th element is 1 then hub i is set to be replenished quarterly and a constraint $\sum_{d \in D} Z_{id2} = 0$ is added to the model; alternatively if the i-th element is 2 then hub i is set to be replenished monthly, and a constraint $\sum_{d \in D} Z_{id1} = 0$ is added; if a hub is closed the corresponding element is set to 0,
$\boldsymbol{l}$ – a binary vector of order $|H|$ indicating the status of each hub; if the i-th element equals 0, hub i is forced to be closed and we add a constraint $\sum_{d \in D} \sum_{f \in F} Z_{idf} = 0$ to the model; if the i-th element is equal to 1, hub i is set to be open, and we add a constraint $\sum_{d \in D} \sum_{f \in F} Z_{idf} = 1$ to the model,
W_f^k – locally optimum objective value at step k when frequencies are fixed,
W_l^k – locally optimum objective value at step k when frequencies are fixed.
STEP 1: Initialization. Generate a random vector of length $|H|$ where every entry is on of either 1 or 2 and define it to be $\boldsymbol{f}^{\mathbf{1}}$. Note that initially, every hub is allowed to be open, and if it is open it must use the replenishment frequency specified via $\boldsymbol{f}^{\mathbf{1}}$. Let $k = 1$.
STEP 2: Local optimum with fixed frequencies. Set $\boldsymbol{f} \leftarrow \boldsymbol{f}^{\mathbf{k}}$ and solve Program 1 under this fixed frequency vector with the corresponding additional constraints. Let W_f^k be the local optimum value obtained, with corresponding hub locations defined by the vector $\boldsymbol{l}^{\mathbf{k}}$. If $k = 1$ go to STEP 3 after deleting all the constraints added at this step. Otherwise, if $W_l^{k-1} - W_f^k \leq \varepsilon$, i.e., there is no improvement, stop the algorithm with objective value W_f^k. Otherwise, it means that the algorithm is still improving the solution, so we delete the additional constraints added in this step and continue on to STEP 3.
STEP 3: Local optimum with fixed open locations. Set $\boldsymbol{l} \leftarrow \boldsymbol{l}^{\mathbf{k}}$ and solve Program 1 under this fixed location vector with the corresponding additional constraints, let W_l^k be the local optimum value obtained, with corresponding replenishment frequencies defined by the vector $\boldsymbol{f}^{\mathbf{k}}$. In the case that a hub (say, the i-th) is not open in the solution obtained at STEP 2, the i-th element of $\boldsymbol{f}^{\mathbf{k}}$ is set to 0. If $W_f^k - W_l^k - \leq \varepsilon$, there is no improvement; stop the algorithm with value W_l^k. Otherwise, delete the additional constraints added in this step and go to STEP 4.
STEP 4: Update frequency. Set $k \leftarrow k + 1$ and update the frequency vector via $\boldsymbol{f}^{\mathbf{k+1}} \leftarrow \boldsymbol{f}^{\mathbf{k}}$; return to STEP 2.

4 Computational Results

We tested our algorithm using a number of problems; as stated in Sect. 2.1 we generated these from the data we had for four different LMICs. Table 1 lists results for the 27 test problems that we were able to solve optimally.

Table 1. Computational results.

No.	Hubs	Nodes	0/1 Vars.	Pop. Dens.	CPU: Opt.	CPU: Alg.	Gap %
1	1	10	68	Sparse	<1 s	<1 s	0%
2	1	18	116	Moderate	<1 s	<1 s	0%
3	2	11	148	Sparse	<1 s	<1 s	0%
4	3	22	420	Sparse	2 s	<1 s	0%
5	2	49	604	Sparse	<1 s	<1 s	0%
6	3	39	726	Moderate	2 s	<1 s	0%
7	4	44	1,088	Sparse	3 s	<1 s	0%
8	4	48	1,184	Moderate	<1 s	<1 s	0%
9	4	55	1,352	Moderate	4 s	<1 s	0%
10	4	64	1,568	Moderate	7 s	<1 s	0%
11	4	65	1,592	Dense	8 s	<1 s	0.27%
12	5	77	2,350	Moderate	1.6 s	<1 s	0%
13	8	56	2,752	Sparse	16 s	4 s	0%
14	7	99	4,214	Dense	4.4 s	<1 s	0%
15	11	96	6,424	Moderate	10 s	5 s	0%
16	10	117	7,100	Moderate	146 s	29 s	0.56%
17	14	101	8,596	Sparse	119 s	32 s	0.28%
18	12	128	9,312	Dense	116 s	29 s	0.17%
19	8	206	9,952	Dense	~10 h	43 s	0.17%
20	14	148	12,544	Moderate	103 s	49 s	0%
21	17	141	14,518	Moderate	79 s	50 s	0%
22	16	162	15,680	Dense	1,304 s	46 s	0.46%
23	13	210	16,484	Moderate	~1d	76 s	0.52%
24	14	235	19,852	Dense	~2d	83 s	0.62%
25	19	176	20,216	Moderate	4,649 s	207 s	0.24%
26	20	295	35,560	Moderate	387 s	89 s	0.32%
27	26	333	52,156	Moderate	2,748 s	126 s	0.54%

For each problem we list the number of potential hub locations, the total number of nodes in the network, the number of binary variables in the formulation of Program 1, and a label that identifies the population in the area as being dense, moderate or sparse. The number of nodes and potential hub locations in these problems ranged from 10 to 333, and from 1 to 26, respectively, while the total number of binary variables in the full problem ranged from 68 for the smallest problem to 52,156 for the largest problem we were able to solve optimally. We also list the CPU times for the CPLEX solver to find the optimum solution and for our algorithm to converge, along with the percentage gap between the cost of the solution from the algorithm and the true optimum cost.

5 Discussion

We now discuss the results from the previous section. First, it is clear that there is no obvious, direct relationship with any one specific factor listed in the tables (nodes, hubs, binary variables, and population density); rather, the effort required to solve a problem optimally depends on the combination of these factors. However, as might be expected, the total number of 0/1 variables seems significant. Smaller problems with under (say) 15,000 binary variables are directly solvable in a matter of seconds.

Second, with larger problems, solution times start to increase; there is one problem (no. 18) that took almost 10 h to solve, and in at least two instances (nos. 23 and 24) the solution time was on the order of days. However, there was also a problem (no. 6) that was larger than either of these and that could be solved in a little over 6 min. In general, it is hard to pinpoint what specific characteristics make the problems harder to solve optimally, and if we are presented with a new problem there does not appear to be any obvious way to say how CPLEX might perform on it.

Third, the iterative cyclic approach of our algorithm appears to be much more stable in its performance when compared to CPLEX. Convergence is achieved in under one minute for 22 of the 27 problems tested, and the longest it took (no. 19) was about 3.5 min. More importantly, the solution that it finds has a cost that is always within 1% (and most often within about 0.5%) of the true minimum cost.

Finally, it is worth mentioning that we also generated much larger problems (including problems that represented the complete network for each country) but these could not be solved optimally by CPLEX; our algorithm also failed to converge because solving even the restricted problems in steps 2 and 3 becomes impossible.

6 Conclusions

The problem of designing a distribution network for WHO-EPI vaccines is a complex one and one that becomes increasingly harder to solve as the problem size grows. We present an algorithm that generates high quality solutions within a fraction of one percent of optimality while using a substantially smaller amount of computation time than direct solution. Due to the ease with which it can be implemented, it can serve as a simple alternative to solving MIP-1 directly when a good solution is required quickly. However, this method – like direct solution – cannot handle country-level problem formulations. Thus it is clear that future research calls for other heuristic approaches that can generate high quality solutions for these larger problems, and the authors are currently working in developing these.

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The Perception of Knowledge Management by Small and Medium-Sized IT Companies, Campos Gerais, Brazil

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Abstract. Knowledge Management (KM) is important tool for small and medium sized enterprises (SMEs) survive in the market. Information technology (IT) facilitated inclusion the SMEs in the KM process. Therefore, it was investigated the perception of knowledge management in IT SMEs in a region of Brazil, through the application of a questionnaire. Then it was identified that, although some variables had a frequent occurrence, the creation of new knowledge is not effective in the companies interviewed.

Keywords: Small and medium-sized enterprise · Information technology · Knowledge management

1 Introduction

Organizations recognize that knowledge management (KM) is a very important tool when it comes to increasing, competitive advantage and performance. Knowledge management corresponds to the set of activities developed to use, share, develop and manage the knowledge of an organization or individual, as well as creating new knowledge for new creative and transformative visions.

Knowledge can be continuously implemented and incorporated into products, services and processes [1]. Like benchmarking processes that are systematically developed in order to obtain new knowledge and develop new practices or new business models [2].

Through this context, it can be observed that organizations that implement knowledge management have more opportunities for growth, both personal and organizational. This factor tends to give small and medium-sized enterprises (SMEs) the competitiveness necessary to compete with large companies.

According to [3], while large companies have led the introduction and implementation of knowledge management, it is increasingly important that SME's manage their collective intellect.

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The new economy, called the knowledge economy, is based on the intellectual capacity to generate wealth. As a contribution and improvement of this management, the information technology (IT) generated through the knowledge of the people, has been increasingly used as an instrument of assistance in the KM process over time. IT is used by organizations and individuals to keep up with the rapidity with which transformations are happening in the world in order to increase production, improve product quality, market analysis and make interaction between markets, customers and competitors faster [4].

The advancement and growth of information technologies developed in the last decades favored changes in the management of SMEs through a better integration in the business process [5], since it is a tool of communication and business management, where organizations and individuals can remain competitive and operative in the markets they serve.

However, the best of what are not yet available in the literature study the knowledge management in small and medium information technology companies in the Campos Gerais region. From this, the present study is of a comprehensive and detailed form for the countries, and for the state of Paraná.

This article is composed of five sections, Sect. 1 being composed by the introduction; the Sect. 2 presented below approaches the theoretical framework that makes a brief review of the concepts of knowledge management, knowledge management in small and medium enterprises and knowledge management and information technology; Sect. 3 with the description of the methodology used; Sect. 4 the presentation of the results and, finally, Sect. 5 bringing the conclusion of the work.

2 Theoretical Reference

According to Drucker [6], knowledge management is the ability to efficiently manage, discover, map, classify, capture, distribute, create, multiply and retain knowledge in order to allow the organization to position itself in competitive advantage in relation to the organization, in order to generate profit and ensure its survival and expansion in the market.

The overall goal for an organization to act smarter and ensure its viability and overall success is to maximize knowledge-related effectiveness by constantly renewing knowledge [7]. Knowledge does not depreciate over time and is less likely to become obsolete, it can be used as a strategic tool to create and sustain competitive advantage [8].

Also, in this context, [7] proposes that knowledge management be explored in four perspectives, being: as knowledge practices, information technology, organizational and a rate of development, supply and knowledge.

In today's business models for organizations, information technology is essential to success. All efforts should focus on sharing the knowledge and making it available to anyone who needs it. In this stage it is necessary that there is contact person to person, which will allow new collaborations in works. However, the success of this project depends on the corporate culture that promotes the sharing of knowledge [8].

2.1 Knowledge Management in Small and Medium Enterprises

Today, knowledge management has become an essential component for the maintenance of competitive advantages. Since then, many organizations are exploring knowledge management to improve and sustain competitiveness. In order to overcome dilemmas of competitiveness, the implementation of knowledge management emerges as a method to solve this problem. In this context, knowledge management aims to make small and medium enterprises more competitive and innovative [9].

Literature divides the knowledge of a company into two categories: explicit and tacit knowledge [10]. Tacit knowledge relates to the personal knowledge of a person gained from years of experience. Tacit knowledge is very difficult to put into a structure and to imitate, since it is embedded in a person's abilities and in the practical knowledge of the individual [11].

In this context, it should be noted that SMEs tend to place more emphasis than large companies on tacit knowledge management, and communication channels within SMEs are more likely to be between firms, not internal to the organization. The SME sector appears to be less advanced in terms of knowledge building, adopting a broader concept approach and relying less on social interaction [12].

In order to further utilize knowledge management for business operations and uninterrupted decision-making, its adoption in SMEs has become the emerging agenda in the development of business strategies. Managing knowledge resources is considered the main goal of the knowledge management search in business operations in SMEs. However, most of the studies of the implementation of KM have been strongly focused on large companies. As such, existing search results are mainly geared towards large companies, thus reflecting their situations. SMEs face unique KM challenges that are distinct from those of their larger businesses. The direct application of these results in the SME environment may not be enough without an understanding of their own specific conditions [9].

2.2 Knowledge Management and Information Technology

The information technology is pointed out by several authors as one of the factors of greater influence to the process of knowledge management, as it acts as a facilitator tool of KM practices, helping in the dissemination of knowledge within the organization [8–13]. Its importance is so great because, according to [14], "can improve the exploitation of resources to take advantage of existing market opportunities and explore new opportunities to meet the challenges of emerging markets," resulting in organizational growth and market competitiveness.

These are the possible implementations of IT tools within the KM. [15] point out a relationship with the provision of information, communications and information exchange and the automation of internal business processes, while [16] points out a facility in searching, accessing and retrieving data, means of communication allowing an exchange of information between the members of the company.

In this context, one can see in the literature the development and evolution of these tools over time and their wide use in large companies, playing a necessary infrastructure role for good KM practices to occur. As a result, this growth scenario has also resulted in increasingly effective and affordable tools for companies, favoring their adoption in SMEs and allowing them to become more competitive in the market [8, 14, 15].

As in large companies, IT provides SMEs with the easier implementation of the KM and allows the exchange of information more quickly within the organization, as well as promoting increased knowledge creation [8–15]. However, a differentiation between these two means is the greater exposure of the SMEs to the tacit knowledge, which is very present, being necessary the development of means favorable to the capture and transformation of this knowledge in explicit knowledge, because according to [8] “formalizing tacit knowledge is the best way to generate new ideas”.

The adoption of more evolved IT techniques even in SMEs shows greater efficiency in the companies’ performance [8]. However, these should be applied properly and cannot be used alone in the search for good KM practices [15]. Thus, the difficulty of IT implementation found by SMEs is the cost involved in obtaining full access to modern tools and the lack of high investments that reduce the cost of application [17], as well as difficulties related to use [13].

3 Methods

The research presented a qualitative and quantitative approach in order to identify how micro and small information technology companies in the Campos Gerais, Paraná region perceive the use of knowledge management within their companies.

To do so, a review of the literature was carried out at the international databases Web of Science and Scopus, adopting the words “knowledge management”, “information technology”, “small and medium-sized enterprises” and their variations as keywords for search, without temporal delimitation to find research already done on the subject. The search result can be found in Table 1.

Table 1. Initial search in databases.

Combinations	Databases	Number of articles
“knowledge management” AND “information technology” AND “small and médium-sized enterprises”	Web of Science	29
	Scopus	43
“knowledge management” AND “information technology” AND “sme’s”	Web of Science	3
	Scopus	53
“knowledge management” AND “information technology” AND “sme”	Web of Science	22
	Scopus	53
	Total	203

The tool used in this work was based on the research developed by [18] and use a questionnaire to investigated the perception of knowledge management in IT SMEs. The questionnaire was composed of 10 open-ended questions and 46 objective questions. The open-ended questions characterized the population studied and the information was related to the respondents' background, working time in the company and projects developed. The objective questions were divided into eight variables that allow assessing their perception of the occurrence of knowledge management in the companies. Moreover, these variables served to analyze how the knowledge management is perceived by the companies in the projects, in the phases of analysis, execution and finishing. The variables are described in Table 2.

Table 2. Description of eight variables.

Variable	Description
Tacit knowledge	Concerning personal knowledge, refers to specific context and difficult to be formulated
Explicit knowledge	Refers to the knowledge transmitted in formal and systematic language
Creation	Creation process occurs when new knowledge is generated in the organization. And when the organizations interact and absorb information that are transformed into knowledge
Codification	The aim is to present the knowledge in a way that makes it accessible to those who need it, turning knowledge into something intelligible and cleaner, portable and as well organized as possible
Transfer	Consists in the transmission and absorption of knowledge, effectively allowing individuals to talk and listen to what one has to say
Conversion modes, specific knowledge, and knowledge spiral	Deals with dynamic processes of transformation of tacit and explicit knowledge. The knowledge spiral allows the transfer of knowledge from one level to another, taking into account the sharing of experiences, knowledge creation, systematization and internalization
Ba - space of creation of knowledge	BA is a sharing space where relationships emerge, and it can be a physical, virtual or mental space. This can be understood as a multiple interaction mechanism. The BA is important to facilitate the creation of organizational knowledge
Enabling conditions for the creation of organizational knowledge	Refers to conditions that must be met for creating the knowledge spiral. Among these conditions, it is intended by their goals, employees' autonomy for knowledge quest, the creative chaos to the formulation of new knowledge, the intentional redundancy of information and the variety of requirements that provides the ability to face different situations

The objective questions were composed of a linguistic scale of five points (Table 3), ranging from "never occurred" to "always occurrence" related to the occurrence of knowledge management in companies. Each variable and the general perception of the companies were analyzed using the mean and standard deviation of the questions.

Table 3. Linguistic scale.

Linguistic scale	Value
Never occurred	0
Rarely occurred	1
Sometimes occurred	2
Often occurred	3
Always occurred	4

For the research, it was conducted interviews with 15 small and medium-size IT companies in Campos Gerais region, Paraná, Brazil. But only 5 companies answered the questionnaire and participated effectively in the research. The contact with these companies was made via telephone and the questionnaires sent via e-mail by the online form.

4 Results

The first part of the questionnaire was composed of open-ended questions to characterize and know the reality of the participating companies. Thus, it was identified that 100% of the respondent leaders were male, in which of them 40% had completed higher education and the other 60% had postgraduate courses. In terms of working time, 20% worked in the company at 1 year, 40% worked between 5 and 10 years, and the remaining 40% worked in the company for more than 15 years.

Most of the respondents, 60%, were owners or partners of the company, 20% held some leadership position and 20% were dedicated to specialized positions. On average, 2.75 projects were carried out in the last 2 years, with one of the companies as an outlier, in which 70 projects were carried out. Among the last projects carried out, most of the 60% had short and medium duration, taking a maximum of 6 months to complete, the remaining 20% had a long duration of 1 to 2 years. These projects had 80% evaluation as "very good" and 20% as "good", then they are supposed to have reached the proposed objectives. In the same way, 80% of them performed project steps differently than planned.

The edition contained 8 variations, among which Tacit Knowledge; Explicit Knowledge; Creation; Codification; Transfer; Conversion Modes, Specific Knowledge, and Knowledge Spiral; Ba - space of Creation of Knowledge; and Enabling Conditions for the Creation of Organizational Knowledge to analyze how the knowledge management is perceived by the companies in the project and in its phases of analysis, execution and finishing. The following tables present the results of the answers given in the questionnaires. They present an average and the standard deviation (S.D.) the perceptions of the respondents in each phase of the project and a last column depict the project as a whole.

With regard to the results of tacit knowledge occurrence in Table 4, it is possible to notice that, due to the perception of the respondents, it presents a occurrence between sometimes occurred to often occurred by the average of 2.47 and the standard deviation of 0.09, only the finishing phase has a larger standard deviation.

Table 4. Tacit knowledge occurrence.

		Analysis	Execution	Finishing	Project
Tacit knowledge	Average	2,60	2,40	2,40	2,47
	S.D.	0,49	0,49	0,80	0,09

The explicit knowledge occurrence in Table 5 show the average close to the tacit knowledge with standard deviation not significant about phases average, but the standard deviation is significant in all phases, to vary from rarely occurred to sometimes occurred.

Table 5. Explicit knowledge occurrence.

		Analysis	Execution	Finishing	Project
Explicit knowledge	Average	2,80	2,60	2,20	2,53
	S.D.	1,17	0,80	1,33	0,25

Regarding the creation of knowledge (Table 6), companies present an average of 1.50, declaring that there is a sometimes occurred of the use of knowledge management in the project average, but each phase of the project has a significant standard deviation.

Table 6. Creation occurrence.

		Analysis	Execution	Finishing	Project
Creation	Average	1,50	1,60	1,40	1,50
	S.D.	0,81	1,02	1,11	0,08

Knowledge codification (Table 7) showed a sometimes occurred with average of 2.00 and the standard deviation reports little variation between the averages of each phase, but it is repeated as in the other variables in which there is a significant variation of the responses in each phase, varying from rarely occurred to often occurred.

Table 7. Codification occurrence.

		Analysis	Execution	Finishing	Project
Codification	Average	2,10	1,90	2,00	2,00
	S.D.	1,04	1,14	1,00	0,08

The occurrence of knowledge transfer (Table 8) showed that the average of the respondents' perception was of 2.40, it is indicating a sometimes occurred without standard deviation among the average, but showed a significant standard deviation in each phase, varying from rarely occurred to always occurred.

Table 8. Transfer occurrence.

		Analysis	Execution	Finishing	Project
Transfer	Average	2,40	2,40	2,40	2,40
	S.D.	1,43	1,28	1,36	0,00

Regarding the occurrence of conversion codes, specific knowledge, and knowledge spiral (Table 9), respondent companies have rarely occurrence in the project average, with an average of 1.44 and non-significant standard deviation among the averages of the phases. But as has been repeated in the other variables, there is significant variation in each phase, varying from never occurred to sometimes occurred.

Table 9. Conversion codes, specific knowledge, and knowledge spiral occurrence.

		Analysis	Execution	Finishing	Project
Conversion codes, specific knowledge, and knowledge spiral occurrence	Average	1,65	1,35	1,31	1,44
	S.D.	1,16	1,13	1,21	0,15

The occurrence of Ba - space of creation of knowledge (Table 10) reveals rarely occurrence in the average of 1.46 of the project and non - significant standard deviation. The standard deviation in each phase presents significant variation and indicates greater variation in the analysis phase, varying from never occurred to often occurred.

Table 10. Ba - space of creation of knowledge occurrence.

		Analysis	Execution	Finishing	Project
Ba - space of creation of knowledge occurrence	Average	1,60	1,56	1,22	1,46
	S.D.	1,30	1,10	0,99	0,17

Regarding the occurrence of enabling conditions for the creation of organizational knowledge (Table 11), the project average was 2.05, which shows a sometimes occurrence, with a non-significant standard deviation. The average of each phase varies from rarely occurred to often occurred.

Table 11. Enabling conditions for the creation of organizational knowledge occurrence.

		Analysis	Execution	Finishing	Project
Enabling conditions for the creation of organizational knowledge occurrence	Average	2,10	2,13	1,93	2,05
	S.D.	1,27	1,16	1,25	0,09

The project averages of the eight variables are close to 2.00, which represents the respondents' perception that there is a sometimes occurrence of knowledge management in small and medium sized companies surveyed in the general field region. But there are significant variations among the perceptions of the respondents, indicating considerable difference between each company.

5 Conclusion

Knowledge management is essential to the competitiveness of SMEs vis-à-vis the market. Developing good KM practices allows for fast access and management of information and, consequently, the renewal of obsolete information for business prospects, allowing them to resemble large enterprises.

The literature reveals that SMEs are seeing the possibilities brought about by adopting KM practices by presenting a growing debate about the theme. However, some authors emphasize the need of a correct understanding of knowledge management and the adequate use of the facilitating tools of the process.

In relation to the applied research, the data obtained show that the SMEs respondents of the questionnaire identify evidence of Knowledge Management practices in their activities characterized by the sometimes occurrence of the variables tacit knowledge; explicit knowledge; codification of knowledge; transfer and enabling conditions for the creation of organizational knowledge, variables quite characteristic also to the IT branch when analyzed outside the KM context. On the other hand, variables as knowledge creation; conversion modes, specific knowledge, and knowledge spiral and Ba - space of Creation of Knowledge were of rarely occurrence in the companies perception.

Thus, although there is a notion about the importance of KM among Information Technology SMEs in Campos Gerais for identifying the occurrence of some variables, it is possible to perceive the non-practice among companies, since knowledge management is not done in a effective way in order not to help their competitiveness.

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Correction to: Factors Affecting the Adoption of Technological Service Innovations

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In the original version of the book, the names of the authors were identified wrongly as Duzenli Ozge, Felekoglu Burcu, and Tasan Ali Serdar, which have now been corrected as Ozge Duzenli, Burcu Felekoglu, and Ali Serdar Tasan, and the changes have been updated.

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