Initial overview of industry 4.0 in textile companies from Santa Catarina

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Abstract

Industry 4.0 is characterized by the use of several technologies used individually or interconnected, this model contributes to process optimization and waste reduction. Within the manufacturing industry, the Brazilian textile and clothing industry stands out for its high employability rate and for being the largest integrated production chain in the West, from the production of fibers, such as cotton plantation, to fashion shows (ABIT, 2018). In Brazil, the textile industry is disseminated throughout its territory with a high concentration in the state of Santa Catarina, standing out as a textile pole. Based on this, this multi-case study aims to explain and compare the results of applying the questionnaire regarding the use of technologies from industry 4.0 in four textile industries in the region of the State of Santa Catarina. The most used technologies in companies are cyber security, big data, systems integration and internet of things (IoT), the last three being considered more relevant to the industry, in addition to simulation, according to the research result. Investment in new technologies, lack of qualified labor, change to a New Business Model and standardization, were listed as main barriers for the implementation of industry 4.0.

Keywords
Industry 4.0, Textile, Big Data, IoT and Cyber Security.

1. Introduction

According to the National Confederation of Industry - (CNI, 2016a), in the medium and long term, the incorporation of new technologies in a strategy for the development of Brazilian industry will be essential for the country's competitiveness and to improve its participation in global value chains. Therefore, the applicability of industry 4.0 technologies is increasingly on the rise in Brazil. According to a survey conducted by CNI (2018), among the large Brazilian industrial companies, 73% are in Industry 4.0, although in the initial stage of implementing the technologies, these technologies, presented by Rübmann et al. (2015) and illustrated through figure 1.

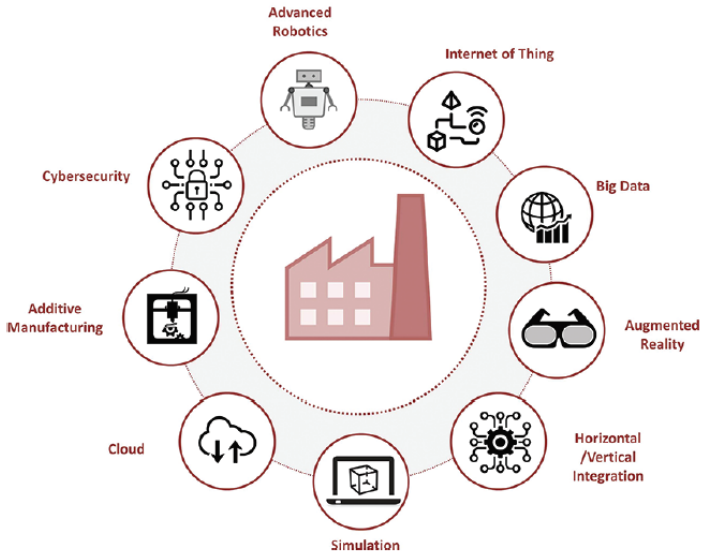


Figure 1. Industry 4.0 technologies. Source: (PETRILLO et al., 2018)

Also according to CNI (2016b), the level of heterogeneity in Brazilian industry will require that policies be adapted to different sets of sectors and companies, which will assume different speeds and conditions. As is the case with the textile and clothing industries, where 47% of textile manufacturing companies use at least one of the technologies of industry 4.0, contrasting with the clothing and accessories industry, with 29% of use of technologies.

Companies in the textile and clothing sectors concentrate most of their activities in the State of São Paulo (41.1%), Santa Catarina (19.6%) and Minas Gerais (12.5%), the first two being considered the largest textile hubs in the country (ABIT, 2019).

In view of these data, the present study aims to explain and compare the result of the questionnaire regarding the use of technologies from industry 4.0 in four textile industries in the region of the State of Santa Catarina, which have the processing sector in their industrial park.

2. Theoretical Background

2.1 Industry 4.0 and its technologies

Defined by Hermann et al. (2015), industry 4.0 is a collective term for technologies and concepts for organizing the value chain. According to Shafiq et al. (2016) promotes the computerization of traditional factories and their ecosystems towards a connected resource management scheme. The term arose in 2011 in Germany with the need to create an approach to strengthen the competitiveness of the country's manufacturing industry (KAGERMANN et al., 2013).

The principles of sector 4.0 are interoperability, virtualization, decentralization, real-time capacity, service orientation and modularity (HERMANN et al. (2015). Its objectives according to Hermann et al. (2015) and Ribeiro (2017) are:

- Enable mass customization by manufactured product information technologies;
- Guarantee long-term sustainability in economic, financial and energy aspects by promoting and optimizing resources and minimizing waste generation;
- Automate and make the production chain more flexible;

- Track parts and products;
- Facilitate communication between parts, products and machines;
- Extend human-machine interaction (HMI) paradigms;
- Optimize IoT-enabled production in smart factories; and
- Provide new types of services and business models for interaction in the value chain.

In terms of resources, Industry 4.0 can provide more flexibility, shorten delivery times, customize with small batch sizes and reduce costs, and workers will gradually be freer from performing routine tasks, focusing on more creative and more value-added. (KAGERMANN et al. 2013; (KAGERMANN et al., 2013; SHAFIQ et al., 2015, 2016).

Also called the fourth industrial revolution, according to Schwab (2016), this new revolution is characterized by the intensive use of digital technologies in order to manufacture new products quickly, with an agile response to demand and real-time optimization of production and the chain supply and may cause possible disruptions in the companies' value chain. According to Rübmann et al., (2015), among these technologies, Internet of things, additive manufacturing, big data, among others, are highlighted in Table 1.

Table 1. Technologies and their definitions

Technology	Definition
Big Data	It consists in the collection of data from systems and objects, such as sensor readings with storage capacity and treatment of a very large volume of information (BRUNO, 2016; PORTER; HEPPELMANN, 2015)
Autonomous robots	They are managed directly by an intelligent factory and connected to the rest of the company's system. Processing is automatically handled by cyber-physical systems. They are mostly used in ergonomically difficult or extreme work (HAIPING et al., 2014)
Simulation	It is a process used in engineering allowing operators to test and optimize machine configurations for the next in-line product in the virtual world before physical change, thereby reducing machine setup times and increasing quality (RÜBMANN et al., 2015)
Horizontal and vertical system integration	It can also be called hardware systems integration, aiming to create and organize the management support platform based on the organization's information for specific purposes (TANG, 2015)
Internet of things - IoT	Represents the integration of sensors and computing in an Internet environment through wireless communication and aims to solve problems of communicability between all objects and systems of a factory (FRANK et al., 2019; TAO et al., 2018)
Cyber security	The main functions of the CPS are to meet the agile and dynamic requirements of production and improve the effectiveness and efficiency of the entire productive sector (LU, 2017)
The cloud	Enables you to manage large volumes of data in open systems and ensure real-time communication to the production system, in addition to allowing access to information from anywhere in the world at any time (HAIPING et al., 2014)
Additive manufacturing	It is a manufacturing technique through the addition of materials in overlapping layers to form an object, it has the benefit of reducing lead time for product launches, rapid prototyping, cost reduction along the value chain and innovation (BAUMERS, 2012)
Augmented reality	It refers to the integration of additional information generated by a computer in a real-world environment, allowing the worker to make decisions and adapt work processes (PAELKE, 2014; RIBEIRO, 2017)

After knowledge about industry 4.0, it is necessary to understand a little about textile processes and their importance in the global and national scenario.

2.2 Brazilian Textile Industry

The textile and clothing chain had an important role in the history of world industrialization, even before the industrial period, where products were manufactured by hand, however, with the course of industrial revolutions, the sector underwent transformations in the configuration of the business model, replacing manual labor with industrial operations (DUARTE, 2017).

Currently, Asia is responsible for 73% of the total volumes produced in the world, with an emphasis, in order, on: China, India, Pakistan, South Korea, Taiwan, Indonesia, Malaysia, Thailand and Bangladesh (ABIT, 2015).

Brazil occupies the fourth position among the largest producers of clothing in the world and the fifth position among the largest producers of textile manufactures, in addition, it has the largest integrated production chain in the West. The sector represents about 5.7% of the total production value of the manufacturing industry, however, it is the second largest employer in the manufacturing industry, second only to food and beverages together (ABIT, 2018).

When analyzing the peculiarities of the Brazilian textile and clothing sector, there is a clear dispersion of companies across the national territory, some concentrations are identified in textile hubs, which is the case in the state of Santa Catarina, in the southern region of the country.

The textile and apparel industries of Santa Catarina, represent the highest employability index within the industries of the state, totaling 21%. In 2017, the gross value of industrial production (VBPI) was R $ 22.9 billion. Among imports from the textile and clothing sector in 2019, the most prominent trade relations are with China, with 65.8% of total foreign purchases in the sector, followed by Indonesia (8.4%) and Bangladesh (4.9 %). In exports, also in 2019, the most important commercial relations are with Paraguay, with 24.9% of the sector's total sales, Uruguay (15.9%) and Argentina (13.9%), according to data from Federation of Industries of Santa Catarina (FIESC, 2019).

To understand a little about the textile and clothing chain, Table 1 presents the main production processes with brief descriptions and applicability of the textile and clothing chain.

Chart 1 - Textile chain and its main processes

Spinning	Weaving	Kinniting	Processing	Confection
Process that transforms textile fibers into yarns, through conventional or ring spinning, open end or rotor spinning, electrospinning (Eletrospinning) or chemical spinning.	The threads are starched and wrapped in a warp roll. Then, through interweaving, the looms transform yarns into flat fabrics, creating diverse structures such as twill, taffeta, satin and their derivations.	The formation of knitted fabrics can be per weft, through the methods of interlacing meshes in the transverse direction, with one or more threads, which can be arranged in a lateral or circular direction. And by warp, through the longitudinal knitting method with numerous threads.	They provide changes in materials through physical and chemical processes. Classified by primary beneficiation process, the preparation of the substrate; Secondary processing, dyeing and tertiary processing, finishing in general, including stamping.	Starts in the broom, a process that organizes the substrate in layers, according to the number of pieces to be produced, then these layers will be cut (manual or automatic) directing to the seam, a process that joins the previously cut components in order to make the desired piece.

Source: (FALANI et al., 2019)

As mentioned before, the textile scope is not limited to the sectors in Table 1, the textile chain starts with the producers of raw materials (cotton, polyester and other fibers), inputs (dye, auxiliary products, among others), and in machinery and equipment manufacturers. It ends with the sale of the finished product to the final consumer. In addition, it is

considered an industrial reference sector due to the rapid change of processes in return to the consumer market and seasonality of products.

3. Research methodology

In the methodological approach of this study, qualitative research of multiple cases was adopted due to the need for relevant data that could facilitate the generation of theoretical categories that could not derive satisfactorily from the existing data (LOCKE, 2001). The multi-case study makes it possible to raise relevant and more reliable evidence compared to single case studies (YIN, 2015).

However, first, a review of the literature on the subject of industry 4.0 was carried out focusing on its technologies identified by Rübmann et al. (2015), aiming to acquire a basis for developing the questionnaire.

The collection of evidence was carried out through structured interviews (questionnaire), in person and in four companies, and the treatment of the data was carried out based on documentary and content analysis, where the results are described in section 4.

For the selection of companies, he considered several aspects, among the main ones:

- Being a company in the textile segment located in the State of Santa Catarina;
- To have aggregation of two or more links in its value chain, that is, to be a vertically integrated company;
- Be characterized as a large company, according to the number of employees (Sebrae methodology) and gross annual revenue (IBGE methodology);

The profiles of the four companies are summarized in Table 2.

Table 2 - Sample of companies surveyed

Company	*Industry size**	*Primary economic activity ***	*City*
A	Large	Manufacture of garments, produced in knitwear and knitting, except stockings	Blumenau
B	Large	Manufacture of garments, except underwear and tailor-made	Jaraguá do Sul
C	Large	Manufacture of garments, except underwear and tailor-made	Pomerode
D	Large	Manufacture of garments, except underwear and tailor-made	Corupá

Notes: * According to the number of employed persons (Sebrae methodology) and gross annual revenue (IBGE methodology).
** According to CNAE Classification (National Classification of Economic Activities).

The questionnaire has three questions: The first, aims to identify the level of use of each technology in industry 4.0 by company; the second question, intends to understand which technologies are relevant for the interviewees and finally, the third question, which intends to analyze the challenges and barriers found for the implementation of industry 4.0 in their companies.

4. Results and discussions

4.1 Level of use of technologies

In the first question, there is a table with nine technologies, where the respondents indicate the degree of insecurity of using the technologies on a 5-point Likert scale: from 0% (Not used) to 100% (Totally used).

Among the results obtained, it can be seen through figure 2 that companies A and C fully use cyber security technology, whereas companies B and C, correspond to the utilization of 75% of utilization in their production processes.

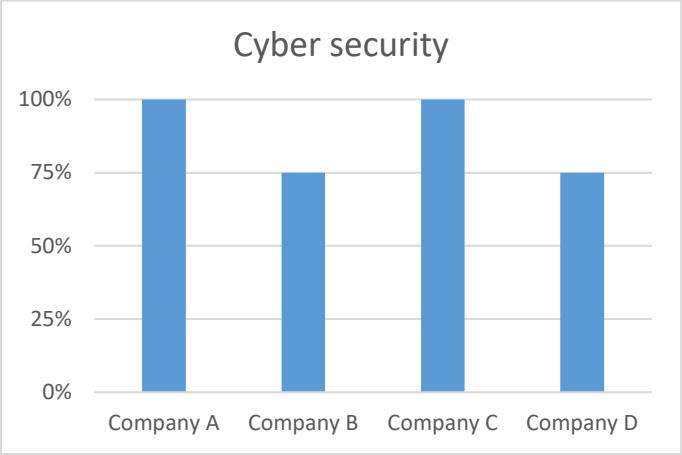


Figure 2. Level of use of cyber security

Another technology with high utilization by the companies surveyed is systems integration, with the exception of company D, all of which have 75% of technology use in their production chain, as shown in figure 3.

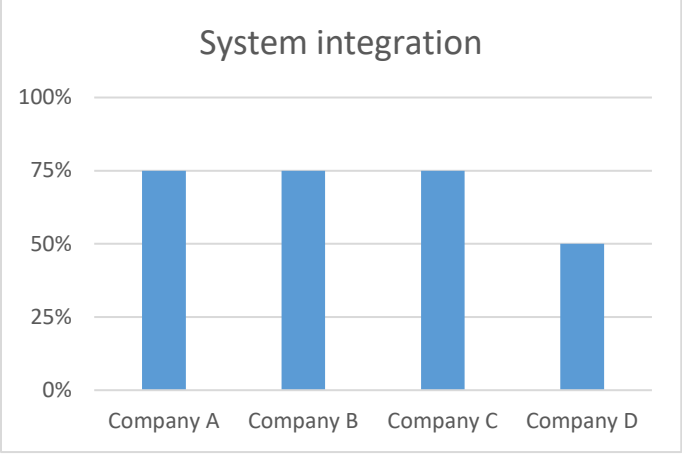


Figure 3. Level of use of system integration

In addition, the technologies present in all companies, even if still on the rise, are big data and the internet of things. Figure 4 shows the level of use of big data technologies, where company A is the one that uses the technology a lot, in contrast to company D, which uses little.

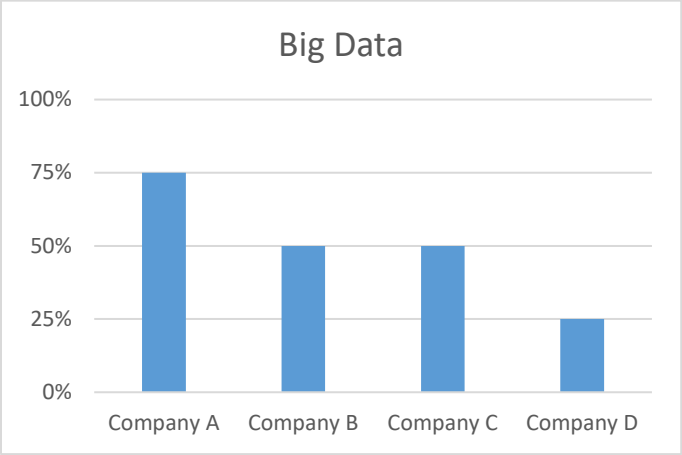


Figure 4. Level of big data usage

Internet of things is the technology that most varies its level of use when compared between companies. In view of figure 5, it is noted that company C is the one that most uses the technology, measured with 75% of use, company A also uses the technology with a lower proportion (50%), whereas companies B and D, little use technologies.

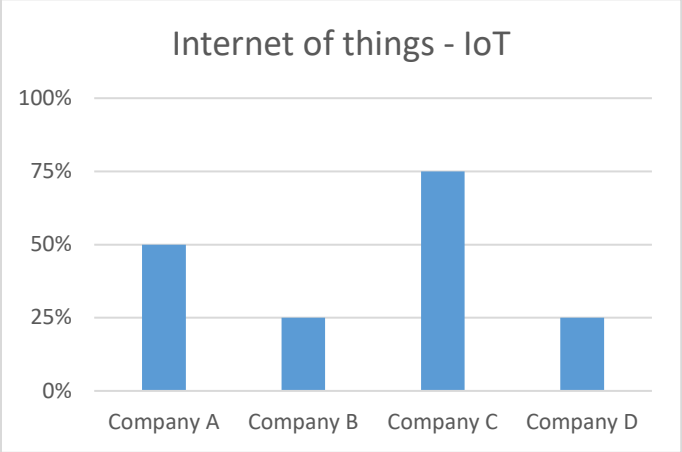


Figure 5. IoT usage level

Even the cloud services considered by Frank et al. (2019) as the basic technology with the most affordable solution used by companies and that for Shafiq et al. (2015) it is very likely that the world of production will become increasingly networked until everything is interconnected, not all companies studied use cloud services, as is the case with company A (Figure 6).

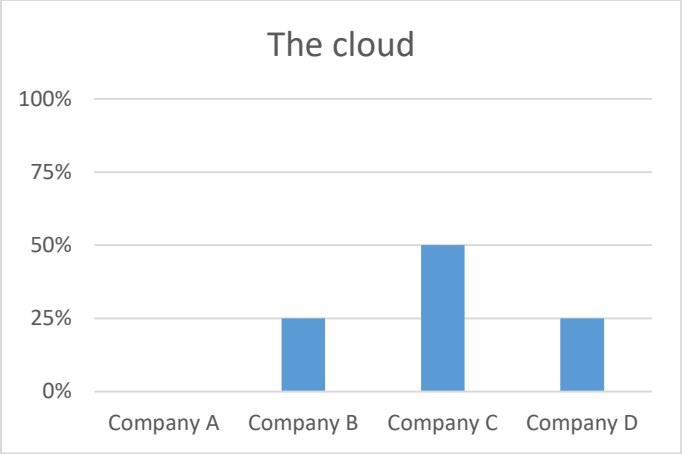


Figure 6. Level of use of cloud technologies

It can also be seen in figure 6 that company C is the one that stores most of its data in the cloud and companies B and D use little technology.

Only companies A and B make use of autonomous robots, even so, still with little use, in contrast, according to figure 7, companies C and D do not use this technology.

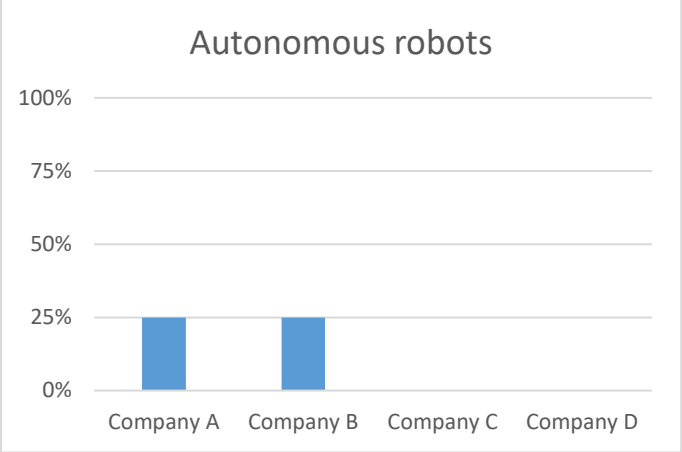
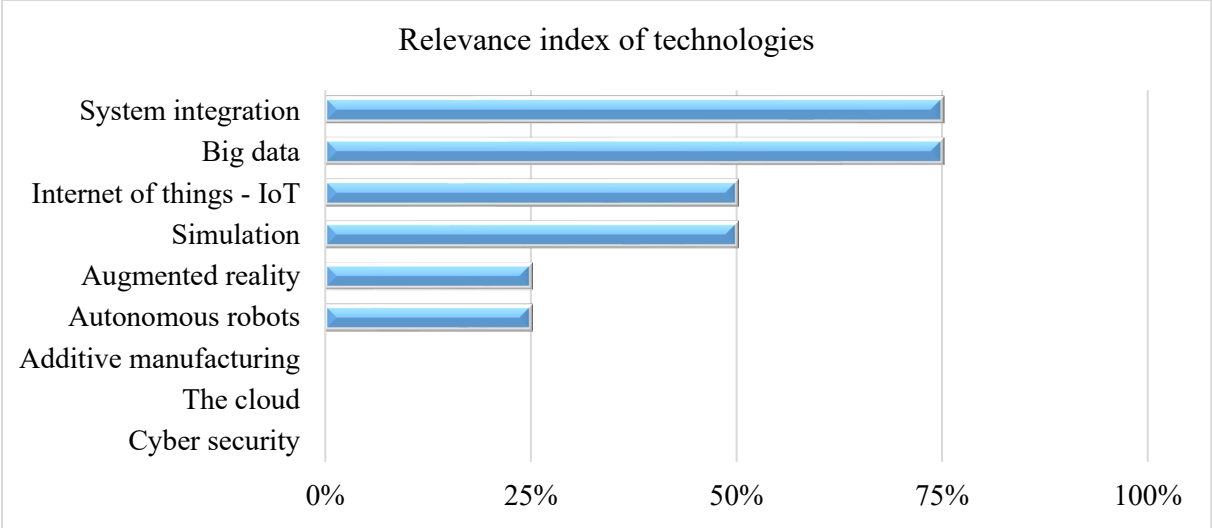


Figure 7. Level of use of autonomous robots

Augmented reality technologies are used only in company A, however, with little use, only 25%. Another technology used by only one company is simulation, also with a total of 25%, representing low usage. Finally, the additive manufacturing technology is not used in any of the companies as a result of the research.

4.2 Level of relevance of technologies

Also considering the same technologies addressed in the previous subsection, in the second question, the interviewees selected three of the nine technologies that they consider most relevant to their companies, resulting in figure 8.



Note: The sum of the percentages exceeds 100% due to the possibility of multiple responses.

Figure 8. Technology relevance index

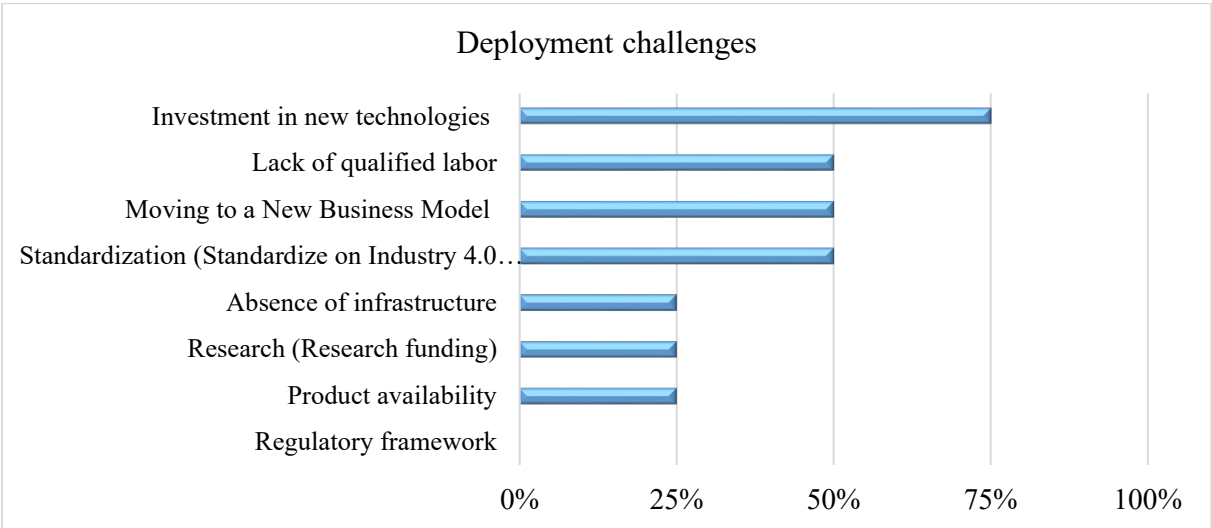
As shown in figure 2, 75% of the companies consider systems integration and big data as the most relevant technologies for their companies and 50% of the companies consider internet of things and simulation also relevant. Additive manufacturing, cloud and cyber security were not mentioned by any of the companies.

For Frank et al. (2019), IoT, big data and cloud services technologies are considered base technologies to provide interconnectivity, in addition to providing the intelligence of new manufacturing systems.

4.3 Challenges

It is known that the development of Industry 4.0 in Brazil involves challenges that range from investments in equipment that integrates technologies, to the adaptation of processes and layouts, in addition to the forms of relationship between companies along the production chain, in the human and technical factor, the creation of new specialties and skills development, among others (CNI, 2016a).

Based on this, the third question suggests to its respondents to select three challenges that they consider most relevant for the implementation of industry 4.0 in their companies, the result can be identified in figure 9.



Note: The sum of the percentages exceeds 100% due to the possibility of multiple responses.

Figure 9. Technology relevance index

It is observed that the investment in new technologies is the biggest challenge identified, representing 75% of the total of the studied companies, in addition, the lack of qualified labor, change of business model and standardize in the industry model 4.0, are considered relevant challenges by 50% of companies.

Seven of the eight challenges were mentioned by the interviewees, with the exception of the regulatory framework. Framework translation is structure and is defined by Cotter and Potel (1995) as an extensible set of object-oriented classes that are integrated to perform well-defined sets of computational behavior.

5. Final considerations

This article described the result of a multi-case study in textile industries in the Santa Catarina Region, in order to identify the technologies of industry 4.0 currently used and the challenges encountered in their implementation.

Based on the results explained, companies A and B are the ones that most use the technologies of industry 4.0, both have six of the nine technologies.

The technologies present in all companies are cyber security, systems integration, big data and IoT, cyber security being the most used. However, additive manufacturing technology is not used in any of the companies as a result of the research.

Investment in new technologies was considered the greatest challenge for the implementation of industry 4.0, CNI (2018) states that technical factors, that is, technology, labor and raw materials, also positively affected the decision to invest.

In three of the four companies, in addition to applying the questionnaire, it was possible to visit the industrial parks and monitor in person the use of the technologies covered in the research. However, it can be concluded that the textile companies in the Santa Catarina textile pole are taking use industry 4.0 technologies to remain competitive in the market and increase your productivity.

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