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The Influence of the Hard and Soft Skills on the Technological Maturity of Industry 4.0: Study in a Multinational Company of the Automotive Sector

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ABSTRACT

This study identified technical and behavioral skills necessary for technological maturity in the context of Industry 4.0, the so-called hard and soft skills. The study also showed the main facilitators and barriers to developing these skills, during the Covid 19 pandemic. The unit of analysis was the sector of production engineering in a foreign multinational of the automotive sector. The in-depth case study was the research method, and we treated data by using content analysis, with the support of Atlas.Ti software. The results showed that hard skills are mostly related to the technical mastery of information systems (IS), industrial automation, process management and data analysis through business intelligence (BI), big data, statistics, and data mining. Soft skills correlate with each other and make up a dynamic set of behavioral skills, such as assertiveness, autonomy, communication, creativity, empathy, and resilience, among others. We found that the research unit developed hard and soft skills in the first levels of technological maturity for Industry 4.0, both through the individual efforts of employees and organizational initiatives, like training and development. The hard and soft skills found allowed us to conclude that the investigated company operates largely in the first levels of technological maturity: digitization (1 and 2), visibility (3), and transparency (4). For more advanced levels of technological maturity - predictive capacity (5) and adaptability (6) – the necessary skills are under development.

Keywords: human skills, hard skills, soft skills, technological maturity, Industry 4.0, automotive industry.

1 INTRODUCTION

The Fourth Industrial Revolution, also called Industry 4.0 (I4.0), is radically changing industry's global organization. Countries have the opportunity to revitalize their production parks and hire highly specialized professionals. The concept of Industry 4.0 was developed in Germany, and considers a set of technologies that involve computerization and automation, as well as data security systems, artificial intelligence, Big Data, Internet of Things (IOT), cloud computing, integrated systems, additive manufacturing, simulators, augmented reality, and autonomous robots. Industry 4.0 tends to be highly automated, using systems with cognitive intelligence and digital processes (Schwab, 2017).

According to this author, in I4.0 automatic machine learning is possible, which can revolutionize the industrial process. In turn, Darth (2014) mentions the flexibility of available resources as one of the pillars of this new industry, where devices and human-machine interfaces are connected, establishing real-time data analysis and enhancing industrial productivity. Industry 4.0 must be implemented in an interdisciplinary and collaborative environment, integrating professionals from the main knowledge areas, like engineering, information and communication technologies' specialties, human resources, as well as professionals from other areas of knowledge additional to Industry 4.0 (Kagermann, Wahlster, & Helbig, 2013).

One of the bases of I4.0 is Digital Transformation (DT). With the principle of implementing technologies that facilitate digitization and storage of organizational information, DT is seen as an accelerator for transforming business activities, processes, skills and models, leveraging the changes and opportunities brought by the use of technologies (Demirkan, Spohrer, & Welser, 2016; Vaz *et al*., 2017). The digital category, which includes Big Data, Internet of Things, and Artificial Intelligence (AI) technologies, relates to what we conventionally call Digital Transformation (DT), which significantly influences organizational elements such as Industry 4.0 culture, strategy, processes, and structures (Schwab, 2017; Hess *et al*., 2016).

The context of the Fourth Industrial Revolution affected the organizational field, by defining new relationships between I4.0 technology and the use of human capital. I4.0 challenges impose the development of new skills, either technical, methodological, social, or personal, to meet the demands of production sectors. The development of these skills involves different stakeholders, such as governments, companies, universities, and society in general (Schwab, 2017).

In addition, the evolution of the technologies required by Industry 4.0 brings opportunities for the contemporary scenario, among them those related to the increase of local demand for qualified labor (Brasscom, 2019).

For Schwab (2017), the I4.0 revolution evolves at an exponential and non-linear pace, which is the result of the current heterogeneous and deeply interconnected world. Moreover, each new technology generates others, newer and increasingly qualified. The range and depth of these changes, based on digital aspects that combine several technologies, has led to unprecedented paradigm break in the economy, in businesses, in society, and in individuals. This transformation not only affects "what" and "how" we do things, but also "who" we are, and influences entire systems among countries and within them, in companies, industries, and throughout society.

The combination of Industry 4.0 technologies and the use of personal resources evolves through new knowledge, the formation of relationship networks, and the development of cognitive and practical skills. Thus, technical and behavioral abilities are essential in this digitization context, since the lack of mastery of such skills can put at risk a company's innovation capacity (Kinkel, Schemmann, & Lichtner, 2017).

Therefore, I4.0 challenges are not limited to financial investment for technology acquisition; they also include the qualification of professionals at all organizational levels, to deal with the increasing complexity of production systems (Erol *et al*., 2016).

Nevertheless, the study of skill mastery for achieving technological maturity in I4.0 is little investigated (Schuh *et al*., 2017). Also recent is the study of structures, maturity models, and scripts for the digital transformation of manufacturing companies in the automotive sector, for developing their capacities for Industry 4.0 (Mittal, Romero, & Wuest, 2018). In addition, studies on Industry 4.0 show the need to know the evolution of work profiles, which create new demands, as in that sector, and how to deal with this gap in employees' skills (AnTosz, 2018).

In view of the above, there is a transition from the industry based on information and communication technologies (Industry 3.0) to Industry 4.0, which shows the novelty and importance of the topic, and the opportunity to carry out this study and answer the following research question: *"Which human skills contribute to technological maturity in Industry 4.0, in an automotive company?"* The objectives of this study were: (i) to identify the human skills that contribute to technological maturity in Industry 4.0; and (ii) to identify the barriers and facilitators for the development of human skills in Industry 4.0, in an automotive company.

2 LITERATURE REVIEW

2.1 Industry 4.0

Industry 4.0 is the new configuration of the automotive industry in several countries. According to Schuh *et al*. (2017), it corresponds to the Fourth Industrial Revolution, characterized by digitization, visibility, transparency, predictive capacity, and adaptability of technological industrial operations.

According to Hermann *et al.* (2015), I4.0 is a technological model that involves connectivity and predictability, and uses cyber-physical systems, the Internet of Things and cloud computing. It creates chains of higher added value, and modifies the classic systems of human organization and production, as well as organizational business models, affecting society as a whole and the environment (Fonseca, 2018). Costa (2017) observes that I4.0 lies upon the development of qualified software and hardware, which enable productive machines to evolve so much that they can learn and collaborate.

The way of working is being one of the most important changes in I4.0, affecting not only the implementation of technology and production, but also the dimensions of I4.0 technological environment (Gebhardt, 2015). The major difference between the most recent industrial revolution and the previous ones is that, despite having improved processes along global production chains, they did not have the capacity to interconnect machines, products, suppliers, and consumers, and did not develop so quickly or generated as much connectivity as I4.0. (Buisán & Valdés, 2017).

For Schwab (2016), it is essential that society perceives the changes caused by Industry 4.0, capable of transforming deeply and radically the way of living, working, and even relating, as it is a revolution different from any other event experienced by humanity, in terms of scale and complexity. The author further classifies the technology drivers of Industry 4.0 in three categories: physical, digital, and biological. The digital driver comprises additive manufacturing systems (3D printing), autonomous vehicles, advanced robotics, and new materials - lighter, stronger, recyclable, and adaptable -, in addition to Internet of Things (IoT) and sensors.

According to Ibarra, Ganzarain, and Igartua (2018), the main characteristics of Industry 4.0 are the interoperability between stakeholders, the virtualization of processes and services, the decentralization of the manufacturing decision, the ability to work in real time, service orientation, and modularity. Such characteristics can affect traditional business models, creating new demands, mainly for the organization of customized mass production, as well as for local production, lower prices, and intelligent goods and services. In addition, I4.0 work will be substantially concentrated in areas like standardization, work organization, creation of new business models, new products, availability of qualified workers, and R&D investment. However, according to Schuh *et al.* (2017), the degree of a company's maturity in Industry 4.0 stands on its global capacity for change and adaptation.

2.2 Technological maturity in Industry 4.0

The term "maturity" refers to a state of being complete, perfect, or ready (Simpson & Weiner, 1989), and implies some progress in the development of a system. Therefore, maturing systems (for example, biological, organizational, or technological) increase their capabilities over time for achieving an intended future state. We can measure maturity qualitatively or quantitatively, in a discrete or continuous manner (Kohlegger, Maier, & Thalmann, 2009).

We use maturity models commonly to conceptualize and measure the maturity of an organization or a set of "conditions where the examined objects reach the best state of their intended purpose, at scalable levels of maturity" (Wendler, 2012, p. 1197).

Given the complexity and multidisciplinarity of the Fourth Industrial Revolution, it is important to determine capabilities and develop strategic scripts required by the new I4.0 technologies. Many of these challenges are addressed in other fields, using scientific references from maturity models, which approximate qualitative and quantitative capabilities, highlighting strengths and weaknesses for the implementation of Industry 4.0 technologies (Tarhan, Turetken, & Reijers, 2016).

The maturity of an industrial company is the state of progress of internal and external conditions that support the basic technological concepts of Industry 4.0. These are the vertical and horizontal digital integration of internet systems and industrial manufacturing processes, which allow assessing, at a given moment, the level of maturity of a particular technology and, in a consistent comparison of maturity between different types of technology, the entire context of a specific system, its application, and its operating environment (Mankins, 1995).

For Schuh *et al*. (2017), the maturity analysis methodology has six different stages for I4.0 capabilities, starting with levels 1 and 2, which form a digitization basis needed to implement levels 3 (visibility), 4 (transparency), 5 (predictive capacity), and 6 (adaptability), the most advanced levels of maturity in I4.0. The main challenges for the maturity model are to understand the meaning of Industry 4.0, and the systematic development of response strategies for its implementation.

According to these authors, the degree of maturity of a company in Industry 4.0 depends on its global capacity for change and adaptation. The last four stages are more innovative and complex, and directly related to the technological benefits of Industry 4.0. All six-maturity levels must be attained sequentially, since the achievement of one supports the following levels, since they are interdependent.

However, I4.0 is a dynamic reality, and its technological implementation evolves at an exponential rate, meaning that companies need employees with multiple skills, and flexible enough to adapt to any technology that may arise as a requirement for this scenario (Ghobakhloo, 2018).

2.3 Skills for Industry 4.0

The human factor is of major relevance for the evolution of the technological maturity levels of Industry 4.0 (Herzog & Bender, 2017). Due to its technological complexity, it is timely for companies to identify the technical and behavioral skills of employees who will operate in this new technological and social reality. It is also necessary to develop such skills for the qualification of professionals already hired (Rosé, 2018).

Further studies on human skills were developed in the mid-1980s, essentially oriented to defining a minimum and acceptable level of performance standards, in a specific task or position, and identifying the necessary abilities to perform the task and meet the previously defined performance standards (Pedro, 2014).

In order to understand the objectives and skill challenges related to the new technologies and processes of Industry 4.0, we need new strategic approaches for the holistic management of human resources in manufacturing companies with an I4.0 technology base (Hecklau *et al*., 2016). To ensure the intended organizational success, companies need to develop human skills continuously, an investment that will create a workforce capable of learning and applying the new knowledge on a daily basis, leading to constant improvements and technological innovations for Industry 4.0 demands (Senge, 2012).

According to Schwab (2016), Industry 4.0 will drastically change the nature of work in all sectors and occupations. Different work categories will change their processes, especially those who perform repetitive mechanical or precision manual work. The human workforce required by this revolution will deal with complex problem solving, and need social skills.

In view of the demands and challenges of new technologies, processes are getting more complex, showing the importance of companies' qualification and development of human resources, especially in the automotive sector, which already implements or will implement new I4.0 technologies (Hecklau *et al*., 2016).

For the new configurations of I4.0 technologies, deep knowledge of intelligent technologies and processes will be essential, as well as system coding and cyber security. According to Lorenz *et al.* (2015), with the intense use of Industry 4.0 technologies integrated into the digital environment, human skills for the development of industrial automation software and ICT knowledge will be required of workers.

The human factor is one of the constraints of the matrix structure necessary for a company to evolve in its level of technological maturity, in addition to managers' style for decision-making and for managing human resources (Vasconcellos & Hemsley, 2003).

However, there are barriers and facilitators that influence the development of human skills for Industry 4.0. Barriers are elements that hinder the implementation of Industry 4.0 technologies in companies. To address them, we used the studies of Suprun and Stewart (2015), and Marzucchi and Zoboli (2015), which classified them as lack of resources, knowledge management, and unfavorable organizational culture.

Among the behavioral aspects that are barriers or facilitators, we find the capacity to bear ambiguities, political skill, and the ability to perform multiple professional activities. These behavioral aspects require new organizational human skills to manage and motivate people in an environment of maturity and advanced technology, as well as competitive maturity, through the management of new skills for I4.0 technologies and innovations.

Barriers to knowledge sharing can be lack of communication skills or of recipient's absorption capacity, casual ambiguities on knowledge, and relationships between sender and receiver. The factors that influence human skills, acting as facilitators or barriers, are classified in three categories: technological, individual, and organizational (Manjit, Jain, & Ahmad, 2011).

Facilitators are elements that encourage companies to implement Industry 4.0 technologies. To present them, we refer to the studies of Suprun and Stewart (2015), and Ribarić (2015). Taking into account the innovation context of Industry 4.0, an important aspect is the development of technological capacity as a facilitator, because the greater this progress, the more relevant company's innovation measures will be (Horbach, 2014).

Technological capacity regards research and development (R&D), which provide the company with the ability to adjust more easily to market needs, due to its technological potential, by changing its production process and products because of environmental concerns raised by top management (Khanna, Deltas, & Harrington, 2009). Technology is the initial stage of product development, since after having an idea, R&D is necessary for creating production technologies (Rennings, 2000).

3 METHODOLOGY

This study is mostly descriptive, with some exploratory elements (Creswell, 2010). We followed the nine research phases indicated by Sampieri, Collado and Lúcio (2013). The investigation method was an in-depth case study, which sought to understand the dynamics of a phenomenon based on its uniqueness (Yin, 2015), specifically the influence of hard and soft skills on technological maturity in Industry 4.0, in a foreign multinational company.

The unit of analysis was the engineering sector of a multinational car company, with subsidiaries located in the cities of Curitiba-PR and Campinas-SP. We chose it according to the following criteria:

a) Be a subsidiary of a foreign multinational company in the automotive sector, a pioneer in solutions for Industry 4.0;

b) Have professionals in the production engineering sector that work with I4.0 technologies;

c) Keep hard and soft skills development to increase technological maturity of I4.0; and

d) Be able to identify barriers and facilitators for the development of human hard and soft skills.

We developed the instrument for data collection through the following steps:

a) Preparation of the interview script based on a mooring matrix resulting from studies by Eberhard *et al*. (2017), Hecklau *et al.* (2016), Cardoso (2006), Fleury and Fleury (2000), Iversen (2000), Senge (2012), Schuh *et al*. (2017), Tarhan *et al*. (2016), Wilding *et al*. (2012), Suprun and Stewart (2015), Marzucchi and Zoboli (2015), and Ribarić (2015);

b) Academic validation by members of a research group on Innovation, Technology and Entrepreneurship; and

c) Validation of the interview script and pre-test by professionals from marketing, production engineering, and human resources areas.

We collected data in August and September 2020, during the Covid-19 pandemic, through semi-structured interviews, by using digital communication applications and visiting the two plants. We carried out 10 interviews with employees of the analysis unit, with a total duration of 467 minutes, until we reached data saturation. We defined the participants based on their active operation with Industry 4.0 technologies. In addition to collecting primary data, the company provided secondary data, to strengthen information from different sources on the same facts and phenomena, as suggested by Yin (2015).

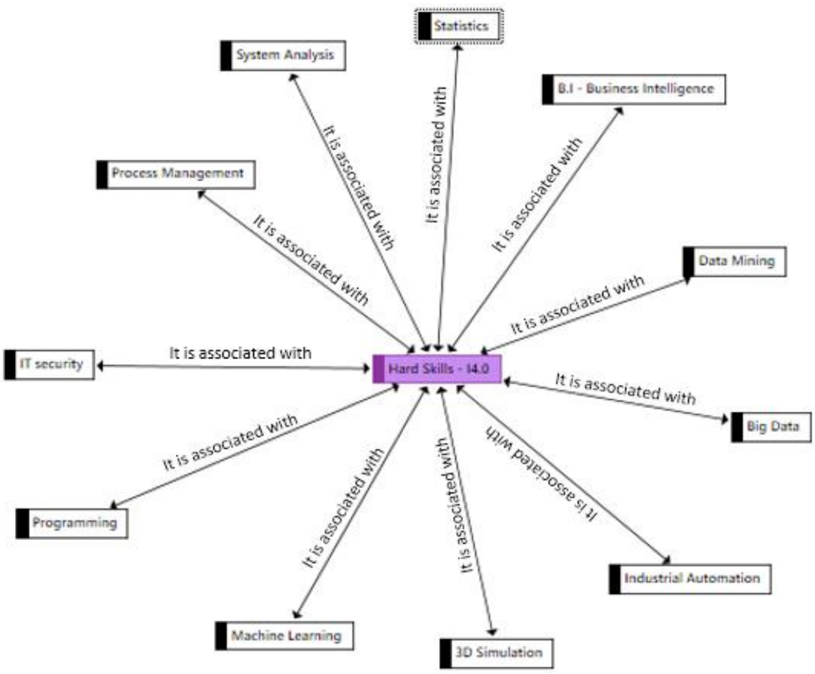
We used content analysis for data treatment and analysis (Bardin, 2010), through the following stages: organization of analysis, coding, categorization, result treatment, inference and interpretation. To organize and present the collected data, we used Atlas TI software. We arranged them in text clippings, grouped in 37 codes. Later, after defining the categories, we created association networks of the analytical categories and subcategories, for data interpretation.

4 RESULTS AND ANALYSIS

The study's first specific objective was to check which human skills influence the technological maturity of Industry 4.0 in an automobile company.

Through the collected data, we generated the study's first network, of the hard skills applied to Industry 4.0 in the investigated company. To describe the codes relevant to the study, we considered the magnitude criteria, regarding the number of citations linked to the described code, and the density criteria, related to the amount of codes linked to the main code. This network, Industry 4.0 hard skills, gave rise to 11 subcodes, seen in Figure 1. We describe the subcodes after the figure.

Figure 1 –Network of hard skills



Source: Survey data

- **System analysis**: involves programming, production controls, and data measurement through systems, essential for the company to achieve I4.0 levels of technological maturity. The system analysis ability also provides other benefits, as mentioned by interviewee 5 (E5):

> [...] At the technological maturity level, adaptability and hard skills are important for the development of I4.0, and need a deeper knowledge, mainly in information systems and IOT, which encompasses these technologies.

- **Industrial automation:** commands the operation of automated equipment in production processes. Professionals need to create and manage automated production lines, thus mastering technologies in electrical and electronics fields. Additionally, also relevant for industrial automation, they must master robotics, which increases company's quality and production capacity.
- **Business intelligence (BI):** ability that enables data collection, organization, and graphical analysis, besides monitoring results and metrics, in order to assess trends and perspectives of current and future company's scenario.
- **Big Data:** allows collecting and managing a great amount of data, for supporting company's complex decisions. The efficient management of data is essential to advance I4.0 levels of technological maturity, since it provides an integrated view of technological efficiency and standards of Industry 4.0.
- **Statistics:** allows quantifying the expected result in industrial manufacturing processes; reliability of data collection through sensors in equipment (IOT) is essential, besides data transmission and management, mainly from the shop floor.
- **Process management:** required for the transition towards the "intelligent factory", but not necessarily related to large technological investments; it enables managing essential activities for Industry 4.0, such as the Statistical Process Control (SPC).
- **Machine learning:** a system that can learn with new data, recognize patterns, and make decisions with minimal human intervention. It represents the capacity of problem solving, which means the prediction and pattern recognition of technology applied in I4.0, as it is a branch based on artificial intelligence. The relevance of the machine learning skill improves the performance of production processes, as mentioned by E2:

> [...] Within the scenario of product analysis, machine learning and IOT improve and identify analytical models, know all product's variables better, and how to interfere in a given product, in case of failure, by changing its hardware and software as needed.

- **Data mining:** use of specific technical skills and technological tools to explore information and select patterns, sequences, or rules that identify problems in operation, production, or opportunity creation, as well as the optimization of industrial processes.
- **Programming:** especially in Phyton language and in Programmable Logic Controller (PLC). It provides a systemic view of production processes, by understanding their interlocutors, and using its capacity of risk analysis in situations that involve I4.0 new technologies to be implemented in the company.
- **IT security:** necessary to operate the required security levels for I4.0 operations, for ensuring data protection, privacy, and availability.
- **3D simulation:** involves activities of augmented reality and/or computer vision. It should be mastered especially by engineering professionals and by those that deal with products, processes, mechanics and electrical fields, as E6 observed:

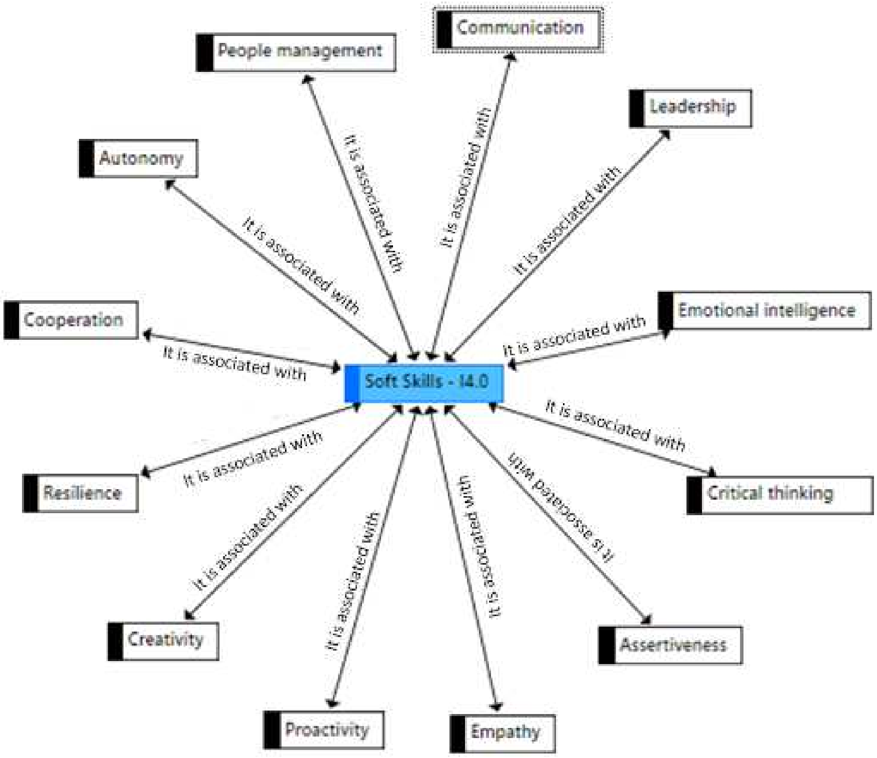
> We work with product tests, and we test them until they reach the end of their lives; hence, what has happened a lot here in the company, in the digitization part of this process, is making the simulation of these tests before going to the bench, based on mathematical models and 3D representations, which can be used for different purposes such as production, for simulating it through different processes.

The results of hard skills' identification showed that different technical skills are necessary for operating with the technologies required for I4.0. Mastering skills in several areas, such as computer science, information technology, electronics technology, and automation technology can enable industry to progress in terms of technological maturity and interface mastery in I4.0.

Therefore, considering that each industrial revolution has advanced in a specific technological development (Schwab, 2017), industry 4.0 will require professionals with technical skills different from those required by industry 3.0; as digitization and industrial automation evolve, jobs will demand flexible answers, problem solving, so employees will need greater capacity for working together with I4.0 technologies.

The second network generated was for *soft skills*, shown in Figure 2. It gave rise to 12 subcodes, described below.

Figure 2 – Network of soft skills



Source: Survey data

- **Assertiveness**: ability to state clearly, knowing when and how to communicate something, avoiding unnecessary conflicts, favoring constructive relationships and self-confidence, and reducing stress and frustration in communication. Assertiveness allows employees to generate more and more confidence in their work environment and in themselves, by speaking frankly and honestly, firmly and directly, without causing embarrassment, as E4 mentioned:

> [...] [it is important] to be assertive and convey the information clearly, dynamically, regarding what you are doing at work, in order to achieve quality in activities and work processes, and not just delivering a well-done work, but being aware that the

> other side, the "customer", is expecting a better result.

- **Autonomy:** allows you to make decisions that expedite daily activities, manage new projects, and achieve effectiveness in company's results. We noticed the importance of self-management for the firm, through which employees participate actively in the choices and decisions for adopting I4.0 technologies.

- **Communication:** when it is fast and efficient, it provides agility in managing manufacturing processes and decreases the duration of activities, with a consequent productivity enhancement, which can favor operational efficiency and firm's sustainability.

> […] Communication helps a lot in presenting the results, how to present them, how to interpret and communicate effectively; so, I think that communication within the department is very important, and employees should have this human ability more developed (E5).

- **Cooperation:** especially for teamwork, as it supports the development of new knowledge, essential for activities and projects, communication, and understanding the work demands that need efficient planning, execution, and delivery.

> [...] one of the more important soft skills is the ability to work as a team, dividing the activities in order to manage your team better, according to the new demands (E5).

- **Creativity:** important for changing something that exists, or for creating something new, using novel and imaginative ideas to achieve a better result. Training and developing employees can enhance it, in order to improve the innovation environment and autonomy for seeking technological solutions for I4.0.

- **Empathy:** it can be exercised together with other skills, to actively listen to and understand employees in their work environments. It involves connection and real understanding of other people's feelings.

- **People management:** the purpose is to motivate and attract employees, by detecting their best skills and applying them to reach their best potential. It allows us to understand the challenges for knowledge and skills related to the new technologies and processes of Industry 4.0.

- **Emotional intelligence:** a relevant *soft skill,* both professionally and in employees' daily situations. Its development is encouraged by the leader and by company's human resource management.

> [...] One of the relevant skills for I4.0 development should be emotional intelligence, since in work routine there are many activities and meetings, the activities have doubled; therefore, we must have a different behavior, to accomplish all duties.

- **Leadership:** ability to lead a team for the development of complex activities, ensuring that employees grow together. It is also knowing how to influence and motivate people within the work environment, in order to enhance the development of I4.0 technological maturity.

> I see that, if there is leadership and attitude, any person can develop all the technical part necessary to accomplish a given personal task (E1).

- **Proactivity:** relevant for implementing Industry 4.0 technologies in the company, which involves initiatives for information and knowledge exchange, participation in joint meetings, and constant communication between the areas.

- **Critical thinking:** a very important soft skill for solving conflicts and problems in a distant and rational way. To develop this attribute, we must always question ourselves and be interested in finding more and being impartial, in order to analyze things critically.
- **Resilience:** overcoming adversities and, often, restarting an activity, especially when working with heterogeneous employees and sectors. Thus, understanding the dynamics of each professional is of outmost importance, so that everyone adapts to the company.

This study contributes to the literature by showing that soft skills are essential in Industry 4.0, because their combination with hard skills enables the systemic mastery of technologies and processes related to it. The study by Hecklau *et al*. (2016) on soft skills, mostly theoretical, presented a generic view of skills, without describing and articulating them with the different technologies necessary for I4.0, a gap covered by our study. The results revealed that the company is seeking which of these skills are necessary for I4.0, in order to understand qualification gaps and take actions for their development.

The second specific objective of this study was to identify barriers and facilitators for the development of human skills in Industry 4.0, during the Covid-19 pandemic. The results are summarized in Table 1.

Table 1
Barriers and Facilitators for developing human skills in I4.0

Barriers		Professional updating	The need for constant updates, especially in technology, is directly linked to the dynamic profiles of the different positions at the company.
		Communication	It can hamper or prevent the agility of manufacturing processes, the reduction of working time, with the resulting improvement of productivity and operational efficiency. It can still affect interpersonal relationships within the company.
		Generational shock	It is evident the need to know how to deal with different generations and find a common ground between them, so that one accesses the other and can take advantage of its knowledge, with possibilities for building joint solutions for the company.
		Cooperation	It results in working toward an individual goal, which can delay the achievement of higher levels of maturity in Industry 4.0. Without it, employees may view their peers as competitors, as they tend to feel threatened.
		Industrial connectivity	All data must be shared between equipment and devices, sectors and different hierarchical levels of the company. This demands investments in IT infrastructure to increase industry's connectivity in order to improve the capture, speed, and volume of data transmitted and analyzed.
		Management incentive	It is necessary to increase budgetary resources for the development and implementation of I4.0 technologies. Management incentive also avoids the lack of coordination between units, which must interact at different levels, for example, with headquarters and other branches.
		Time management at work	It is a barrier, due to the need to meet the daily demands in the best possible way, besides meeting project deadlines. The appropriate time management results in high professional performance and high productivity.
		Technological innovation for Industry 4.0	Without investment in technological innovation, fundamental skills for I4.0 tend not to be developed in core areas such as digitization and automation, data security systems, Big Data, internet of things, cloud computing, integrated systems, additive manufacturing, augmented reality, etc.
		Disciplinarity	Multidisciplinary practices should favor eclectic, holistic education, in order to

			enable the gradual understanding of the different technologies involved in I4.0. Although learning by doing is expected in I4.0 professional development, training should evolve into multi or interdisciplinarity
		Resilience	Identified when adapting to new technologies and relationships. It is essential to understand how to overcome adversities and start over, especially when working with heterogeneous employees and sectors, as well as understanding the dynamics of each professional.
		Hierarchical structure	The division by sectors tends to affect communication and the achievement of strategic goals negatively. In the horizontal structure, employees have more autonomy, processes are less bureaucratic, and decision-making is more assertive, giving agility to the implementation processes of I4.0 technologies.
Facilitators		*Cross functional activities*	Especially necessary in work environments or high-performance teams for developing innovative products and services that involve complex technological processes. Their major advantages are increased and more efficient communication and knowledge exchange between employees in different functions.
		Communication	It is an incentive for manufacturing processes, in addition to reducing working time, and consequently improving productivity and operational efficiency. Digital technologies have a direct impact on enhancing communication and knowledge sharing, in both reception and dissemination.
		Internal creative spaces	They contribute to innovation and for looking beyond the routine environment, besides stimulating research on trends and group interactions. They allow meetings and debates on new projects and ideas, together with the support of the technological resources available in these spaces.
		Training & development (T&D)	Training is associated to specific qualification, such as short-term capabilities, and development is associated with a long-term process, which comprises employees' career plans. T&D allows motivating and engaging teams, by identifying and enhancing the best skills of each employee.
		Technological innovation for Industry 4.0	The result of using several digital technologies, from manufacturing processes to industrial management. These include computerization and automation using data security systems, Big Data, Internet of Things, cloud computing, integrated systems, additive manufacturing, simulators, augmented reality, and autonomous robots.

Once identified the barriers for developing hard and soft skills, the company needs to undertake actions oriented to their employees, as well as to external partners, in order to reduce the barriers and convert them into development of technologies for Industry 4.0.

We realized that the biggest challenge is not implementing the right technology, but the lack of digital culture and skills in the company for Industry 4.0. For PWC (2016, p. 12), “firms need to develop a strong digital culture and ensure that changes are driven by an objective resource management of the sectors that work directly with I4.0”, which is in line with our findings.

The study’s results contribute to the literature by identifying new facilitators for the development of skills for Industry 4.0, such as creative spaces and training and development (T&D), not mentioned in the previous studies by Suprun and Stewart (2015), and Ribarić (2015).

The Covid-19 pandemic created a new reality for the company studied. Despite the new challenges, the pandemic created opportunities for changing organizational routines, enabling the development of new technical and behavioral skills by the professionals. One evidence was the remote training that became a routine adopted by the company, making its professionals more technically effective and more open to healthy interpersonal relationships.

5 CONCLUSIONS

This study sought to fill the theoretical-empirical research gaps in the field of hard and soft skills necessary for Industry 4.0, since the scientific literature often mentions this topic in a generic or dispersed way. The main objective of this study was "to identify the human skills necessary for technological maturity in I4.0 in an automotive company". In addition, the study aimed to identify barriers and facilitators for the development of hard and soft skills in I4.0.

We conclude that hard skills for increasing technological maturity in I4.0 are strongly linked to a graduation degree and specialization studies, as they stand on university curricula. In addition, important skills in solving complex problems and managing technological processes emerged, leading to the conclusion that technological maturity in Industry 4.0 requires advanced levels of cognitive abstraction from employees. In fact, repetitive skills should be automated, with the support of information systems, so that employees can develop more complex skills, which agrees with Schwab's (2016) conclusions, that Industry 4.0 is changing drastically the nature of work in all sectors and occupations.

We also concluded that most of the hard skills identified in the investigated company relate to information systems (IS), since skills in IS subsystems were considered relevant, like those for business intelligence (BI), data mining, Big Data, 3D simulation, machine learning, software programming, information security, systems analysis, and statistics.

The main soft skills identified correlate with each other, and comprise a dynamic set of behavioral skills, which leads to the conclusion that such skills can eventually be developed individually, but especially maximized through teamwork and interpersonal relationships. Skills strongly dependent on teamwork and relationships are communication, leadership, empathy, cooperation, and people management. On the other hand, skills regarding emotional intelligence, critical thinking, assertiveness, proactivity, creativity, resilience, and autonomy can be, directly or indirectly, dependent on teamwork and on efforts to build good interpersonal relationships.

According to the results, the identified soft skills are not specific for Industry 4.0, being useful for any professional and technological area of the company, confirming Matturro's (2013) findings. In any case, the identified soft skills are crucial for the professional, managerial, and leadership roles required in I4.0, since the challenges related to the high technological complexity intrinsic to I4.0 tend to be solved through teamwork and healthy interpersonal relationships, which go far beyond hard skills.

Thus, investments in the qualification of behavioral skills are a differential for accessing work opportunities within the scope of Industry 4.0 technologies. This result supports the conceptual understanding that incorporating technological innovations is not an isolated challenge in the universe of Industry 4.0, since behavioral attributes are necessary for a proper professional performance in this scenario.

Once the company understands the set of skills needed for its future role, it can identify the skills currently available among employees and plan how to reallocate them over time, besides identifying gaps to satisfy both parties, the existing and the new roles.

The hard and soft skills found allow us to conclude that the investigated company operates in a higher degree in the first I4.0 levels of technological maturity proposed by Schuh *et al*. (2017): digitization (1 and 2), visibility (3), and transparency (4). The skills required at more advanced levels of technological maturity - predictive ability (5) and adaptability (6) – are under development. Therefore, developing skills for these levels, especially hard skills, may be limited due to the lack of investments in technological innovation for I4.0, which still need to be done.

The main barriers to the development of human skills are individual factors, related to the professional development of workers, and organizational factors, related to company's management, which confirms Riege's (2005) findings. They also are in line with Vasconcellos and Hemsley (2003), who mention that the human factor is one of the constraints for a company to evolve in terms of technological maturity, in addition to managers' style in decision-making and in human resource management.

The largest set of barriers for developing skills for I4.0 relates to organizational factors. They involve changes that the company can make, especially in the hierarchical structure and management incentives, which are linked to other barriers that emerged from the research, such as problems in internal communication and cooperation. Additionally, there are generational shock barriers, which can decrease through management initiatives, and the lack of technological innovation, mainly in industrial connectivity, which can be reduced through an effective strategy of technology investment in Industry 4.0. These conclusions confirm the results of Suprun and Stewart (2015), Marzucchi and Zoboli (2015), and Riege (2005).

In turn, the facilitators for the development of human skills identified in this study are mostly organizational, like technological innovation, training and development, cross-functional activities, and communication, which confirms the findings of Suprun and Stewart (2015) and Ribarić (2015). In particular, the 'creative spaces' facilitator proved to be essential for developing skills, as it allows team integration, engaging employees in activities that require cooperation and creativity.

Although we expect individual efforts for developing skills, the company is responsible for facilitating the development of human skills for Industry 4.0, through actions that involve all levels of management and provide the implementation of strategies and a corresponding culture.

As for the impact of the Covid-19 pandemic, it accelerated both hard and soft skills for increasing technological maturity in Industry 4.0, since remote work changed organizational routines. In addition to remote technological mastery through interconnected systems, employees were encouraged to develop their behavioral skills further, for dealing with the new challenges posed by the pandemic.

Finally, the study has limitations regarding the theoretical frontier of investigation on Industry 4.0, a wide phenomenon with conceptual divergences. It also shows methodological limitations; although the method allowed an in-depth study of a company, replicating it in other firms could reach different results. We suggest, as future studies, a comparative research of human skills developed in national and foreign companies. Additionally, studies with foreign multinationals, to check to what extent the flow of knowledge from headquarters to other R&D centers contributes to increase technological maturity in Industry 4.0 at the subsidiaries. These studies could also investigate the necessary competencies for achieving technological maturity in I4.0, considering the sum of knowledge, skills, and attitude (KSA).

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