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The impact of Industry 4.0 revolution on SMEs'organisational structure

Prof. Sara Lombardi

SUPERVISOR

Prof. Luca Giustiniano

CO-SUPERVISOR

Massimiliano Manzini
Matr.756251

CANDIDATE

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Abstract

When talking about "Industry 4.0" we are referring to the "Fourth Industrial Revolution" that allows an agile interconnection between the physical and digital world. This has been possible thanks to the development and convergence of a variety of technologies and ideas, such as Big Data, Artificial Intelligence (AI), machine learning, the Internet of Things (IoT), and cyber-physical systems, marking the beginning of a new technological revolution according to *Lennon Olsen, Tava, and Brian Tomlin (2019).*

Industry 4.0, recently, has had a considerable impact on many aspects of society including environmental sustainability and supply chains in substantial ways (*Ghadge, Abhijeet, et al, 2020*).

According to a study, many businesses worldwide have started the process of digital transformation towards I4.0, which entails potentially radical changes to every aspect of a business including its organisational structure, human resources, process management, manufacturing operations, …(*Cimini, Chiara, et al., 2020*).

The main goal of this thesis is to understand on which basis a company that adopts Industry 4.0 technologies decides to renew, change and adapt its organisational structure. On what basis does a company that decides to adopt Industry 4.0 technologies restructure itself?

In doing so, I will take into great consideration a study that highlights the fact that higher levels of technology adoption create a higher need for non-technical competences (*Cimini, Chiara, et al., 2020*). In order to do the above-mentioned, I will also focus on studies that describe and study the similarities and differences between what competences and soft skills are and how they are perceived by both employers and employees. That will enhance clearness and allow me to be more precise both during my analysis and when dragging final conclusions.

This analysis has been conducted through a semi-structured interview, in order to give the respondents a guideline but at the same time allowing them to lead their answers to get to the desired results.

The findings of this analysis highlighted three aggregate dimensions that significantly affects companies after the implementation of an I4.0 technology: drivers for adoption, resistance to change and flexibility enablers.

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Introduction

The general concept of Industry 4.0 was first established by a German government program in 2011 to introduce a paradigm shift toward a digital future in industrial production and to boost the manufacturing industry's competitiveness. The use of sophisticated Information and Communications Technology (so called ICT) to increase the degree of automation and digitalization of production, manufacturing, and industrial processes is referred to as Industry 4.0. Its goal is to manage the entire value chain process, enhance production efficiency and deliver high-quality products and services. Indeed, Industry 4.0 continues to relate to many possibilities and benefits, such as highly flexible mass manufacturing, lower complexity costs, the introduction of whole new services and business models, and real-time coordination and optimization of value chains.

The Internet of Things (IoT), Big Data, Cloud Computing, Additive Manufacturing, Autonomous Robots, System Integration, Augmented Reality (AR), Cyber-Physical Systems (CPSs), 3D printing, electric vehicles, and Simulation are all part of this global movement. To be more specific, IoT technologies enable the interconnection and sharing of information between "things" and human beings (*Bigliardi, Barbara, et al., 2020*)

The vast majority of research (*Mittal, S., Khan, M.A., et al., 2018*) on best practices and implementation procedures of I4.0 technologies is mainly conducted for large-sized organisations or multinational corporations (MNEs). Although MNEs make significant contributions to the economy, it cannot be ignored that SMEs account for 90% (*European Commission, 2016*) of companies operating in the EU. The impact of SMEs is equally relevant; they produce jobs, economic growth and ensure social stability.

In comparison to MNEs, SMEs must face different constraints, such as financial and knowledge resources. As a result, numerous authors notice a misalignment between current I4.0 theory and the specific requirements of SMEs. While I4.0 innovations are revolutionising production research across planning, execution, and maintenance-related research clusters, implementation of I4.0 technologies in SMEs remains hard, particularly in production, logistical, organisational, and management perspectives (*Masood, Tariq, and Paul Sonntag, 2020*). Industry 4.0 necessitates greater flexibility and customisation for businesses to move beyond the first step (*Torn, I., & Vaneker, T., 2019*). A study conducted on a SME company in the Czech Republic, specialised in the machining of aluminium and metal, highlights how

many aspects must be taken into consideration when a company decides to invest in such a technology.

During its initial approach to implement an Industry 4.0 technology, the section of the company that was hit by the change was organised in this way: one manager in charge of operations, one secretary, and two shifts with one shift leader and fourteen workers. The company disposed of eight machines for the production that were not interconnected with the company's custom-built information system. The result of this study, conducted after a period of four years that the company planned as the implementation time needed to successfully transition the company, showed that out of six "Items of introduction of industry 4.0" (*Rolf Pfeifer, Marcel, 2021*) four resulted to be successful. That was mainly due to the company's strategy that shifted its goals throughout the course of that period, resulting in no additional benefits from upcoming initiatives. That is a risk that companies must take into great consideration when deciding whether to implement a technology that takes such a long time to be finalised. Furthermore, the perception of the employees concerning the four fully implemented technologies was rated by them with a high score (on average more than 4 out of 5 on the Likert scale) while the two incomplete tasks were rated on average less than 2, "suggesting that the employees appreciated the first four stages, thinking that the company is not yet capable of going into these areas (*Rolf Pfeifer, Marcel, 2021*)". On the company side, they opted to stop these initiatives since the need for additional talents and resources was a risk that the management did not want to incur.

Another case study was conducted at the international truck and bus manufacturer Scania to examine the actual development of their purchasing department after the implementation of a technology I4.0. While investigating Scania's options for Industry 4.0, the qualitative data was gathered from a purchasing manager and employees of the digital factory department. It was then analysed using a maturity model and linked to one another. Its results showed that, although having a clear implementation plan for Industry 4.0 features in manufacturing, the purchasing department lacked knowledge and that any application of Industry 4.0 features was still in its infancy. That, according to the study, is mainly due to the lack of knowledge about the technology and the process across departments and purchasing department managers were not fully aware of what was happening in the manufacturing one. For the buying department specifically, there are no planned further moves. On the other hand, it is evident that the purchasing department is nevertheless impacted by Industry 4.0 procedures even if they are not directly applied throughout the purchase activities. The company was fully aware of the potential that such implementation would have had in the purchasing area, but due

to the mistake they have made they missed this huge growth and development opportunity (*Torn, I., & Vaneker, T., 2019)*.

I decided to use these two real cases as an example to show how practically implementing such a technology entails numerous variables to consider and how using a wrong approach can be strongly detrimental for a company.

The main objective of this study concerns the understanding of the effects that the implementation of a I4.0 technology have on the organisation design of a company, analysing the main drivers of this change and if and to which extent the restructuring process will make the company look for employees with less technical skills.

On what basis does a company that decides to adopt Industry 4.0 technologies restructure itself?

To conduct this study, the methodology I used consists in a questionnaire that allowed me to gather a substantial amount of information without imposing strict constraints. The survey was designed in a semi-structured way in order to let the interviewee be free to disclose the most relevant parts concerning the study I am carrying on. The sample size of the analysis consists of 10 Italian SME that recently went through the process of implementing an I4.0 technology, without imposing any specific constraints neither on the sector in which they operate nor on the typology of I4.0 implemented, to widen the range of possible future developments in this field.

Literature review

2.1 Industry 4.0 and its critical impact

Economic development is one of the issues that specialists in the system of state economic regulators discuss and study continuously.

Scientific proof of the ability and necessity of specialisation in industry to ensure high global competitiveness triggered the industrialization of economic systems.

The essential landmark of economic system development is sustainability, which has two major characteristics: stability and balance (*Oláh, Judit, et al., 2020*)

These qualities are present and combined in Industry 4.0, which belongs to the real sector of the economy and is focused on innovative industrial production processes. Intensification of Industry 4.0 development in modern economic systems will assure both innovation and development, stable economic growth, and balance of the national economy's sectoral structure (*Sukhodolov, Yakov A., 2018*).

The term "Industry 4.0" was originally introduced in Germany in 2011 at the Hanover show to describe the change process in global value creation chains. According to K. Schwab's report "The Fourth Industrial Revolution," presented at the World Economic Forum, Industry 4.0 includes business processes in industry that picture the organisation of global production networks on the basis of new information, communication and Internet technologies allowing a progressive number of “production objects” to interact (*Schwab, K., 2017*).

Brynjolfsson and McAfee, prestigious scholars from Boston's famed MIT, defined Industry 4.0 as a “golden age of machine industrial production organised around digital technologies and totally automated”.

E. Loshkareva, O. Luksha, I. Ninenko, I. Smagin, and D. Sudakov defined Industry 4.0 as a revolutionary method of organising industrial production based on widespread digitization and automation of manufacturing and distribution processes in industry that erases physical object boundaries, transforming them into a comprehensive complex system of interconnected and interdependent elements. These experts also distinguish the following basic characteristics of Industry 4.0:

- the transition from manual labour to robototronics, which ensures the automation of all production processes;

- the modernization of transportation and logistical systems caused by the mass distribution of unmanned vehicles;
- the increase in complexity and precision of manufactured technical products, the manufacture of new construction materials due to advancements in manufacturing technologies;
- the development of inter-machine communications and self-management of physical systems using the "Internet of things";
- the use of self-teaching programs to provide continuous development of production systems (*Loshkareva, E., Luksha, P., Ninenko, I., Smagin I., & Sudakov, D., 2015*).

The process of forming and developing Industry 4.0 affects all aspects of the economic system, including the social sphere, which is notable for significant changes related to the need for humans to adapt to new economic conditions. Thus, entrepreneurs optimise company operations by utilising the opportunities afforded by Industry 4.0, the employee (industrial specialist) either masters new competencies required in Industry 4.0 or seeks employment in another field, and the consumer masters new industrial items.

In the future, the establishment of Industry 4.0 may lead to the gradual modernization of other industries. This means that Industry 4.0, as a domain of industry, has the capacity to change the current technological pattern. Its sectorial affiliation is defined not by the provided products, but by the organisation of the manufacturing process. The universality of the new industrial model provided by Industry 4.0 allows for the manufacture of any industrial product. This opens the door to a new industrial revolution, with Industry 4.0 set to become a new global industrial milestone and standard by which the real economy of the entire global economic system will evolve.

In order to raise the level of automation and digitalization of production, manufacturing, and industrial processes, Industry 4.0 makes use of cutting-edge Information and Communications Technology (ICT). Its goal is to manage the complete value chain process, increase manufacturing efficiency, and provide high-quality goods and services (*Silva M, Vieira E, Signoretti G, Silva I, Silva D, Ferrari P., 2018*). Industry 4.0 was and continues to be linked to a variety of advantages and prospects, including highly adaptable mass production, lower complexity costs, the introduction of completely new services and business models, or real-time coordination and value chain optimization (*Galati F, Bigliardi B., 2019*). This global

movement involves a number of technologies: Big Data, Cloud Computing, Additive Manufacturing, Autonomous Robots, System Integration, Augmented Reality (AR), Cyber-Physical Systems (CPSs), 3D printing, electric vehicles, and Simulation are all examples of terms related to the Internet of Things (IoT) (*Romeo L, Paolanti M, Bocchini G, Loncarski J, Frontoni E., 2019*).

The two fundamental components of Industry 4.0 are integration and interoperability (*Lu Y., 2016*). Vertical integration in particular makes it possible to employ CPS (measure of how fast information moves from one computer or file to another) to build flexible and changeable manufacturing systems in factories. It describes how different IT systems are integrated at various levels of hierarchy across a manufacturing process. Horizontal integration, on the other hand, refers to the use of these technologies to share and manage information across various agents involved in a manufacturing process, including intercompany value chains, marketing, resource management systems and supply chain (*Posada J, Toro C, Barandiaran I, Oyarzun D, Stricker D, de Amicis R, Vallarino I, 2015*).

Research on the deployment of Industry 4.0 in supply chain networks is becoming more and more necessary as a result of the movement toward Industry 4.0. Despite various studies on frameworks and roadmaps for the Industry 4.0 transformation, a comprehensive system approach that takes complex systems like SCs into account is lacking (*Sarvari, P.A., Ustundag, A., Cevikcan, E., Kaya, I. and Cebi, S., 2018*). Anyway, in order to become more digitised, automated, and flexible in their operations, supply chains are making significant progress (*Ghadge, Abhijeet, et al*). The effects of Industry 4.0 can be seen at various stages of SCs as well as in supply chain management (SCM) strategies. For example, improved forecasting and planning due to integrated flow and increased control on materials and products flow, improved supplier performance due to real-time information sharing and synchronisation with suppliers, and intelligent warehousing and vehicle routing systems (*Hofmann, E. and Rüsch, M., 2017*). A study conducted in 2020 (*Ghadge, Abhijeet, et al*) highlighted how the implementation of an inventory control software positively impacted on different key measures. Due to the significance for the manufacturer's inventory level, inventory costs, and order fulfilment as SC performance criteria, these metrics were taken in great consideration. After a simulation was conducted, the main findings showed improved inventory levels and a decrease in inventory costs. While before the implementation the manufacturer's inventory displayed an oscillating curve as a result of process instability, after the adoption of the technology the curve became smoother, resulting in less instability and unpredictability, since the supply chain network is now constantly sharing information about demand, orders, shipments, and production output.

Businesses need to reconsider how their SC network is constructed in light of the disruption brought on by digitization. The rivalry in supply chains is fueled by the transparency and accessibility to a wide range of options for what and when to buy, as well as where to shop. These factors are made possible by e-commerce platforms. In particular, the Internet of Things (IoT) has had a significant impact on the transformation of SCs by offering a variety of opportunities like remote and real-time monitoring of the position and speed of vehicles, the condition of perishable goods via temperature sensors, status and performance of machines, and more (*Manavalan, E. and Jayakrishna, K., 2019*). The adoption of Industry 4.0 technology also caused these networks' business models and management approaches to change.

2.2 The relationship between I4.0 and organisation design

The relevance and impact of organisation design is widespread and cannot be summarised in just a few words so I decided to focus my analysis on how organisation design and I4.0 technology are linked together.

The move from the third to the fourth revolution was built on digitalization and the production of innovations based on technological combinations. The speed and scope of these processes have been described as revolutionary and "creatively destructive". The rise of platform economy companies such as Uber and Airbnb, which substantially transformed the competitive environment of their respective industries, best exemplifies the concept explained above (*Cunha M., Clegg S., Gaim M., Giustiniano L., 2022*).

A theoretical study conducted in 2020 based on 50 articles considered "Organisational Learning" to be one of the most important subjects identifying dimensions present in the literature regarding the relationship between Organisational Learning and Industry 4.0, in order to clarify how learning can be understood in the context of the fourth industrial revolution (*Belinski, Ricardo, et al., 2020*).

Organisational learning is the process through which a company improves itself over time by gathering experience and then applying that experience to produce knowledge. The acquired knowledge is subsequently disseminated throughout the organization (*Belinski, Ricardo, et al., 2020*). According to the authors, companies' cultures have a relevant impact on this phenomenon.

Among numerous findings, the author highlighted that digitization is the primary emphasis of learning in Industry 4.0, followed by: horizontal integration, digital engineering deployment among partners, vertical integration, creation of new social infrastructures, and

implementation of cyber-physical production systems. Industry 4.0 assumes the presence of management methods such as the Lean mindset, employee participation in decision making, knowledge exchange among employees, and so on. These drivers are all keys for a company to understand that re-designing its structure is becoming a necessity.

Organisational Learning in the context of the Fourth Industrial Revolution is an important component of business transformation in the digital age, with a focus on more agile technological products, procedures, and processes in a complex and interconnected environment.

Among the practical implications of this research, the author highlighted the need to adapt university curricular content, particularly in the engineering field, to the requirements of new technologies associated with Industry 4.0, such as 3D printing, assistance systems, augmented reality, automation, cyber-physical systems, digital transformation, digitalization, and the internet of things.

Continuous professional and student training is required in an industrial system that is constantly changing technologically, requiring competence for new learning as well as the skills to implement new systems aimed at increasing industrial efficiency, such as action orientation, active and collaborative learning, constructivism, e-learning, game-based learning, hands-on education, problem-based learning, simulation, and work-based learning.
Furthermore, that study provides instructions for the development of people skills to be incorporated in training and industrial training programs, such as digital skills, capability building, interaction, interdisciplinary knowledge, and socio-technical skills. It contributes significantly to lifelong learning strategies in Industry 4.0 projects.

2.3 The relevance of soft skills and competencies

The three industrial revolutions mentioned above had an impact not only on production and business strategies, but also on the skills needed by future employees in many industries. Some jobs vanished while others were created from one industrial revolution to the next. More importantly, some abilities became less relevant while others gained value. In terms of employment and skill replacement, the next fourth industrial revolution is no exception. Industry 4.0, a well-known project driving the fourth industrial revolution, is distinguished by tremendous technical innovation that necessitates a specialised and experienced workforce (*Benešová, A. and Tupa, J., 2017*). This, in turn, generated a global competition for employment requiring specialised skills for the digital and sharing economies. People working

in a digitalised and networked workplace that promotes interaction with algorithms and robotics, as well as operating in a virtual world, come from the adoption of Industry 4.0 technology (*Richert, A., Shehadeh, M., Plumanns, L., Groß, K., Schuster, K., Jeschke, S., 2016*). Consequently, new employment requirements for a distinct and specialised skill set have emerged. As a result, there will be a noteworthy difference in skill needs between the fourth and preceding three industrial revolutions (*Grzelczak, A., Kosacka, M. and Werner-Lewandowska, K., 2017*). Industry 4.0 is more than just technology advancement; it must also prioritise human resource development, which includes acquiring the skills that will be needed in the future (*Schallock, B., Rybski, C., Jochem, R. and Kohl. H., 2018*). Furthermore, according to Shvetsova and Kuzmina, there is a current gap between the abilities necessary and the talents developed in the I4.0 age. This could be due to a lack of understanding of the abilities required by Industry 4.0 (*Shvetsova, O.A. and Kuzmina, A.D., 2018*).

Throughout the industrial revolutions, the complexity of jobs has risen. In the Industry 4.0 age, conducting a skills requirements study is important because it informs job seekers and skill development institutions on what to work for and what to expect. Adolph, Tisch, and Metternich pointed out that technological megatrends will have a substantial impact on the skills and abilities required in production environments. As a result, organisations must design plans, and skill development institutions must be imaginative in developing the necessary skills and abilities. Although the competences required in various sectors may differ, there are certain commonalities between the competencies required in other industries. They go on to say that in the future engineer, soft skills will be just as crucial as technical skills (*Adolph, S., Tisch, M. and Metternich, J., 2014*).

Focusing on engineers, which are the most affected by the I4.o revolution, according to Grebski no one inquires about the necessity to adapt engineering training curriculum, in particular to enhance specialists' soft skills and enable efficient communication between them and other corporate personnel (*Grebski, W., Grebski, M., 2018*).

As a result of Industry 4.0, traditional industrial engineering methodologies are giving way to data-driven functions and cyber-physical systems. Based on this idea, human resource management in the context of Industry 4.0 could change their approaches to deploy new technologies for more directly connecting learning with job demands (*World Economic Forum, 2016*).

Following a study by Wisniewska and Salek, they develop the profile of employee 4.0, who uses learning methods and teaching concepts during the educational process to meet the criteria of the revolutionised economy. Slight discrepancies in responses from entrepreneurs and students share a common denominator: knowledge, or more specifically, a lack thereof.

The authors emphasised that it is not enough to simply present knowledge to students; it is also necessary to transfer it through practical utility in order for students to understand the material of engineering studies, and teachers should focus on the methods of transfer, thereby creating new opportunities for learning that are both interesting and practical (*Wiśniewska-Sałek, A., Na Ayutthaya, D.H., Mesquita, D., Chattinnawat, W., 2019*).

They stated that, until recently, the engineering profession was associated with having professional knowledge and suitable certifications. Engineers' hard talents, however, are insufficient in light of Industry 4.0 objectives and should be augmented with non-technical qualities, so called soft skills.

Research Methods

3.1 Research settings

In order to gather the data I was in need for the research, I conducted a qualitative analysis by performing 10 semi-structured interviews to mixed level employees from 10 different companies that have recently adopted any Industry 4.0 technology.

For the sample selection, some constraints were drawn to enhance a clear direction of the analysis and to allow me to conduct a meaningful analysis. Those constraints are:

- companies that have implemented/is implementing any technology that can be referred to as part of Industry 4.0;
- companies that are founded in Italy and still have businesses there;
- companies that can be included in the category of SMEs, having less than 249 employees;

I decided not to focus on a specific industry because this would have limited the extent of my analysis, since my intention is to provide a study with a broad scope, also for future research; for sake of clarity, the sample is composed of 10 Italian small-medium enterprises (SMEs). To assess the dimension of a company I referred to Istat (Istituto Nazionale di Statistica) classification concerning the number of employees of each company: under 9 employees are considered to be micro-enterprises, from 10 to 49 are considered to be small and from 50 to 249 are considered to be medium sized.

According to Istat, in 2020 more than 97% of Italian companies (precisely the 97.2%) were considered to be SMEs, with an overall average of 4 employees per company. Furthermore, they account for more than 70% of Italian total revenues generated by Italian companies: they really are the pillars of the Italian economy.

This is the main reason why I decided to focus on SMEs in Italy, which is well known to be a country in which small and medium sized companies are significantly more than MNEs.

3.2 Data collection

The approach that has been used in this analysis is a qualitative approach. Qualitative research is a helpful strategy that allows scholars to get a grasp of the complexity and infinite shades of economic phenomena. Its exploratory aspect distinguishes it, with the goal of uncovering the underlying motives, perspectives, and experiences of individuals and communities in response to economic concerns. Qualitative research, which employs

methodologies such as interviews, focus groups, and case studies, provides richer, more context-specific related insights that quantitative methods may do. This method enables researchers to record individuals' subjective and different perspectives, offering light on the social, cultural, and psychological elements that impact economic behaviour. Furthermore, qualitative research excels at revealing unexpected patterns, developing new theories, and providing detailed explanations.

Qualitative research approaches aim to improve knowledge of the meaning and experience components of people's lives and social settings (Fossey, Ellie, et al., 2002).

To perform the empirical qualitative research, I decided to design the interview in a semi-structured way. By doing so, the interviewees were freer to provide details that were not explicitly asked; since I decided not to narrow down this analysis focusing on a specific sector, designing the survey in a multiple-choice manner would have both limited the deepness of the answers as well as forced respondents to stay within a predefined burden. In addition to that, a semi structured interview allowed me to dive deep on crucial points, which were unique case by case.

The questionnaire (available fully in the appendix) was introduced by a short paragraph in which I greeted the interviewee and I explained the aim of my research. This allowed him to properly understand the direction of my research and to focus on narrow and precise information while answering my questions. I think such a concise introduction should always be made before asking open questions to help the counterpart to start the brainstorming process even before the actual survey is conducted.

Each point I wanted to touch was divided into three steps:

- Question
- Question probe
- Expected Answer

The question was written clearly to get a certain piece of information, without leading the answer of the interlocutor to a certain direction to prompt the effectiveness of the analysis. The question probe was designed in case the interviewee did not get the question or had any doubt about the meaning or the goal of it. Basically, it is meant to provide the same information as the question paraphrasing differently the sentence. If the interviewee understands and answers pertinently the questions, the question probe will not be presented to him. The expected answer is not illustrated to the counterpart anyway: by the way, it is significant while gathering the answers to see how the response is in line with expectations. The expected answer is not a specific answer and does not imply an expectation about the content of the answer; rather than

this, it helps the interviewer to figure out if the question and question probe designed in this way allows him to get to the point he is aiming to.

The questions follow a logical order to lead the interviewee through the process. The questionnaire was composed by the following questions, in the following order:

[1] “What was the I4.0 technology implemented by the company and what were the reasons for this change?”.

[2] What business structure was used before the implementation of I4.0 technology? What prompted you to change it later?

[3] What changes has the implementation of I4.0 technology brought within the company* compared to your expectations? (*If no organisational changes are mentioned in the answer, supplement the question with, "On the other hand, with regard to the organisational structure of the company, what changes has the implementation of I4.0 technology brought compared to your expectations?")

[4] When did the corporate organisational structure change from the implementation of I4.0 technology?

[5] During the process of changing the company structure, the innovation brought by the implementation of technologies related to Industry 4.0, what new positions did it open up within the company? Were they already present even before the implementation, or did the implementation generate the need to create new ones?

[6] What have been the main benefits and/or difficulties encountered during the period of I4.0 technology implementation? Which of these effects produced by adoption were you able to predict and which were unexpected?

[7] In conclusion, is there any information that you were not asked for during the interview that you would like to add to make this research more relevant?

I decided to ask for personal information after the interview rather than before it because I wanted to prioritise the goal of the interview rather than “formal” piece of information.

The interviews were conducted by phone, so I was directly in contact with the person I was speaking to: this allowed me to take into account also their confidence while answering as well as some (apparently) minor details that they gave me while answering the main questions. Furthermore, this gave them the possibility to add as many details as they want, since the effort for speaking is lower than writing. The fact that we were face to face during the whole interview process reduced the risk of them making up those answers that they were not ready to answer, reinforcing once again the accuracy and fairness of gathered data.

All the phone calls were recorded; that allowed me to keep the focus on the questions I was asking rather than trying to grasp as much information as I could. All the participants were informed before the interview and signed a privacy module to allow me to report their words for the purpose of this study. Furthermore, the interview module was not given to companies in advance not to provide them any incentive to prepare their answers before the interview was conducted.

3.3 Sample of respondents

Sample: company's relevant information			
Company	Size (employees)	Sector	Geographical Area
1	250	Tech	Italy
2	11	Grocery	Italy
3	26	Logistics	Emilia Romagna
4	200	Industrial Automation	Europe
5	40	Industrial Automation	Worldwide
6	90	Mechanical	Italy
7	240	Hydraulics	Worldwide
8	27	Brick Manufacturing	Northern Italy
9	25	Metal Mechanics	Emilia Romagna
10	40	Grocery Analysis	Italy

Table 1

Sample: interviewee's relevant information			
Company	Gender	Working Experience (years)	Role
1	Male	33	CFO
2	Male	26	Owner/ CEO
3	Male	22	Sales Manager
4	Male	35	Purchasing Manager
5	Male	33	Production Manager
6	Female	16	Assistant Director
7	Male	35	Production Manager
8	Male	20	Production Manager
9	Male	40	Managing Director
10	Male	30	Quality Manager

Table 2

In table 1 I summarized the relevant companies' information, while in table 2 I summarized all the relevant interviewee's information.

Results

4.1 Data Analysis

To make a proper analysis, I used a method theorised by Denny Gioia. According to his article "*A Systematic Methodology for Doing Qualitative Research*", there are a few essential principles that support everything else:

- the social world is a world of meaning; the majority of what is essential in human experience is socially built by individuals interacting.
- people are knowledgeable, and they can explain topics to researchers in simple terms. When you converse with them and treat them as competent people, you will discover that they may provide an insightful description of their experience in terms that are significant to them (*Gioia D., 2020*).

According to Gioia, it is crucial to remember that the goal of grounded theory is to ground the emergent theory in the informant's understanding of their constructed world. That is why it is called "grounded theory": not because it is based on data, but because it is based on the informants' personal experiences and comprehension of the latter.

This implies that the findings of this kind of research should be understandable both to the informants as competent actors and must also be adequate in terms of theoretical knowledge, which means they must make sense to scholars seeking deeper answers.

The author divides data in two macro-categories:

- first-order or informant-centred data.
- second-order or theory-centred data.

A first-order analysis employs informant-centric terminology and codes, while a second-order analysis employs researcher-centric concepts, themes, and dimensions. Taken together, they provide the kind of insight that is the distinguishing feature of high-quality qualitative research.

According to Gioia, the overall analysis should be divided according to the former data in a 1st order analysis and a 2nd order analysis.

- 1st order analysis:

- tries to stick to informant words as closely as possible, we make little effort to condense categories, therefore the number of categories tends to expand at the start of a study.
- we begin by looking for similarities and differences among the many categories
- we then assign labels or phrasal descriptors to those categories

- at this point, we treat ourselves as knowledgeable agents who can (and must) think at multiple levels simultaneously
- trying to gain a better understanding through a gestalt analysis (emphasising the whole rather than its single components)

- 2nd order analysis:

- we are wondering if the emerging themes offer notions that could help us describe and understand the things we're seeing
- we pay special attention to emerging concepts that do not appear to have acceptable theoretical references in the current literature, as well as existing concepts that "jump out" due to their relevance to a new domain.
- we study if it is possible to further refine the emergent 2nd-order themes into 2nd-order "aggregate dimensions.
- we now have the fundamentals for creating a data structure, which may be the most important stage in our entire study strategy. The data structure not only allows us to build our data into a useful visual tool, but it also provides a graphical depiction of how we proceeded from raw data to terms and themes while conducting the analyses.

Finally, at this point we also start cycling between emergent data, themes, concepts, and dimensions and related literature, not only to check if what we are discovering has precedence, but also to see if we have uncovered new concepts.
According to Gioia, the crucial concern is how to account not just for all of the fundamental emergent concepts, themes, and dimensions, but also for their dynamic interrelationships. This allows to create a semi-fixed scheme, readily adjustable according to possible future inter-relationship changes.

After collecting all the interviews, I decided to write down the content of the former in order to have a clear and visual representation of what they told me. Since the interviews were conducted by phone and put into writing later on, the style of the document reflects the freedom they had while answering my question. There is low punctuation and in some sections the form is similar to a stream of consciousness. This aspect, on the other side, made the identification of relevant information a little confusing, partly because often they used an informal language that I did not want to change (to avoid tampering the intended meaning of the interviewee).

For the purpose of this thesis I targeted Italy as the geographical area of interest and therefore I conducted all the interviews in italian. Despite that, I decided not to translate the entire interviews but only the parts that I was interested in. Then I carefully read all the interviews,

trying to point out all the quotes that were relevant for my analysis. This step has not been intrinsically challenging, but managing to get the information that I was intended to get can be tough. I have understood that, practically speaking, some terms I have studied in my university career are more abstract than I thought and furthermore in real-life companies some concepts have less tracked boundaries than the literature teach us. To be more precise, the question [2] in which I asked the interviewee which organisational structure the company has adopted was the one that the majority of them struggled to answer. This, in research terms, means that sticking to the respondents' quotes may be slightly misleading to some extent, making my analysis harder to continue.

In table 3 I would like to show you the "raw" first order categories that came up after reading the interviews and before starting to look for similarities and differences. Each person I spoke to gave me different insights about their experience in the implementation process, some of them were directly involved in the process while some of them were not. Each sentence reported below is a translated quote from each of them.

Relevant information emerged during interviews	
Company #1	• "We were able to develop new technology and new products" • "We could enter a new market" • "Tax benefits facilitated the investment" • "There has been no corporate revolution" • "Slight change in teams/divisions" • "Economic growth potential for the company" • "The reality was above expectations" • "The result was more invasive than expected, we hired fewer staff than we should have" • "Within a year the situation was normalised to continue with the amount of work" • "The change occurred after the implementation" • "We went through an initial moment of total chaos"

	• "Such a company to organise itself well needs investment planning" • "We promoted figures already there to follow this process, natural selection for specific skills" • "Repopulation of figures that have been promoted following a logic of affinity with I4.0" • "Unforeseen contingencies of a primarily technical implementation nature"
Company #2	• "Increase productivity and quality" • "Our way of working before was much more artisanal" • "We did not reduce the number of employees" • "Interdependent relationship between the various employees and collaborators has changed" • "Roles did not change" • "More flexibility and better outcomes" • "Implementation was in line with our expectations" • "Short testing phase, adjustment" • "IT security has increased" • "The biggest difficulty was learning how to use the machinery to get the most out of it"
Company #3	• "About 95% of our customers' requests were all for 4.0" • "We also did it for us internally (interconnection and more control)" • "Structurally it was not a "Copernican revolution" but an arrangement that did not affect the roles" • "Machine monitoring is a task that was not there before"

	• "Implementation gave us the results and problems we expected" • "Has brought us contractual and security benefits" • "We were pushed by fiscal benefits" • "The development of the organisational structure occurred hand in hand with the implementation" • "The main difficulty has been the expansion of the job responsibilities of colleagues"
Company #4	• "We were pushed by fiscal benefits" • "Raising to employment level (hiring three operators)" • "In line with expectations (we already knew the product)" • "Hiring occurred after implementation" • "Search for specialised personnel in technologies" • "A second 4.0 investment gives less problems"
Company #5	• "We were able to develop new technology and new products" • "Initially the intention was to reduce jobs" • "Difficulties in setting up the machines" • "Higher difficulties than expected" • "Reduction in jobs as a result of technology deployment" • "For the future, I recommend listening to various consultants before implementation"
Company #6	• "Specific competences" • "Change in perspective" • "Increase control"

	• "Greater impact = research transversal (horizontal) skills" • "We are considering creating a section dedicated to planning and control" • "Greater amount of data to manage" • "Change in the management system due to the I 4.0" • "Need for a network of facilities to enable interconnection" • "Creation of an office dedicated to additive manufacturing (hiring 3 figures)" • "Difficulty in finding people with suitable skills and a change in mindset/mode of working" • "Inclusion of junior figures who are more "malleable" as needed" • "Tax benefits facilitated the investment"
Company #7	• "Process performance tracking" • "Sometimes it happened that the customer complained that some components were missing" • "Reduces inefficiencies" • "No hiring was necessary but we relied on outside companies" • "Change in mentality and approach" • "Everyone must work in the same mode of operation" • "The big problem there is habits"
Company #8	• "More control" • "Has not brought organisational changes, you do the same things differently" • "Brought great changes but we did not encounter any difficulties" • "Employees' duties have changed as a result of the implementation" • "During the transition there was a need to support 4.0 with the old methods" • "After an year the technology was ready to be exploited" • "As always it is difficult to change the way people work after many years of working a certain way" • "I would think that on people the effects would be much more impactful, even according to their level of education"

Company #9	• "Management and control of the production process" • "There was no increase in staffing but training was required as well as new procedures" • "Changes were a natural consequence of the implementation" • "The main difficulty was learning how to use the technology"
Company #10	• "There has been no change in the corporate structure" • "Expectations beyond confirmed" • "Tne difficulty concerned the first phase of implementation"

Table 3

I ended up with 82 categories and this was both misleading and confusing at first glance.

After collecting and translating the interviews in the most literal way possible, I proceeded by finding similarities and differences among the categories I found, managing to reduce the number of categories to (according to Gioia, this process is more than natural: for the purpose of getting to a comprehensible and valuable result, the "revised" version of the first order categories should be a number that allows us to have them all clear[36]).

The process was carried on multiple times to get to an acceptable number of categories: it can happen that two similar but different categories are erroneously grouped together or it can also happen that two categories that are very similar are not agglomerated. Starting from 82 categories is hard, so the process should be carried on step by step.

By doing so, I tried to group them by their underlying meaning rather than dividing them by company/interviewee in order to have a better understanding of the overall experience they had and to be able to proceed further in my analisis.

In the table below I shrunk the 82 categories into 21; these are the so called "First-order categories" of the model I am trying to achieve.

#1. New product and technology development

#2. Increased control

#3. Tax related benefits

#4. I4.0 technology limitations

#5. Over performance of the technology
#6. The reality was below expectations
#7. Organisational size change
#8. Subsequent structure development
#9. Initial difficulties
#10. Change in working relations
#11. Cybersecurity increased
#12. Machinery use issues
#13. Change in habits and mindsets
#14. Change in management systems
#15. Adjustments period
#16. Horizontally skilled employees
#17. Time generates value
#18. Machine monitoring
#19. Diversify professional advices
#20. Incomplete transition
#21. Education effects

I will now proceed explaining each category and its relevance, supporting my analysis with real quotes from all the respondents.

#1. New product and technology development

This aspect has been discussed many times during the interview process, since for many companies it was one of the main drivers for the adoption of the technology. Company #1 said that "The technology implemented [...] allowed us to develop a new technology. This, in turn, opened for us the doors of a new market that was previously inaccessible [...] Thanks to the investment we found ourselves for a good span of time world market monopolists", underlying the fact that this technology was a crucial kick-off for the company's growth. After the company #1 implemented and started to exploit the technology, they defined it as a "Product with up-to-date commercial possibilities and huge economic potential".

Company #2 said that "We approached Industry 4.0 to include some new production technologies, to improve the working conditions of warehouse workers, to expand our business and to increase both plant productivity and product quality [...] The way of working before this

technology was much more artisanal/manual where mechanisation was very limited". From this statement we can see how adopting a technology from 4.0 allowed them to both advance technologically and to reduce inefficiencies due to manual labour.

Company #3 made this transition because, according to its main business (forklifts for rent), "We decided to implement this technology to respond to the market demand, after two years where basically about 95% of the potential clients' requests were all for forklifts with a 4.0 technology implemented on them".

Company #5 and #7 too agreed with the statements made above.

#2. Increased control

Alongside with the previous category, the increase in control is a strong driver for those companies who decide to adopt a technology from Industry 4.0.

Company #3 said that "We have integrated this technology for the needs of the end customer but we have also done it for us internally, to monitor the machines that we rent". This technology allows them to have remote control over the forklift they rent, being able not only to check the status and possible malfunctions of the machine, but also to provide a warrant against possible claims for damages.

Company #7 added that "[...] this project that we have been pursuing for some time now aims to manage the traceability of the process performances for economic purposes [...] also ensure the correct assembly of our product; they can be shown to the customer in case of disputes or activities of this kind and ensure that we meet certain quality standards". This company needs to grant certain quality standards since it also works in the automotive industry with huge players; thanks to the implementation of this technology they can ensure the standards they are asked for.

Company #6, #8 and #9 also mentioned that the increase of control is an aspect that made them adopt an I4.0 technology.

#3. Tax related benefits

Tax related benefits played a crucial role, especially for SMEs. Even if I4.0 technologies are undeniably something all the companies that want to be competitive in the market should have, for some of them the economic effort could have prevented them from adopting it.

According to company #1, " [...] since these investments are very expensive, regardless of the 4.0 facilitation"; even if tax benefits exist, for some companies it may not be financially feasible to invest in this way.
Companies #3, #4, #6 explicitly said that they were pushed to invest by fiscal benefits.

#4. I4.0 technology limitations

According to company #1, the implementation of such technology did not represent a striking phenomenon related to its organisational structure but had a slight impact on the people management: they said that "I4.0 per se did not lead to an organisational revolution but a change that affected the team that used that specific product". For company #3, "A change there certainly was, let's say it was not a "Copernican revolution" but simply an accommodation of things that already existed". Ccompany #2 claimed that "things are done in an automatic, repetitive and systemic way (like an assembly line) but let's say the parties involved did not change". The same happened for companies #8 and #10

On the other hand, this transition had a huge impact on company #6 structure, "With the transition to the new management system, we are actually considering the creation of a new office dedicated to production planning and production progress control". Furthermore, "The innovation concerning the additive manufacturing process pushed us to open a dedicated section that made us hire two full-time engineers and two additive engineers [...] and every year we put in an intern".

#5. Over performance of the technology

For companies #2, #3, #4 and #8 the technology produced an impact that was in line with their expectations, while for companies #1, #8, #10 the technology had a greater impact than they expected. More in detail, company #1 stated that "Compared to what we expected and predicted, the reality has been above expectations. Thanks to the investment we have found ourselves for a good span of time world monopolists in the market". Company #8 added that "It was less difficult than we thought honestly, we quickly adapted and it changed the approach to some problems [...] it exceeded our expectations". Company #10 concluded saying that "The expectations have been beyond confirmed, over what was initially assessed also because it

allowed us to automate a process that allows certain ways and certain activities to be kept standardised [...] reducing significantly human error".

#6. The reality was below expectations

The only company whose expectations were not confirmed was company #5. According to the interviewee, "In light of the effort we had to make I don't know if I will choose the same path once again, in the sense that when we started particularly for the robots I expected difficulties, but I didn't expect these difficulties. We overcame them, but I feel like saying I did it and we have to look forward."

#7. Organisational size change

Out of the 10 companies under interview, 7 had to face an organisational size change. Company #1 was not able to correctly predict the magnitude of such change, in fact "The reality has been more invasive than expected; we had planned to hire 5 people to be able to manage the transition but afterwards we understood that the right number of people should have been 8 or 9".

Instead, company #4 "We opened three new positions by looking for staff outside the company who were skilled and familiar with the technologies we were going to use" making clear that they designated only three job positions for this role and that the professional figure they were looking for had to be specialised and familiar with such technologies.

Whilst, the technology adopted by company #5 allowed them to reduce the workforce: "The purpose of part of the investment was precisely not to increase jobs but to reduce them, in the sense that whereas before in the assembly line we had a man-machine relationship, after the implementations the machine become fully automatic and there is no longer the need for an operator for each machines but one that supervise everything".

Company #9 did not hire new employees but rather have their workforce trained: "However, we received trining from the company that sold us the technology to get the most out of it".

#8. Subsequent structure development

Among the companies interviewed, no one prepared itself to bear such a change. In fact, those that made adjustments to their internal structure due to the adoption of the technology saw the need to do so as a response to the implementation.

Company #3, for example, said that "The change occurred naturally as things developed", company #9 "It was a natural consequence because for us it was totally a new thing that we had no experience about".

#9. Initial difficulties

From the interview has emerged the tendency for small and medium sized companies to have issues with the initial implementation phase: company #1, for example, defined the first implementation phase "[...] after the initial moment of total chaos [...]", company #5 "Our biggest issue concerned initially setting up the required machinery", while company #2 "we needed at first some time to take some trials and adjustments to calibrate the shot".

#10. Change in working relations

Those companies who experienced a little/none change in their structure understood that a change was needed anyway; mostly, this change was reflected in the relations among employees who are the main actors in integrating this technology and putting it into work. Company #2 stated that "Instead, the interdependent relationship among employees and collaborators has changed because this technical-organisational transformation has caused some things to work differently". Company #3 highlighted that this change has been the most challenging aspect: "The greatest difficulty has probably been the expansion of the task by colleagues who have to keep track of devices to make this become progressively a standard activity".

Moreover, company #7 highlighted an aspect that other companies had underestimated: the tendency of the employees to unify their way of working. In fact, "I think a big obstacle are habits because when you have to unhinge a habit that everyone has, at first you may find resistance from them".

#11. Cybersecurity increased

Another aspect that emerged from the interviews is the fact that I4.0 technology does not only impact the structure, productivity and control of a company, but also increase its cybersecurity.

Company #2 stated that “In addition to that, this technology fostered cyber security, increased internal interconnections, information security of systems, making the company definitely less vulnerable from the outside.” In addition to that, company #3 said that “Keeping the machines monitored from remote certainly brought us benefits also in terms of contractual terms with end customers as well as in terms of internal security”

#12. Machinery use issues

Learning how to practically use the technology has been an obstacle for some of the companies. Once the company invests in such a technology and correctly implements it in the company’s mechanisms, it is trivial that the next step is exploiting it to get the most out of it.

In this scenario, company #1 asserted that “What we didn't expect was the fact that we approached an extremely sensitive and complex technology, and therefore there were quite a few problems in nature and mainly in implementation”. Company #2 and #9 shared their vision with company #1, since company #2 said that “The biggest difficulty certainly was learning how to use the machinery in the right way to exploit it as much as possible. We did not expect this kind of impact” and company #9 “the biggest difficulty was not related to the pure implementation but to learn how to get the machines to talk to each other to work properly”.

#13. Change in habits and mindset

A further crucial step that emerged from the interviews concerns the change in habits that the workforce must face after the implementation of a I4.0 technology. After the implementation and subsequent interconnection of internal systems, the habits of the employees must be adaptive; among the companies I spoke to, many of them see the refusal of their employees to change their habits as a potential threat to the correct development and growth of the company.

Company #6 confirmed that “[...] requires a whole range of specific skills in addition to a change in perspective [...] changing the mindset of employees because beyond skills it

changes the way you work", while company #7 added that " I think it can be a great step forward and also should bring a change in the mindset of our employees [...] I think the big problem is habits, when the whole organisation needs to align on their modus operandi". Also company #8 agrees on that.

#14. Change in the management system

Company #6 hand in hand with the implementation of such a technology decided to change its internal management system to comply better with the new challenges that its implementation and utilisation posed to them. "It was an accelerator of some business dynamics and led us to other choices, for example the change in our internal management system because by acquiring technologies with such high potential we decided to adapt on the rest".

#15. Adjustment period

It should not be thought that, right after implementing the technology the company will be able to use it properly, to correctly understand the mechanics and to be personally ready to work with such a technology: to get to full circle, those companies in my sample pool that disclosed this information needed one year. For example, company #8 told me that "This was not making one step forward but making ten, however it was probably the right time, after one year of set up in the end we are happy with the results".

#16. Horizontally-skilled employees

As highlighted before, many companies had to hire employees to face this change. In the hiring process, the figures that companies looked for the most were figures with horizontal/transversal skills who are able both to deal with this technology and add value to the company.

Company #6 said that "What impacted the most was the fact that horizontal skills had to be researched: those skills mainly concerned technology and interconnection processes and did not reside in a single function especially in terms of IT skills [...] inserting newer, junior figures to grow helps from a mindset perspective also as an investment in initial training".

Company #4 added that "We are looking for staff outside the company who are familiar with the technologies we are going to use".

#17. Time generates value

While discussing the multiple problematics that can emerge from the implementation of an I4.0 technology, what has emerged from the interviews fostered the importance of time. Company #1 highlighted that a long term investment plan is needed, "The basic concept is that if such an investment is made every one/two years so that a new product comes out with advanced technological features you could design a repeated investment schedule over time; this will allow the management to organise the company accordingly, being ready to cope with peak times".

Company #4 states that many difficulties they faced during the period previous to the finalisation of the implementation (and subsequent use of the technology) were due to their lack of knowledge in the specific technology. They experienced that a second investment was much easier to handle in terms of processes and implementation: "We did two projects, we did first one then the other so the second one that is being developed now anyway is much simpler since we had already done the first one and in my opinion we used it mostly for products that we already knew well".

#18. Machine monitoring

I4.0 has brought in a new task for companies: in this section I already reported quotes about the struggle many companies had to face concerning the change in job roles and how some relations had to change too with the implementation of Industry 4.0. Company #3 highlighted that "So on the one hand there is access to the portal with all its functions from which we precisely keep track of the machines and on the other hand there is a greater involvement by some colleagues in the after-sales service who precisely have this task every now and then".

#19. Diversify professional advices

Company #5 experienced a struggling phase after he bought the technology because the person he was speaking to was not able to set some aspects of the technology, assuring him that he had the experience to do so. Learning from his experience, he now strongly believes that "The experience I've had is that the next time I have to do something like this I will no

longer rely solely on who sold me the technology but [...] before I start doing anything I will ask for the opinion of other experts".

#20. Incomplete transition

Company #8 mentioned something peculiar among the pool of respondents: they were the only company who kept using their previous method in parallel with I4.0. This was mainly due to double checking the results of the technology before completely switching to it. in fact, they told me that "We continue to keep the two roads at least for this year (old and new) at the same time even though in some areas we are putting them out of use because there is no need, it is simply redundant."

#21. Education effects

Something that positively shocked company #8 was the ease with which employees with a low level of education got used to this kind of technology: "I would have expected more difficulties from people, especially those who work at a more low-skills-required level, who often have much more difficulties in adapting. Instead some have shown a positive initiative for the role they hold considering the basic level of education they have".

Gioia's method is definitely a qualitative approach but also shows quantitative rigour, as he explains (*Gioia, Dennis A., et al, 2021*). After having identified the first order categories, he suggests proceeding by identifying the second order categories, a further step for the grounded theory. The second order categories have been derived both from the findings of the study and from the already existing literature. As Gioia says, while looking for the second order categories we start to behave as "*we treat ourselves as knowledgeable agents*", starting to make inferences among the various categories that have emerged.

The result of this process, in this specific scenario, produced the following results:

First order categories	*Second order categories*
• Tax related benefits • New product and technology development • I4.0 technology limitations • Overperformance of the technology	**Business and financial opportunities**
• Cybersecurity increased • Increased control • Machine monitoring	**Wider span of control**
• Implementation issues • Incomplete transition • Machinery use issues • The reality was below expectations	**Digital transformation issues**
• Change in habits and mindsets • Change in management system • Change in working relations	**People centric approach**
• Adjustment period • Time generates value	**Timing criticality**
• Education effects • Horizontally skilled employees • Diversify professional advices	**Professional skills' relevance**
• Structure development • Organisational size change	**Organisational development**

Table 4

The next step consists in finding the aggregate dimensions among the second order categories. In doing so, Gioia's method suggests not to draw second order categories from scratch (Grounded Theory) but to find evidence in the literature.

When we refer to the Grounded Theory we are (*Walker, Diane, Myrick F., 2006*) talking about an approach that allows the researcher to build a substantial theory based on empirical evidence in a systematic manner. The goal is to find a hypothesis that grabbed attention, suited the data, and worked in practice. Even though it is a qualitative method, it tries to combine the positive aspects about quantitative and qualitative methods.

The second order categories that emerged from my research are 7, and each of them is coherent with an agglomeration of first order categories but also with literature.

The "rigour" that I was referring to above has proofs in this method: drawing the second order categories by only looking at the first order ones can surely enlarge the amount of literature and expand already existing frameworks, but could also represent an erroneous path

to follow. Having found proofs and evidence of the emerging second order categories in the literature strengthen the inferences I had made and the ones I am about to make.

To pull the strings of the speech, Gioia's method is based on the so-called "grounded theory", but does not rely solely on this; managing to get a match with the pre existing literature, according to him, increases the value, the accuracy and the deployability for future research.

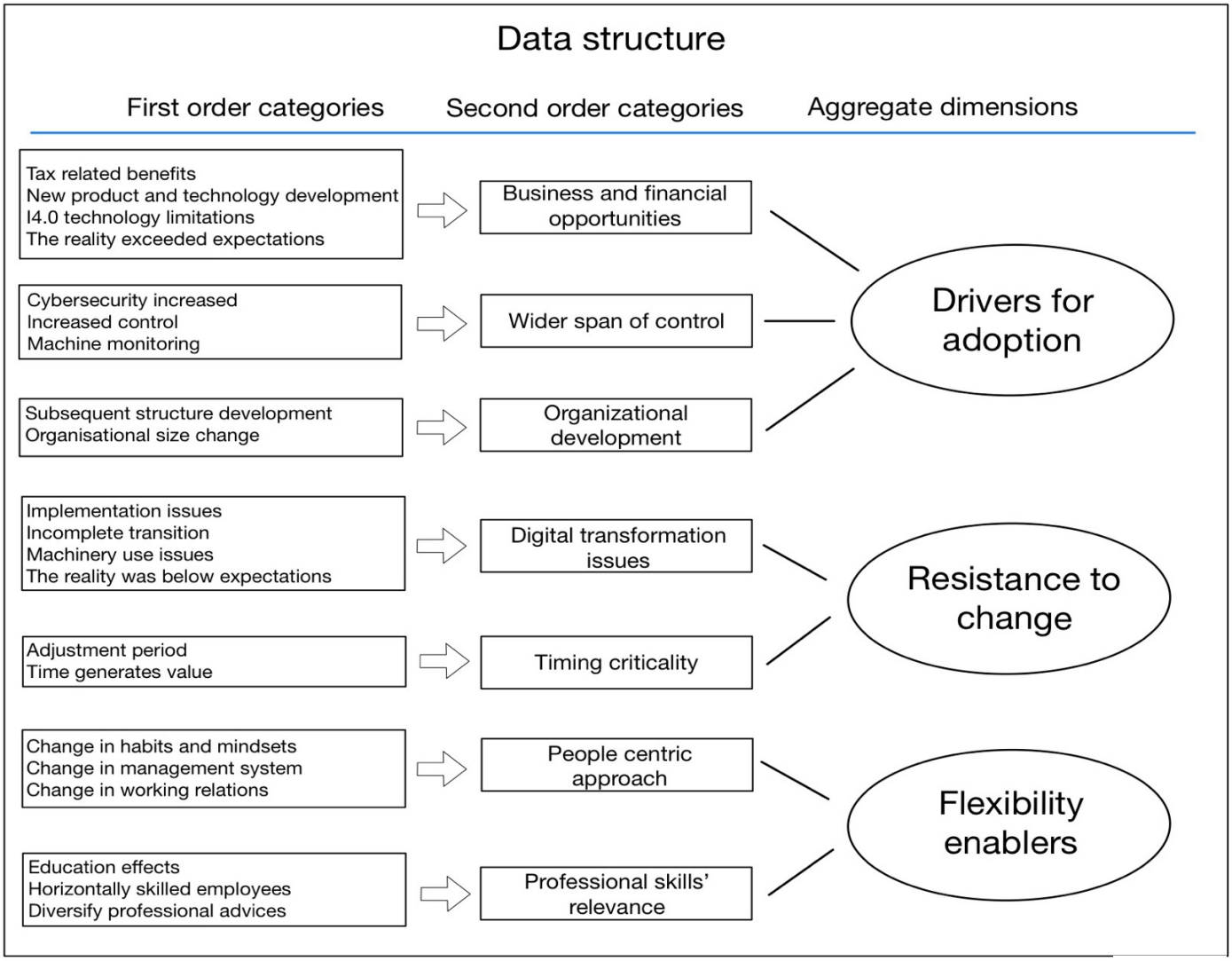

Table 5

In order to conclude the data structure model, defined by Gioia as "the pivotal part in our research", I drown the aggregate dimensions of my model. This step is crucial for my research since the three dimensions I have arrived at are the core of my research, starting from the raw data collected from the interviews.

4.2 Findings

Starting from the second order themes that have emerged, I managed to define three aggregate dimensions:

- Drivers for adoption
- Resistance to change
- Flexibility enablers

These three represent the "macro-categories" in which I aggregated all the relevant data collected from the beginning of the study..

The first dimension is "Drivers for adoption" and includes all the categories that influenced companies in taking the decision to adopt such a technology. What emerged from the interviews is that there are many factors that push a company to adopt a technology belonging to the 4.0 revolution.

This dimension is the aggregation of three second order dimensions:

- Business and financial opportunities
- Wider span of control
- Organisational development

The fit that I have found between them and "drivers for adoption" follows this reasoning: business and financial opportunities are always a great incentive for a company to make a change, and this is proven by the research itself. Most of the companies interviewed mentioned the creation of new product lines and huge tax benefits in adopting such a technology. If a company has the possibility to widen its span of control it will probably do so; once again, this aspect has been widely discussed with the respondents, who confirmed that this aspect is crucial for them even if my sample of respondents is composed of small and medium enterprises. Another factor that can be considered a driver for adopting these technologies consist in organisational development, since most of the companies experienced the fact that I4.0 technologies entail a development in their organisational structure. This process has embedded new challenges for the firm, but at the same time allows it to grow.

During the interviews it has emerged that I4.0 technologies present many aspects that can represent business and financial opportunities for the company. Company #3 made a focus on how tax benefits allowed them to make such an investment that would have been too onerous for them otherwise, stating that "In our industry, keeping track of machines remotely is not new, it has been around for many years, but the big news is that now it allows you to access

certain tax benefits". Company #1 highlighted a different business opportunity, since thanks to this technology they managed to become the global monopolist for a considerable span of time; "Thanks to the investment we found ourselves for a good span of time world market monopolists". Most of the companies find themselves in a position of power in which they did not expect to be in the short run; for most of the companies, including company #1 (mentioned above), the implementation of such a technology had a greater positive impact than they were able to predict. Company #10, to make an example, told me that "The flow of data from the management system to the tool was a new phase for us that resulted in a development stage for the company, a testing phase, and then on to full operation, which is now largely embedded in everyday life". In addition to this, the implementation of an I4.0 technology allowed some companies to develop and add to their core business new products. This is the case of company #5 that thanks to the implementation managed to expand their product line "we implemented the technology on a semi automatic assembly machine that served for the new product line".

Another crucial aspect that has emerged from the interviews is a general increase in control that the management has over the company, allowing them to be more aware and up-to-date mainly concerning processes, but not only. Strictly connected to this point, these technologies allowed companies to work in a more interconnected environment, making the flow of information easier. Company #2 said that this aspect is among the greatest benefits for them, in fact "The main benefits we found were related to control, process automation and thus speed and productivity". Company #3 were able to monitor their machines remotely, and this helped them a lot: "One of the main advantages is the possibility for us to keep the machines lended remotely controlled". They had struggles and disputes in the past because it may happen that during the various logistics processes some parts get lost or damaged: thanks to this technologies they are able to keep track of every unit they ship and to prove the status of all the material they sell, in other words they are now 100% aware of what happens, when and why, allowing them to be sure of what happens, increasing their status and reliability towards customers.

Another crucial point concerns the structure and the size modifications of the company: each company member I interviewed told me that I4.0 technologies per se bring with them new and fresh air, but this certainly impacts the company's structure and size: a huge difference is made by the size of the company before the implementation but also the magnitude of the novelty brought in by the technology. Company #10 did not see a huge upheaval after the implementation because, according to them, "Technicians do the same tasks but after the implementation everything is more performant and therefore the same technicians can devote

themselves also to different activities. These processes do not need to include specific figures".

For other companies, instead, the implementation allowed them to enter new markets, develop new products but also slightly modify their existing ones; in these cases the effect on the company's structure and size was greater. Company #1, #4, #6 and #7 increased their workforce or had to rely on external support, company #9 did not raise its employees' number but trained them to get them prepared for the changes the technology would have brought. In particular, company #6 is considering to open a new section solely dedicated to planning and control after the implementation, "We are actually considering creating an office dedicated more to production planning and production progress control because we will have a lot more data to manage".

The second aggregate dimension that has emerged from this study is "Resistance to change". This aspect is the result of many categories that outline the relevance of this topic for companies during the implementation process of the technology but also once the implementation ends.

This dimension is the aggregation of two second order dimensions:

- Digital transformation issues
- Timing criticality

Among the pool of respondents, most of them experienced troubles both in the technical aspects related to the implementation of various technologies but also in the resistance that people exerted, comprehensive of their modus operandi, their mindsets and their previous experience. This aspect may be underestimated in favour of more apparently relevant issues, but in the end these technologies require a high level of integration and cohesion among the employees. In addition to this, time plays an important role to achieve a level of implementation such that the technology is exploitable at its best. After the implementation period, which is self explanatory in the sense that a certain amount of time is required for the technology to be implemented, some companies had struggles in learning how to use it at its best capacity and some of them even had troubles in setting everything up to make it work.

What I previously said has emerged during the interview process: many companies had early stage implementation issues, in fact company #1 described it as a moment in which they were almost lost, stating that "[...]after going through an initial moment of total chaos[...]". Company #5 highlighted once again the impact that the initial phase had on them, saying that

“When we started especially for the robots and the lathe I expected difficulties, but I didn't expect these difficulties”.

The third aggregate dimension is “Flexibility enablers”, because among the various changes and novelties a company needs to face after the implementation of a technology I4.0 being flexible represents a huge advantage for the single employee but also for the entire company.

I have come to this aggregate dimension by grouping together two second order categories:

- People centric approach
- Professional skills’ relevance

It is always a good sign if companies are able to hire skilled, talented and flexible employees, but what has emerged from my sample of respondents is that after implementing such a technology having flexible employees helps significantly. Taking up a previous concept, Industry 4.0 technologies require a change but the workforce must be ready to embrace it: if employees stick to their pre-implementation working routine/tasks and refuse to adapt to the new working methods the company may have serious troubles in successfully completing the transition.

Education itself plays a relevant role, since usually people with a low education level are less prone to change and are more vertically skilled (especially if they have had the same job role for many years). It has emerged that companies tend to hire junior figures for these mansions because they are more horizontally skilled and are more willing to move and grow in the same direction of the company, making less resistance.

Moreover, the impact of such a transitions can entail also other changes in the day to day tasks of a company; company #6, for example, had the need to change its management system. This aspect was identified as a crucial one, since to be implemented correctly people must have complied with the new chosen one.

As I have mentioned above, another crucial aspect that has emerged for italian small and medium enterprises concerns their resistance to change: to be more precise, it has not emerged a clear and voluntary resistance to these new kind of technologies, but such a revolution has impacted working methods, habits and approaches towards working tasks and problem solving. Company #6 underlined this aspect, saying that “It obviously requires a whole range of specific skills and a change of perspective” and “[...] difficulty in skills, in changing the mindset of resources because beyond skills it changes the way you work and there is always

a clog of internal resistance" and company #7 reinforced this concept by saying that "It requires a change in mindset where the person or company does not think in their own little garden".

Moreover, it was highlighted a difference not only in the way people works by themselves but also a change in inter-relations dynamics: company #2 asserted that "Instead, the interdependent relationship between various employees and collaborators has changed because rightly this technical-organisational transformation has caused some things to work differently"

The aggregate dimensions emerged from the analysis are related and dependent on one another. These are the result of a progressive macro-categorization of the key elements gathered during the interview process, and it has emerged that each dimension affects the others.

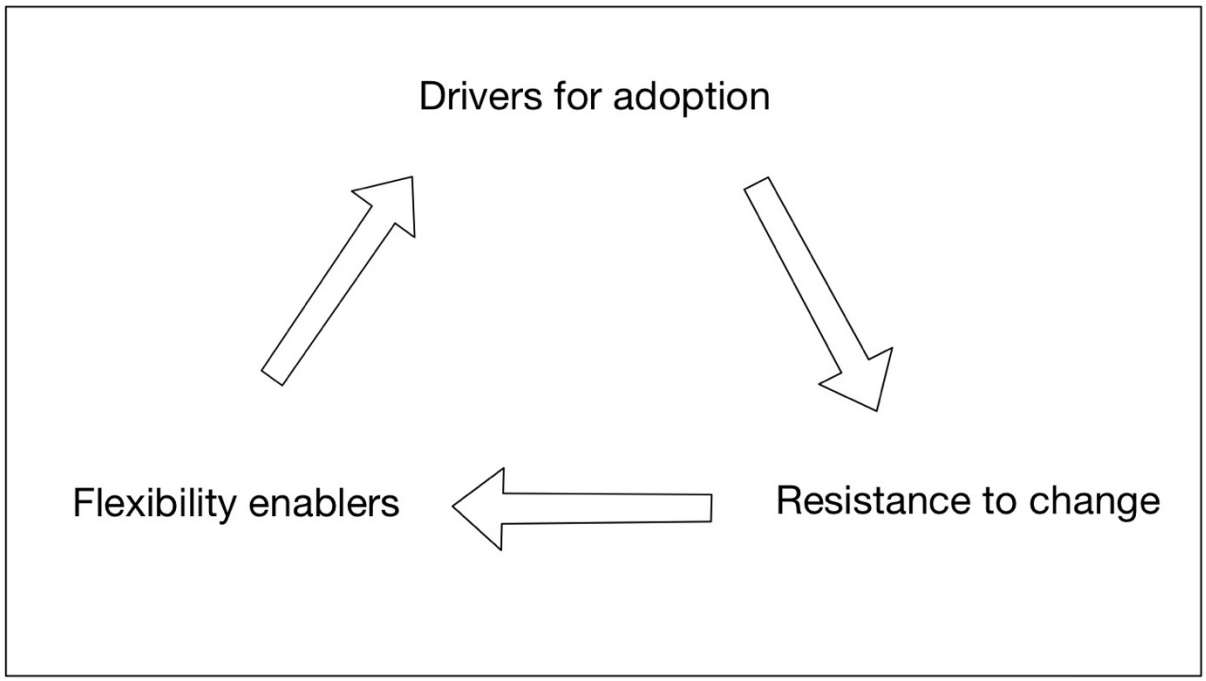

Table 6

Drivers for adoption are technologies I4.0's features that drive the acquisition and implementation of such technologies; this process, in turn, may cause internal resistance to change. As I analysed and explained earlier, resistance to change is a major issue concerning the effects that implementing a technology I4.0 has on companies. To face this issue, a solution may be pushing for flexibility enablers, which help companies to face the internal resistance that may cause serious further difficulties other than regular and day-to-day issues related to the implementation of the technology. At this point, we can also argue that flexibility enablers gives the opportunity to companies to strengthen their willingness to adopt an I4.0 technology; if companies are able to find flexible employees, this will become an added driver for the

company to implement the technology. On the other hand, if the workforce is stiff and does not have the characteristics formerly described, that could be a deterrent for a company willing to switch to I4.0 technologies.

Discussion

Once i have drawn the findings of this research, I will proceed by comparing my results with the already existent literature. In the literature part I highlighted those topics concerning industry 4.0 revolution that I considered to be the most relevant for my analysis; the first part concerned the impact and relevance of these technologies, the second one was about the general impact that those technologies have on organizational structure and the third one was about the relevance that soft skills and competences play in a general environment. These aspects were the ones that, according to me, could have been interesting investigate more.

Surprisingly or not, each aggregate dimension deals unintentionally with one section of that chapter, strengthening the aim of this research and providing a more narrow and interesting path to follow.

Concerning the drivers for adoption, the ones I have found in my research are aligned with the literature described. One aspect that has been stressed significantly is the innovation that these technologies bring with them: both in the literature and in my findings it is described that Industry 4.0 has the capacity to change the current technological pattern, bringing with it distruprive innovation.

In addition to this point, the literature highlighted some other key features of I4.0 that has been investigated throught the interviews, finding a match in the results:

- the increase in complexity and precision of manufactured technical products: company #5 clearly stated that this aspect was very important for them.
- the development of inter-machine communications: also this aspect has been widely discussed and it appeared to have a significant importance. This driver caused many companies to change also their organizational structure because of the great amount of innovation it entails.
- machine monitoring: this aspect has been widely discussed in the literature and its relevance has clearly emerged in the analysis I have conducted. A representative case concerns company #3, who implemented the technology on forklifts to be rented: the implementation of this technology allowed the company who owned the assets to monitor the status of the machine, potentially on a day to day basis, being in constant control of the machine and allowing it to be responsive if any inconvenience occurred.

Another factor that emerged from the findings was the increase in control: also this aspect has been widely discussed and proven in the literature. Moreover, there has been empirical studies

that highlighted how thanks to these new technologies monitoring become easier and therefore allowed companies to increase productivity.

The second aggregate dimension is about resistance to change: in the literature this concept is discussed since, generally speaking, a "creatively destructive" technology (as formerly referred to) usually generates resistance, despite of the kind of technology.
Different authors have expressed the concern about "Organizational learning", the process through which a company improves itself over time by gathering experience and then applying that experience to produce knowledge. This concept fits with the vast majority of the issues companies have while implementing the technology, such as implementation and machine use issues, the cases in which the reality does not match the expectations of the employees, incomplete transitions, ….

To face of this issues and to reduce their potential impact on companies, scholars think that (reference to the literature section, 2.2) "student training is required in an industrial system that is constantly changing technologically, requiring competence for new learning as well as the skills to implement new systems aimed at increasing industrial efficiency, such as action orientation, active and collaborative learning, constructivism, e-learning, game-based learning, hands-on education, problem-based learning, simulation, and work-based learning.

Furthermore, that study provides instructions for the development of people skills to be incorporated in training and industrial training programs, such as digital skills, capability building, interaction, interdisciplinary knowledge, and socio-technical skills. It contributes significantly to lifelong learning strategies in Industry 4.0 projects".

This aspect is also related to the criticality of time: many companies in my sample stated that implementing such a technology requires a substantial amount of time and this in some cases causes losses in revenues and potential clients; being able to select and hire the right professional figure, horizontally-skilled and ready to face quick and unexpected changes and issues can help the company to fasten this process and subsequently to operate at a faster pace.

Concerning the flexibility enablers, this dimension too has been discussed in the literature and is once again connected to the former paragraph. As i explained before, scholars strongly underlines how having transversal skills plays a crucial role for the fourth industrial revolution; one difference between my findings and the current literature lies on the spectrum and specialization of the skills. Benešová, A. and Tupa state that it's important to have highly specialized people, with deep and proven competences in a specific field, while from this study emerges that companies are looking for more flexible figures that can be "formed and trained" also within the company. This difference can be due to several factors,

such as the different pool of respondents, a specific business sector chosen by the authors or maybe the size of the companies taken into consideration. It is well kown that, as company sizes increase, the level of specialization required increases too due to a progressive fragmentation of roles and tasks. Since my sample was composed only by SMEs, it has not surprised me their willingness to hire more flexible and horizontally skilled people rather than more vertically specialized ones.

In addition to that, one aspect that emerged from this study that in my opinion is underestimated in the literature is the impact of people concerning these technologies. The pool of respondents in my study is heterogeneous in many business aspects, such as the industry in which they operate, their business models, the application of the technology and the technology itself; some companies implemented the technology for internal use, some of them bought new machines and others implemented it for a third parties. This in turn entails differences in their approach towards the I4.0 technologies, as one may expect, but something they all have in common is the reliance on people to get everything working properly. There is a double effect in this process: the technology influencing people (effect of the technology) and people affecting the technology (effect on the technology).

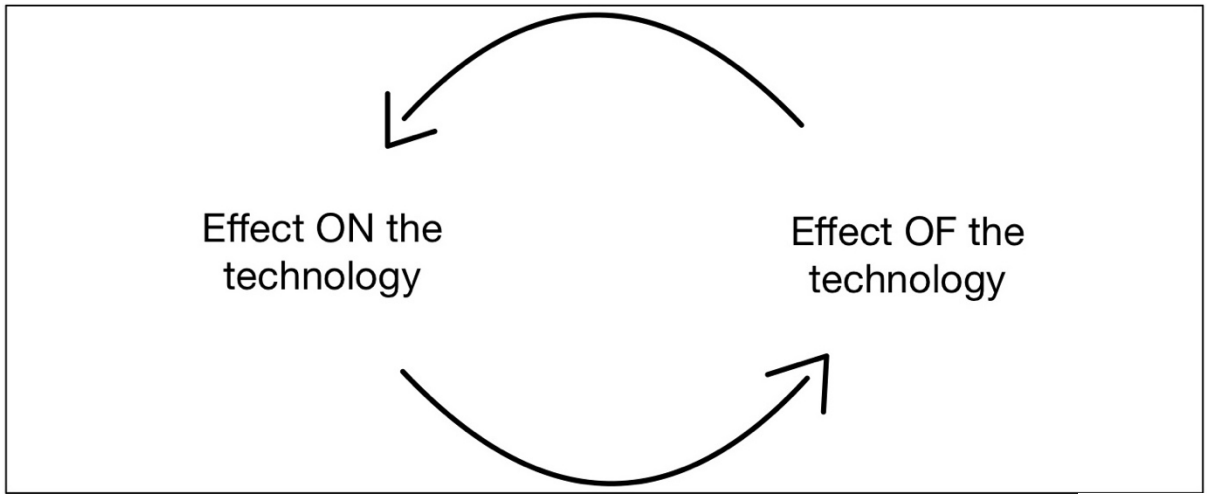

Table 7

The former has been widely discussed in the literature and my findings are in line with what has been said, the technology basically change employees' way of working other than their specific tasks. The latter, instead, has not been discussed as it should; people affect the technology itself (obviously I an not referring to technical/practical implementation changes) and the final result of a technology I4.0 is connected to how people metabolize and

understand not only the features of the technology, but also the final aim of its implementation. This aspect has a great impact con companies because it sets the direction of the new internal processes the company will undergo after the implementation. How workers use the technology and how they understands it is the key for achieving corporate goals. We always need to bear in mind that in the end, companies are made of people. These two effects are cyclical, the technology changes the way of working of employees that in turn work trough the technology influencing it.

Conclusion

6.1 Implications

To summarize the findings of this research discussed so far, we should start by focusing on the three aggregate dimensions that emerged from the analysis. Drivers for adoption, resistance to change and flexibility enablers are three aspects that should be taken in great consideration while implementing a technology I4.0 mainly looking for possible changes in the organizational structure. Adopting an I4.0 technology is not an easy job and not every company is ready to face such a change: being aware of this risk already puts companies one step ahead. It is crucial for firms to understand their business needs before implementing the technology, but it is also of paramount importance that the company, including its workforce, is ready to embrace this change. In some realities this entails a huge organizational change, in some others some minor adjustments: in any case the aspects to be taken into consideration are several. To conclude, it is important to bear in mind that models and schemes can be of great importance to get a first idea of the main aspects to keep into consideration about the final goal of the reader but must be adapted case by case. I think that this research can be a good starting point for future research that may deepen the topics discussed by sectorizing them.

6.2 limitations and future research

In conducting this research, I had to face numerous difficulties. Some of them were related to data gathering, since finding 10 companies who were willing to share with me this information dedicating their time to this process was not easy.

A strong limitation of this research was encountered when I was finalizing the analyses of the data and I had to deal with the issue of different authors interpreting some informant terms and passages differently; we always need to bear in mind that literature papers are subject to their authors' biases. Furthermore, interviewees personal experience may have biased their perception about the technology and in turn some answers may have been slightly different from the reality. Other limitations consisted in the width and characteristics of the chosen sample since scientific papers mostly focus on big corporations rather than SMEs. This aspect, in turn, allows room for future research, especially for the Italian market, dominated by SMEs. Another aspect that is interesting to get in a more detailed way concerns the different macro-kind of technologies of I4.0. The scope of this research was to give the informant a broad view,

letting him aware of the major opportunities but also the major threats that a company will face during its transition.

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