POLITECNICO DI TORINO

Collegio di Ingegneria Gestionale

Corso di Laurea Magistrale in
Management and Engineering

Master's Degree thesis

Industry 4.0 in small and medium enterprises

Supervisor

prof. Guido Perboli

.....

Candidate

Chiara De Conciliis

……..

A.A 2017/2018

Indice

Summary

This script talks about the new industrial revolution, Industry 4.0, and the aim is to represent the general situation all around the world compared with the state of art in the small and medium enterprises in Italy. The strategy to have an overview on the development of this paradigm was a literary review of about 60 articles published in the first half of 2017. To better understand the Italian's SMEs situation, we distributed a questionnaire in the north of Italy, for the biggest part in the region of Emilia Romagna, and we obtained 101 answers which we then analysed and scrutinized to have an even more realistic perception of the general knowledge when it comes to Industry 4.0.

The analysis aims to explain the concept bond with the Industry 4.0 framework and the results were compared with other world wild studies since many have touched upon this 'hot-topic' in this field of research through the years. The focal point of the three steps of the analysis where the implementation and knowledge of the technological tools as well as the advantage and disadvantage that this revolution will rise.

The analysis were performed singularly and separately and in the end they were analysed together. It appears that the Italian's firm are too focused on their work and do not really consider the effect that an integrated digital supply chain could have on their production and the competitive advantages they would get out of it. The level of awareness is in constant grow, more and more employers and business owners are opening up to the innovation but the knowledge about the topic and, more than anything, the lack of expertise in the firms creates a significant gap that needs to be covered in order to proceed with the implementation Industry 4.0.

1 Introduction

According to the Oxford Dictionary, the word revolution stands for: “A forcible overthrow of a government or social order, in favour of a new system” (1). But, what is an industrial revolution? The following paragraphs will introduce the reader to the notion of industrial revolution and what was its evolution during the time.

Back in the 18th century, new discoveries were made which completely changed the perspective of production. It was indeed a time of transition; from a system based mainly on agricultural, manufacturing and commerce to building the first industry. New sources of energy were discovered such as steam, petroleum and coal. Also, worth mentioning, the practice of using iron and steel as raw materials. All new findings led to significant changes in product manufacturing as well as changing everyday life for the people. Later, this historical time has been referred to as ‘industrial revolution’ and today, it still preserves its name symbolizing a time of great achievements, the first of many.

From that moment on, innovation in the industry was rapidly increasing. What had always been considered ‘a commodity’ was becoming more of a necessity and the population was gradually moving from the countryside to the city. The machines invented were fast and effective, but workforce was still needed and ultimately the demand was increasing so much that also women and children started to give their contribution to work. As mentioned above, the industrial revolution also contributed to changing everyday life for the people of that time. It was, in fact, the start to new ways of communications and travelling; exchanging of information became faster with the invention of the telegraph: the first real-time communication and getting around was easier with the trains and the steamship.

Shortly after, during the second industrial revolution which dates to the 19th century, serial production and the standardization of products, procedures and works were introduced in the job. More new inventions like the light bulb and the diffusion of the electricity revolutionised the life of the population. Distances are cut down even more with the aeroplane and the car and their internal combustion engine. The communication becomes easier with the

first telephones and the radios, life starts to feel better for the people who can afford the innovations.

At this point in time, mass production requires more and more workers which imply that cities become overcrowded, although the work demand in the fabric industry was not so very high as workers were machines and they had the same dignity as objects. The number of children and women in the factories was rapidly increasing due to their lower prices and disabled individuals were being hired to take care of mechanical duties. All the above lead to positives and negatives; on one hand, the industry becomes the centre of the city life but on the other, this new system also lead to huge increase in pollution.

Thanks to the progress there was always more research and more instruments, which lead to a significantly rapid development of great technology which contributed to a complete revolution in the industry. As time passes by, machinery used in the factory kept changing and in the ’90 the first computer started the third industrial revolution. Mankind decided to explore space and this time the innovation in transport is the spacecraft, and at the same time also the field of communication becomes stronger than ever with undertakes serious with the birth of mobile phones.

Everything happens so fast, one could say that innovative technologies become obsolete the day after discovery as the new projects become more and more interesting. The scientific research became the basis of modern development. With all the revolution the biggest part of the population is subject to changes without really understanding what was happening. Despite history, today, thanks to globalization we are more attentive and involved.

Today, for the first time in history, we are planning an industrial revolution. Summarizing this was the evolution in the industries: the first machine was invented, production became mass production, digital and now it is becoming cybernetic (Figure 1.1). For the first time in 2011, we hear about Industry 4.0, in Germany as the government decided to promote a project to develop digitalized manufacturing. It was only a project but it meant the start of a new era and the beginning of the fourth industrial revolution.

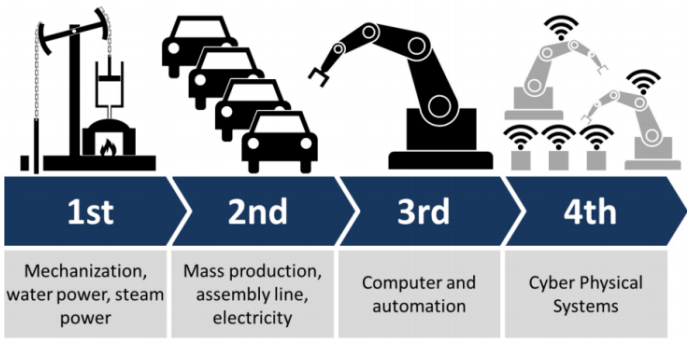

Figure 1.1 The industry evolution (STĂNCIOIU Alin, 2017)

The extraordinary power of this revolution is that is still a "work in the progress". A few years ago with some ideas and scientific basis, someone started to apply this new technique but it became the trend of the industry and now everyone is trying to apply and adapt this new paradigm. A lot of universities and companies are performing research studies in order to be able to implement such innovation to the different industries and scales.

Worldwide, a huge effort is put in the manufacturing plant so that it can be flexible and efficient as much as possible. Using digitalization, connection and statistics it is possible to make a decentralized system that is adaptable to demand changes whilst trying to reduce the expense of the industry in terms of raw material as well as energy.

The three-basic innovation of this revolution have been strictly working together:

- Internet of all things; nowadays everybody talks about it, the Internet is always been a great network and it allows us to have access to an immense source of shared knowledge, but the IoTs "interconnect intelligent components" is what creates a smart computerized system. Sensors, computers and humans can communicate in real-time to get help if their product is lacking and increase the quality of the product itself.
- Cyber-physical system is an informatics system that monitors the real process, by creating an intelligent structure that can autonomously communicate with other systems thanks to the IoTs. This way, physical instruments have their own memory and independence but are strictly bound by the whole structure. The digital twin (DT) is an example of the application of CPS as it creates a virtual representation of systems and their lifecycles. Through synchronization of the data, from the sensors of the real process, the optimization, decision making, and

predictive maintenance mechanism are updated in real time and its simulation could be performed with very realistic results. (2)

- Cloud Computing, the quantity of data produced, stored and shared becomes greater every day and this is the most practical way to have a ubiquitous access to this data. It minimizes the necessity of IT infrastructure and it is easy to manage.

The DT was used for the first time in the aerospace field and it was defined as "An integrated multi-physics, multi-scale, probabilistic simulation of a vehicle or system that uses the best available physical models, sensor updates, fleet history, etc., to mirror the life of its flying twin. It is ultra-realistic and may consider one or more important and interdependent vehicle systems" by the NASA. Its application was used in various fields, in manufacturing it became necessary for many new control methods that needs the real time synchronization simulation that DT implement. (2)

The 'smart factories' are focused on optimizing all the phases of the production process, with virtual simulation they can easily manage a flexible production at higher quality and a reduction in cost. There is a simultaneous development of the product and the process which also allows saving time as everything is based on Data management. (Figure 1.2)

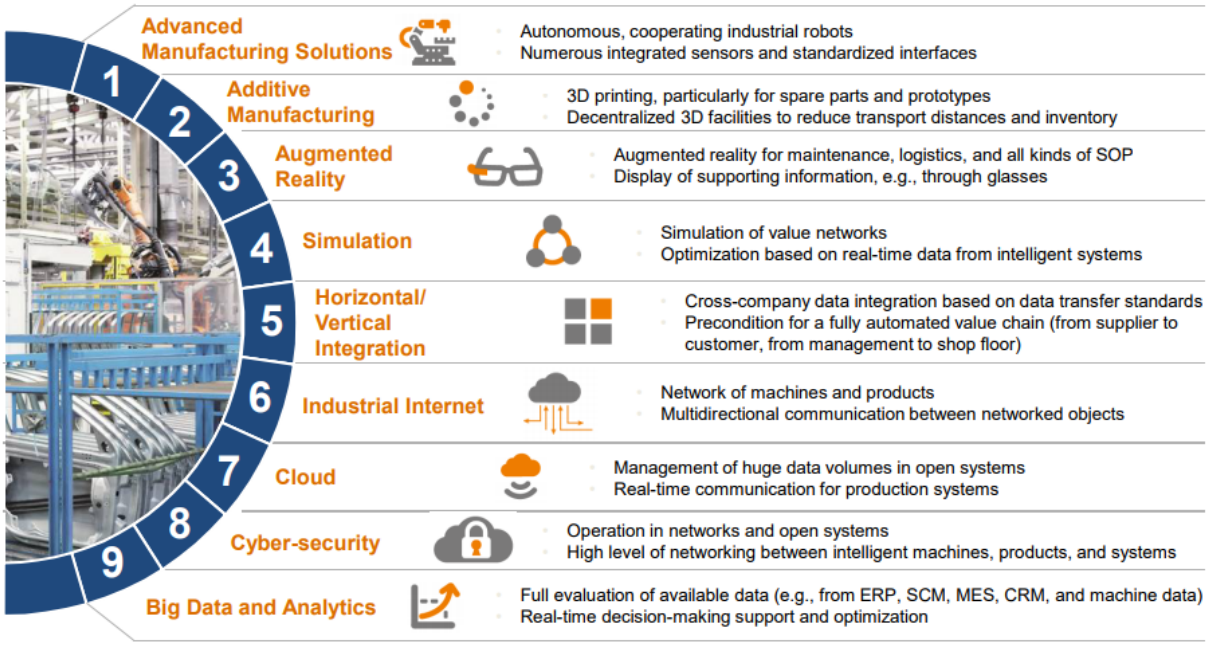

Figure 1.2 Nine technology drivers (Ambasciata d'Italia a Londra, 2016) (9)

This revolution also means a significant change in the roles of workers; the skills required in the factories are now different from the past. New machinery could substitute the work of the employee and even produce a better outcome, but a great investment is required.

Moreover, we have to take into account the fact that automated production still needs manutention and we do not know how the process of production can be fully automated since not yet exist. (3)

Since Industry 4.0 is currently evolving there is not a clear definition of it, many kinds of literature talk about it, but nothing is really officialised. As we see from the history the core of every industrial revolution is to increase the production, all revolutions presented a radical change in factories but this time the revolution is not totally exploited. The research in this field is many because it represents the obvious future of the production: The Smart production.

The combination of the physical and digital world is a great challenge that implies different sectors like robotics, big data analytics, simulations, sustainability and humanity. The great scope of this change is a strong integration of all the value chain, in which manufacturing elements are autonomous and able to exchange information, control themselves and ultimately improve their efficiency and quality without human actions. This decentralization implies that the elements have decision making power, in this way they can be more flexible and adaptive to adapt the production to even more customized market requirements.

The fundamentals of Industry 4.0 are:

- interoperability, that is realized with the capacity of communication between people and machines using the Internet of Thing and Internet of People,
- virtualization, Cyber-physical Systems and Digital twins must create a virtual copy of the reality,
- decentralization, the problem solving, and customization of the product happens without human interaction,
- real-time capability, data are collected in real time during the production process and they are stored in Cloud to be analysed,
- modularity, because the production must adapt itself to the changes in market trend and in customer's specifications.

All this process creates a continuous optimization of the process: there is a minimization of scraps, reduction in downtime, adjusting time and consequently in time to market. The competition increases the prominent level of customization, the communication between maker and consumers becomes easier and, thanks to the customization, also the willingness to pay for the product increases. Needless to say, all discoveries create the need for new research and high

skilled labour to work with it, there is a great necessity of training but also an increasing unemployment because employees became unsuitable for the new kind of job.

Societal change affect the technological deployment influencing the creation of new products and how they could be used. Furthermore, the technology also influence the social behaviour especially after the time were the communication, the interaction and the connectivity is becoming the centre of the social habits. Moreover, if on one hand the customer are willing to find the exactly product based on their online behaviour on other hand they must be protected from all the technological abuse and the security problems that could arise. (4)

The collection of this huge quantity of production data and customer data from Internet creates a consistent problem of privacy and security. Nowadays, the number of data theft is increasing, the value of information is huge, but it is a double-edged sword. From the industry perspective, their production became totally transparent and competitors can catch their success secrete. From the consumer perspective, it can be good to be able to find in the market the product that they want but the price to pay is to share personal information with unknown parties.

Contrary to the unemployment scenario, it is necessary to highlight that this recent technology is very expensive, and the project of a total transformation must be calculated very carefully. Linked with the initial substantial investment there is a significant risk because everything is in development and a new discovery can change again the rule of the game. This is not very kind for the small businesses because without doing the right investment they risk compromising their future (5).

SMEs stands for Small to Medium Enterprises, this definition changes depending on the country because the size of the firm could be measured by the number of employees, the annual sales, the value of the assets or by a combination of factors. In the EU: “A business with a headcount of fewer than 250 is classified as medium-sized; a business with a headcount of fewer than 50 is classified as small, and a business with a headcount of fewer than 10 is considered a micro-business” (6).

As opposed to the big company this kind of firms needs to pay much more attention to their investments, they must be competitive and very careful about their moves considering their position in the market can suddenly change. They cannot always exploit economy of scale, sometimes they don't have a lot of expertise, therefore, they lack productivity. Their competitive

advantage is often based on flexibility and customization of the product, for this reason, Industry 4.0 looks like a great opportunity for them.

SMEs represent 99,9% of the firms in Italy out of which 95% are micro-enterprises with less than ten employees, they account for the 80% of the industrial and service labour force (7) and generate the 12% of gross domestic product (GDP). For this reason, the Government is actively investing in the research helping the firms to keep up with times. The Italian's researchers and many of the firms are trying to apply this new paradigm in order to adapt this advanced technology to the Italian industry. In fact, it is important to study what is the most adaptable technology depending on the specific firm, because it is not easy to apply this radical changing in all the factories.

The focus argument of this thesis is to analyse what is the approach to the Industry 4.0 that the Italian's SMEs had keep until now. Before this, there is a literary review to highlight the last tendencies in Industry 4.0 of the first semester of 2017, to better understand what is the state of art of this revolution. Thereafter, it is presented a survey that was sent to a sample of Italian's enterprises, in this way it will be clearer the Italian situation concerning the innovation and what is the maturity level of the Italian industry respect the rest of the world.

2 Literature review

The process of 'literature review' is essential since it allows us to critically analyse a specific topic and update the state of knowledge that concerns it. As a widespread practice, it is used in all fields to review the overall situation in order to have a reference point for the result of the research.

2.1 Model

To identify the industry 4.0's level of maturity in Italy we must understand what the general level of development is, this common practice is especially necessary for this kind of studies because testing new technology implies a constant change in the approach and application of it. The methodology used for this scope is the literature review, and the aim of the following paragraphs is to explain the framework used.

2.1.1 Literature section

The starting point of the discussion was a model used for the same kind of research in the past; this choice granted the possibility to make a more straightforward comparison of the new results and to have a more unobstructed view of the global evolution of the phenomena. The first analysis was done on the type of articles that were then distinguished in:

- Conference papers are written to present the community with the result of research. The review committee gives the writer quick feedback and accepts or rejects the presentation.
- Journal articles, publishing this kind of articles is more a complicated process because the revision process could last up to one year.

More in details was also collected the source of the articles and when is possible the name of the journal or of the conference in which the article is published. Moreover, this first

section of article's identification also defines the focus argument of the articles chosen, namely: ICT, sensors, computing/automatics /business/manufacturing and production.

ICT stands for Information and Communications Technologies, and it represents all the systems and devices that allow interaction in the digital world. Sensors are devices that detect specific type of input from the physical environment to consequently produce a digital representation of it; the results are usually collected or displayed for further analysis. Computing represents the tasks that involve a computer system from hardware to the software. Differently, automatics represents the entire task that is completed autonomously. Manufacturing is the process of the work spent on raw materials to realise the final goods, it gives value added to the product which allows the business to sell it with revenue, and production is the manufacturing in the large scale.

2.1.2 Technological tools section

The second section of the model contains the macro category of the technological tools in which important innovations in Industry 4.0 are showed to understand their trends of adaptation. It is also interesting because, with the comparison to past results, we could have an idea of the answers of the market to this technology and what are the ones that have been more exploited in the industry. The principle methods and innovations considered in this research were:

- *Cloud computing*, "a method of availing computing resources from a provider, on demand. The process starts with a customer using a computer connected to a network (usually the Internet)" (8), and Wireless Network (a computer connected with no cables). Both these technologies allow for more comfortable communication and storage of data, and money savings.
- *IoX* can be broken down into:
    - *IoT*, it is "a network of physical products embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data, it allows objects to be sensed and controlled remotely across existing network infrastructure" (9);
    - *IoE* (internet of energy)/Smart Grid: an "integrated dynamic network infrastructure based on standard and interoperable communication protocols that interconnect the energy network with the Internet including a variety of operational and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficiency resources" (9). An example of it is the Smart Grid that is an

electricity network that has the technology to deliver electricity efficiently, autonomously and in reliable way;

- *IoS* (internet of services), inside the technology of the IoT it is expected that each component in the network can provide a series of standardised smart services (9);
- *IoP* (internet of people) represents the point of contact between people and machinery. It is the continuous improvement of the IoT world based on the users' feedback; it creates the connection between the real world and the cybernetic one (9).

- *Cyber-Physical Systems* (CPS/CPPS), the combination of a network of highly smart, autonomous and intelligent components that have the flexibility to adapt their selves to the fast changing in demand. This highly digitalised system creates a virtual representation of the reality making it simpler to process data is, adjust the errors, monitor, and control the overall operation (9).
- *Cybersecurity systems,* systems of rules, technology and process which avoid unauthorised asses, destruction or violation of data, software, network, program and computer (all the digital world), it is composed of a physical and a cyber part.
- *3D Printing/Additive Manufacturing,* the technology that creates a three-dimensional object with the composition of following layer of material under computer control.
- *Smart Sensors,* as we have seen so far are one of the more used technology in this revolution; this component gives the possibility to collect information and to monitor situation combined with the autonomously of ignoring the error and so more accurate record of information.
- *Big Data Analytics,* the process of collection and elaboration of large quantities of data; this gives the possibility to discover patterns, tendencies or errors and so to make a better forecast, have a deep understanding of the process and solve the problem.
- *Augmented Reality/Simulation Systems*, a system that creates a virtual image of the reality, it is possible to interact with it, and the system will simulate the combination of multiple variables. Computers make it possible to modify the global environment and add new variables to study the effect, avoiding real-life consequences.
- *Robotics and automation* represents all automated machinery that is receiving instructions to create a set of repetitive tasks. *Artificial intelligence* are all the machines that can autonomously decide and act without instruction. The success of this project

means that these devices can make predictions of future events, deductions and communicate.

- *Smart devices* are widgets that can interact with other devices or do task autonomously; an example is *wearable devices*, sensors that collect information and can deliver information to the human.
- *Smart Machines* are devices that can solve problems, make decisions and take actions based on their computing ability to analyse data and variables. These machines are usually used for o*ptimisation, simulation or operative activities* (production/maintenance).

2.1.3 Target section

There are different types of targets depending on the considered area, in this review were considered the key advantages of the Industry 4.0 revolution. This way is possible to see what is the crucial factor that pushes the industry to invest in this new technological environment.

The operations part concerns the transformation of the resource input in the desired good of output, more operations create a process. The *productivity* is the rate of production of a firm calculated by productivity and quantity of resource used for the output representing the *efficiency* of the firm. Another factor in production is the *high quality* of the product, which can be expensive for companies. One of the elements that can increase productivity is *optimisation* of load, make span or *time-saving* at some point during production. To minimise the errors, that reduce the productivity of the firm, and to have high-quality output could be using three type of technologies: *real-time control, reliability* and *auto diagnostic*.

From the financial point of view, the objective of each firm is the cost minimisation in order to increase the efficiency of the production and to have a higher profit. For this reason, the goals of some businesses could be the adaptation of the Industry 4.0's technology so to have *lower costs*.

The environment is one of the most discussed topics of this century, from pollution to climate changing. The ecosystem is becoming one of the constraints of this new world. S*ustainability* becomes one of the industry's priority, many rules were enforced, and controls on this field were intensified. For this reason, another modern trend is *smart energy consumption;* thus representing a more respectful way to produce as well as a cheaper way to use resources.

Michel Porter, Harvard Business School professor, points out that there are three ways to achieve a competitive advantage for a company aiming to be a cost leader. Reduction of costs to offer the best prices on the market. Another way is differentiation which is offering something different and unique to the customers, different from competitors, and focus meaning the choice of a market niche and create a particular product. The best way to achieve all this is the adaptability, the market's demand changes continuously, and companies must have the *flexibility* to adapt their production. The *customisation* is what pushes the client to choose between buying a product or another. The best way to be adaptable is the use of *small batch* that was a concept that disrupts mass production systems before innovations introduced by this revolution.

The customers' behaviour changes through time, they are no more aseptic consumers, now people are invested in reading labels and wanting to know how and where the product has been produced. The social integrity of production is no longer a background element, and for this reason, the *transparency* became very important in the industrial environment.

Communication has always been essential for human beings, but it became a significant part of the revolution since it is also possible between human and machine. *Data sharing* allows the *exchange of information* among different systems without human interaction. Consequently, there is a secure connection in all the production line, every kind of data is memorized. The whole system could become part of the *decision-making* process, and machines could take their own decisions if it is allowed. This connection in all the systems creates what is called *integration*, which could be: horizontal, between similar companies in the different value chain, or vertical, between firms in the same value chain, or through engineering, between components of the production line.

Decentralization is one of the central columns of the Industry 4.0 paradigm; it represents the possibility to distribute the administrative process through different components. The system that is allowing this mechanism is called CPS. As it has been presented so far, virtual representation gives a global view to each element of the system so that every piece can manage its own decision. This technology is a result of intelligence and autonomies of the manufactories' component, which is the key to the adaptability goal.

The product life begins with the development, continues with growth since the maturity and ends with decline. The product *lifecycle management* is a process that develops and control all the phases to outperform competitors and create a competitive advantage for the firm.

Back in the days, in the early manufacturing proceedings, workers were the companies' principal resources. With the passing of time, catastrophic events in the history of the industry call for deep work security awareness. Raw materials used in the process and the strength of the machines used was evidently hazardous. For this reason, *improving work safety* is one of the fundamental goals of the modern industry.

2.1.4 Approach section

There are two different approaches to the implementation of Industry 4.0 that can also be applied at the same time.

The more common is the *human to machine* communication (H2M) in which there is a user interface that connects an operator to the controller of the industrial system. The data collected by the industrial control system are translated to be understandable for the human, the worker sees the schematic systems and can manage them from a controller. (10)

The second approach is the so-called *machine-to-machine* communication (M2M) which does not contemplate any interaction with humans, hence the name. M2M is based on a series of connections, sometimes wireless, that allow any sector to communicate autonomously with all systems and therefore the human supervision almost disappears. This new technology is fundamental for the IoT because it was primarily implemented for the industry but is what will be implemented in every kind of device for the Smart Society. (11)

2.1.5 Decision level section

Decision making is always a difficult task; every choice comes with inevitable, unpredictable risks. In order to have a better chance at avoiding error, a thorough analysis is needed, taking into account all possible factors and variables that could potentially influence the event.

The standard variables to influence the decision is usually time. Time affects the process on different levels which are taken into account in research:

1) Real-time (same day), with the right tools, is possible to avoid loss of time; they are the kind of decision that the machine of industry 4.0 could take autonomously.
2) Operational (short term, days/weeks), are related to running a business and is a small adjustment to the process.
3) Tactical (medium-large period, month/semester) are some of the most important decisions since they can influence the strategy of the company.

4) Strategical (one or more years) affect the direction of the whole business and can determine the future of a firm.
5) Knowledge is a particular way to take a decision. A group of people discuss all possible scenarios in one or more meetings. Thanks to the discussion some research and meeting could be organised, but no real changes are made to the business.

2.1.6 Method section

In order to take the better decision for the company, there are several methods of data analysis that can be used, these imply to model the problem in mathematical terms and apply different rules.

The *optimisation* method has the goal to find an optimal or near optimal solution with a relatively low effort, but in general, one could say that the higher is the effort, the better is the outcome especially for the non-linear problems. There are two main kinds of optimisation methods: exact optimisation and heuristic optimisation. Not all problems can be solved with reasonable resources in terms of time and space. (12)

The *simulation* method has the aim to create a virtual representation of all the possible scenarios, in order to start the simulation process is fundamental to create a basic model with characteristics and influence factor key for the process.

There is also a hybrid option the *simulation-optimisation* method that "can be defined as the process of finding the best input variable values from among all possibilities without explicitly evaluating each possibility. The objective of simulation optimisation is to minimise the resources spent while maximising the information obtained in a simulation experiment." (13)

2.1.7 Issues section

While in previous sections we have listed some of the pros of Industry 4.0, the following section will analyse cons. Mainly focusing on potential problems that could arise during implementation or with the wrong use of some technologies.

The new technologies invested in the process of production, as previously stated, are very autonomous but it does not mean that they do not need maintenance or to be controlled at all. In fact, it will be necessary to train companies employees, which will have to start familiarising themselves to work with mechanisms that are very different from what they have

been using. Reasonably, the level and function of production will change, so it is essential for the firms to prepare to invest a significant amount of money for *training* of the employees.

Another issue, directly related to the previous problem, is *unemployment*. The level of knowledge required to work with new machinery is considerably high, and the companies' owner has to consider the trade-off of either hiring a specialist or training a labourer. Furthermore, the use of the connected system and such smart components in the line, the number of employees required is reduced, and this is a fundamental social and economic issue.

The innovation introduced by IoT implies a significant digitalisation of all the production systems and increasing complexity of the IT system. The use of complicated software and the coexistence of different technologies could implicate a lack of robustness and the probability of error with high vulnerability. Nowadays, cyber-attacks are very common, and the Internet exposure of the industry is hazardous for the *security* of the production.

Connections between different processes, systems and technologies are hard from a different point of view, but the large issues are the *synchronisation/coordination and interoperability*. The synchronisation in the system must consider a copious quantity of variables because it is necessary not only between single components of the machine but also between the machine of the process and the processes of the systems. Automation could become challenging to manage and to take advantage of the interoperability; *standard*s must be implemented in all the components of the system. The standardisation is not so easy since the development continues and each supplier tends to customise the product for his clients.

Due to the low application of the new system, another issue that worried the firm was *scalability* considering that the use of it, in the vast scale could highlight new problems. The flexibility implies the change of a series of variables, which could be tricky to manage. The analysis and the consideration of different kind of products in a complex system could create the problem of overload and consequently *access delay /congestion.*

The better way to connect all components of the production is the wireless connection because it avoids the noise of the cables but the connection between lots of devices could create a severe problem. The *strength of the signals* together with distance could be affected by the interference, but coordination depends on this signals and it is a core issue for the well function of the system, as we have seen.

Each firm has its structure, and its customised workflow, so standardising could prove difficult for the *environmental characteristics* of their production. Change in the firm is always

a challenge because the equilibrium of the production could become very unstable. The environment could be a problem also with a figurative exception because the scepticism towards new technology can destroy the future of the firm.

As a matter of fact, the whole revolution has a significant cost, and it is not always affordable. As we have seen before the *cost* of training or hiring new workers is high, same goes for the acquisition of the new equipment. One of the promises of Industry 4.0 is to achieve low-cost production, but it will be achieved only in the future with the right amount of ability and know-how.

The fundamental idea for who wants to adopt the new paradigm is that has to learn how it works, the idea of the advantage that it promotes could be interesting but is important to understand the *usability* of it. The fever of implementation could create misunderstanding and to achieve good results user have to study how to apply it in the best way.

The *accessibility* of technology is one of the factors influencing the reputation of the new revolution; it is not easy to have the funds and the mind elasticity to implement it. It is a risk that not everybody is willing to take.

Today's talk about trust in industry sounds like a joke, as always the market is an ocean full of all kind of fish, and the underlying rule has always been: "the big fish eats the small one", but fish eat for hunger, men do not. The lack of trust is a significant issue not only for Industry 4.0 but also for society, with *benefits sharing and trust* could be implemented a connected value chain that can multiply the benefit of the implementation.

The new technological environment calls for new laws and *regulations;* governments have to consider the benefit to the community and respect of their rights. IoT could become very invasive for the customer's life, as mentioned above unemployment issue could rise; for this reason, and others, Governments are working to rule these new technologies. For example, at the end of May 2018, GDPR (14) (general data protection regulation) will become effective to protect the personal data in the EU countries (15). This regulation will impose a strict rule for the firm's use of data and so the necessity to spend more money to adapt their system to it.

The considerable amount of *data* collected thanks is increasing rapidly, but the *use, the management and the interpretation* are what makes the difference between success and failure. It is a new field of enquiry that is studying mainly, companies had created software to do unbelievable things with them, but it represents yet another cost.

2.1.8 Stakeholders section

Stakeholders are all individuals that show interest in the business. The most significant slice of stakeholders for Industry 4.0 is made by the firms; classifying them by size we have:

- *Large enterprises*
- *Small and Medium Enterprises (SMEs)*
- *Start-ups*

Start-ups and SMEs have some aspects in common such as small revenues and staff but a very different intent and function. A start up is built to search repeatable and scalable business models, new products for new customers, instead a SME is an organization that operates for profit, with known product in local markets. (16) Enterprises, in general, could be classified by different criteria, figure 2.1 shows the European Classification for the SMEs and it is clearly over the value of the medium size enterprise that we find the large enterprises.

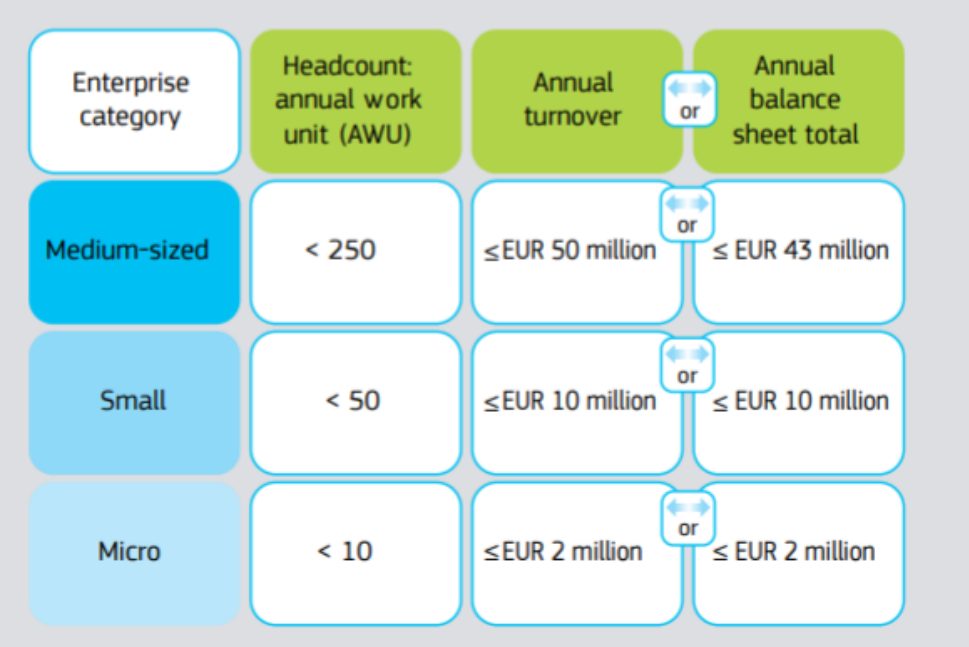

Figure 2.1 User guide to the SME definition (European Commission) (17)

Large enterprises have more resources as opposed to the SMEs and Start-ups, in term of money and expertise in all the sectors. They also have more expense and a brand reputation to manage in opposition to the other; instead, SMEs have a significant pressure because they have to affirm their position in the market and start-ups have substantial help from the State, which gives them the possibility to be more flexible. The great advantage of the small reality is

that they has a thin structure that gives them the possibility to take decision easier, their environment can change fast and thanks to the organization they can change their plan too.

If we see *citizens* as *customers*, this new paradigm could give them the possibility to have precisely the product they want because thanks to the IoT technology the answers of the firms to customer's demand could always be more accurate. However, technologies implemented in this revolution are changing people's everyday life because the world is becoming fully connected and human beings are part of it.

The principal objective of *Governments* is to sustain and assure the benefit of the citizens; for this reason, they must rule the changing and finance that could be good for the population. The roles of the Governmental agencies is to create a market that is competitive as well as possible, to maximise the utility of the consumers. On the other hand, they must protect their rights and insert bounds where necessary to avoid the technology's loss of control.

The core of the knowledge has always been schools, *University and research institution* are investing a lot in the Industry 4.0 to study all the effects and the possible development of it. *Students* all around the world are studying the phenomena from different points of view and for some of them is becoming work. The involvement of the students in the technology implementation gives to the firm the possibility to customise the study of the plant and to the students the possibility to do practical research.

Also with this extreme technological environment *workers* remain an essential resource for firms, their knowledge and their experience will remain fundamental, but their life is destined to change. Probably the Governmental agencies will act to reduce the problem of the imminent unemployment, and they will push workers to expand their knowledge to continue their work.

The optimum implementation of Industry 4.0 implies the connection of all the supply chain, the firm and his *suppliers* became part of the same system, everything must be connected. However, every firm has his time, and to coordinate all systems time is crucial, but with a little more trust in a market relationship, the quantity of benefit sharing could create a significant competitive advantage.

2.1.9 Resume section

In the last section of the table, we had a closer look at the *segment* focus of the article, segments were identified as:

- Supply chain, all processes and events that move raw materials, work-in-progress products and final goods from the supplier to the customer,
- Manufacturing, all the processes necessary to physically make the product,
- Logistics, all the process of transportation, storage, control and organisation for materials and the products.

During the analysis it was highlighted the fact that most of the articles were about more than one segment, so sometimes a combination of them was indicated.

As a result, the part has summarised the content of the article in few phrases to have a fast way to understand the most important result of the content of the papers. This analysis will help to understand what the trend of the Industry 4.0 in both development and research are.

2.2 Procedure

As soon as the perimeter of the literary review was defined, the second step consists in the selection of the articles, followed by the collection of the data. Article's research has been conducted using three different electronic databases "Google Scholar", "Scopus" and the electronic section of the Politecnico of Turin's library. The process was done in September 2017, and it was set as a filter for the condition of publication since 2017.

Samples selected include 60 articles, some papers were discarded during the process for one of the following reasons:

- results that were different from journal article or conference paper as, for instance, books,
- published after July 2017 since the review concerned the first semester of the year,
- that only have the title in English but the text in other languages,
- that are not fully available,
- that use Industry 4.0 only as a keyword,
- that do not talk about the argument in the review perimeter.

If the article passes the selection, it was thoroughly read with the maximum attention span, and all information has been extracted and recorded on a Microsoft Excel sheet which contains the table with all sections explained in the previous subchapter (2.1 Model).

The first and the last section, literature and review, considered the text information. Instead, for all the other attribute a binomial variable was chosen [0, 1] if the argument is the primary focus of the article it has been inserted as the value 1, on the contrary 0.

2.3 Analysis of the review

When presenting the results, we will be following the order of the model's section to maintain a logical flow in the analysis report. Out of the 60 articles analysed for the first semester of 2017, there is a right balance between the number of journal articles (48%) and the number of conference paper (52%) (Figure 2.2). The percentage shows that is possible to have an equal contribution from both types of article and enough scientific support which allows us to see the various points of the argument.

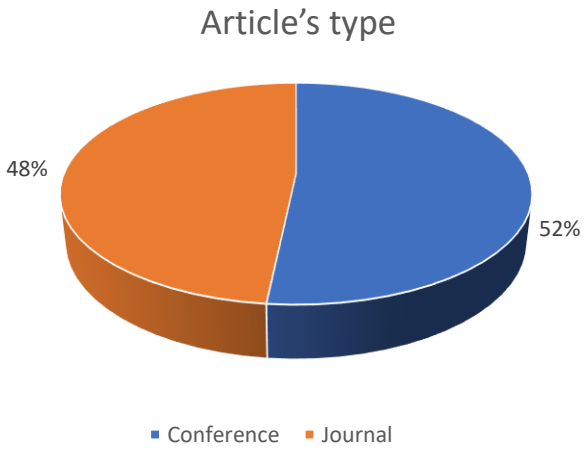

Figure 2.2

All the sources were electronic and after the research for keyword the website source of the article were the following (Table 2.1). This list is composed by different kind of web database; there are online magazines, scientific database and conference sites.

Table 2.1

SOURCE	%
Science Direct	45%
IEEE	12%
SpringerLink	5%
ResearchGate	3%
University of Glasgow	3%
HAL archivers-ouvertes	3%
Taylor and Francis	3%
European CIIP Newsletter	2%
International Journal of Supply Chain Management	2%
Wireless Netvork	2%
Sustainability	2%
Cornell University Library	2%
ACM Digital Library	2%
AMA Association for Sensors-Measurement	2%
DiVA	2%
Univesity of Twente student thesis	2%
University of Huddersfield Repository	2%
Edpsciences	2%
Hindawi	2%
University of Auckland Research Repository	2%
Gospodarka Rynek Edukacja	2%
IOPScience	2%

Most of the resources were found on Science Direct, which is the website with the most significant database of scientific and medical research in the world. The second most important source was the IEEE, Institute of Electrical and Electronics Engineers that both organises conferences and publishes interesting articles on the website. The articles taken into account came all from different journals, all true given the reputation of the web source. The conferences

are not as many as the scientific journal there as it is possible to highlight the group of papers that came from the same conference (Table 2.2).

Table 2.2

TYPE OF CONFERENCE	%
27th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2017	19%
The 50th CIRP Conference on Manufacturing Systems	16%
7th Conference on Learning Factories, CLF 2017	13%
7th International Conference on Information Society and Technology ICIST 2017	6%
IEEE International Workshop of Electronics, Control, Measurement, Signals and their Application to Mechatronics	6%
Manufacturing Engineering Society International Conference 2017, MESIC 2017	6%
International Conference on Applied System Innovation (ICASI)	3%
Proceedings of the 10th International Conference on PErvasive Technologies Related to Assistive Environments	3%
10th CIRP Conference on Intelligent Computation in Manufacturing Engineering - CIRP ICME '16	3%
AMA Conferences 2017	3%
IEEE 15th International Conderence of Industrial Informatics INDIN'2017	3%
IEEE International Conference on Internet of Things (iThings 2017)	3%
13th Global Congress on Manufacturing and Management (GCMM 2016)	3%
24th ISPE Inc. International Conference on Transdisciplinary Engineering	3%
14th International Conference on Mobile Systems and Pervasive Computing	3%
The 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems	3%

The 27th International Conference on Flexible Automation and Intelligent Manufacturing is the source of 19% of the conference papers taken into account in the litera review; it took place in Modena on June 2017, and the theme was “Intelligent Manufacturing and Engineering Methods for Industry 4.0” (18). A significant contribution was also given by the 50th CIRP Conference on Manufacturing Systems, which was on May in Taiwan, and by 7th Conference on Learning Factories, which was on April in Darmstadt.

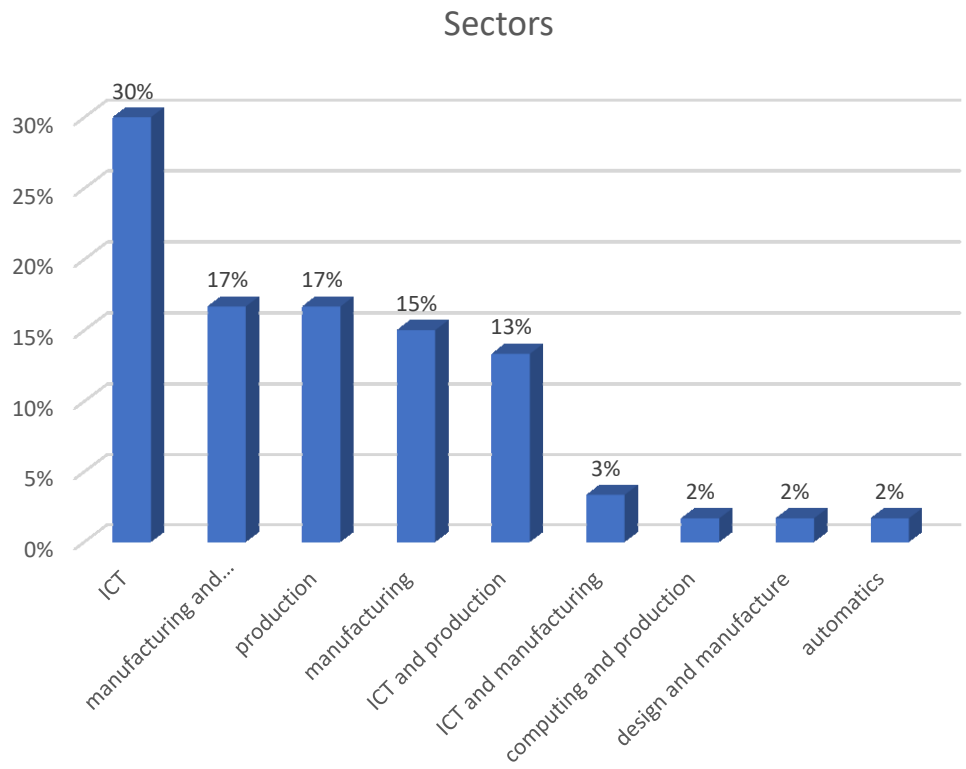

Figure 2.3

As previously illustrated, Industry 4.0 touches different aspects of production and practically for all types of industry. Moreover, it often happens that the sector of the analysis where more than one, as it could be seen from the figure 2.3. Overall, the most discussed argument is regarding sector of ICT, and that should be predictable since the basis of the revolution is the new way of communication between the subject animated or not. Iot, Cloud Computing and Big Data are the technologies that give to the industry the possibility to create the network of information that create the connected and smart industry of the future.

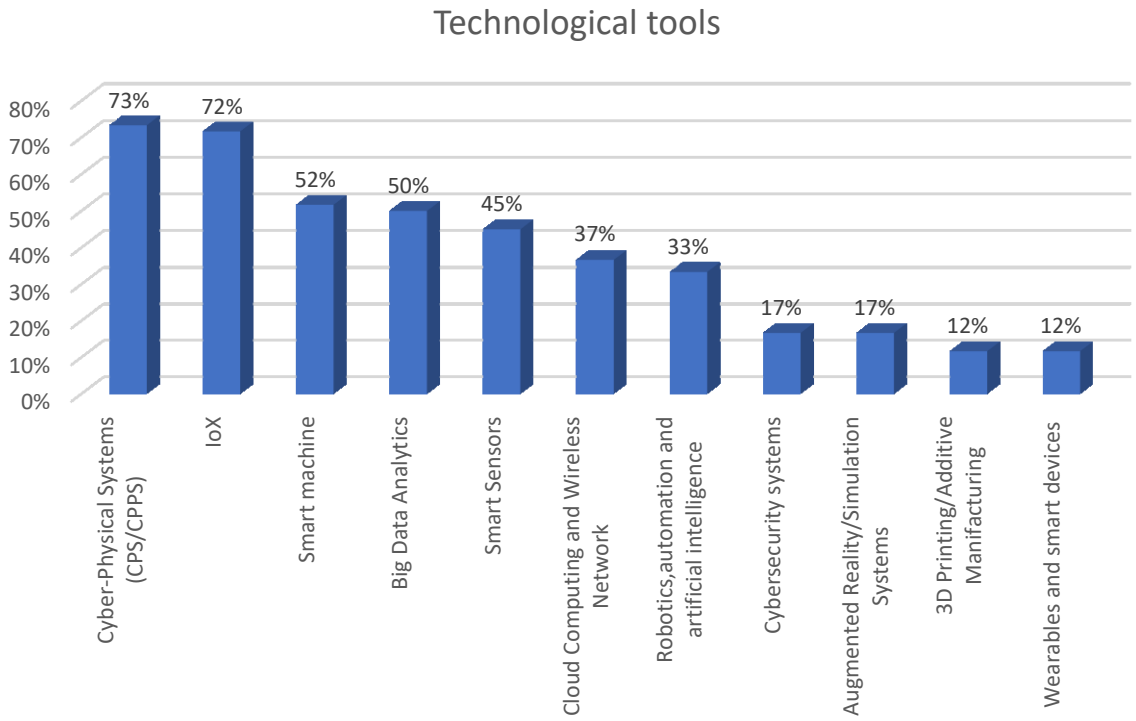

Figure 2.4

The horizontal axis of figure 2.4 shows all significant technological innovation of industry 4.0, about 70% of the texts analysed are about IoX and CPS. These two technologies with Smart sensors, Big Data and Smart machine, that are addressed in half of the articles taken into account, represent the core of the fourth industrial revolution. All other tools are more specific, probably the focus of the analysis to cover different aspect and topics give less critical to the specific utilisation and research about these topics.

It could be interesting to see what the trend of the evolution on the most critical topics of industry is 4.0, using the data of research that the same base (Figure 2.5). Indeed, using the same model other students have collected information about the articles published in 2015 and 2016 respectively with a sample size of 102 and 218. The general trend is almost maintained during the years; the percentage remains more or less in the same area except for the 90% of the articles that in the 2015 focus mainly on smart machines and only the 36% about IoX in 2016.

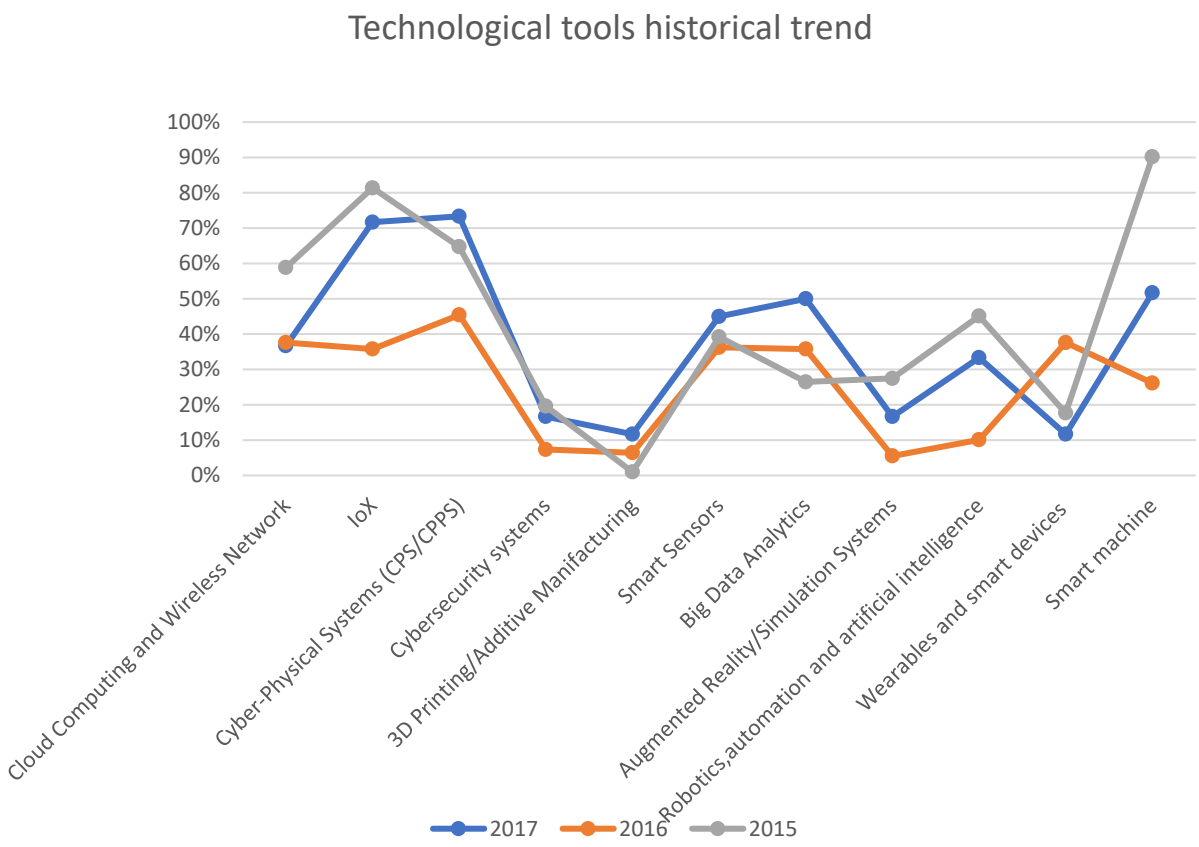

Figure 2.5

To give a general view of the trend of the technological tools the first step of the analysis considered the world of IoX and the world of smart machine. In the second step, we go from the general to the specific explaining the details of these two categories. Figure 2.6 denoted the popularity of IoT; to work efficiently, new technologies need the network to be as big as

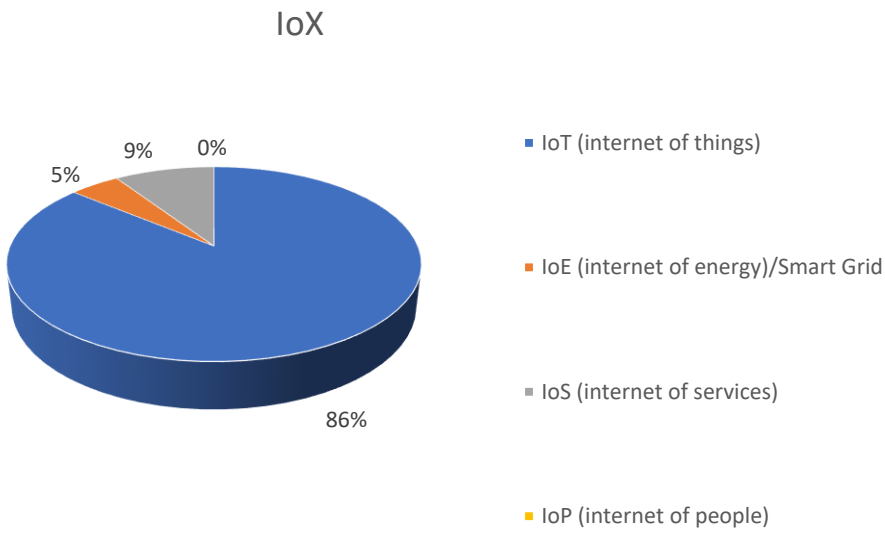

Figure 2.6

possible. Internet of all things represents precisely this necessity of connections so that all other IoXs became secondary. With a focus on the smart machine (Figure 2.7), optimisation clearly prevails, the idea beyond it is to maximise the efficiency of the production, reducing the scrap and consequently the cost.

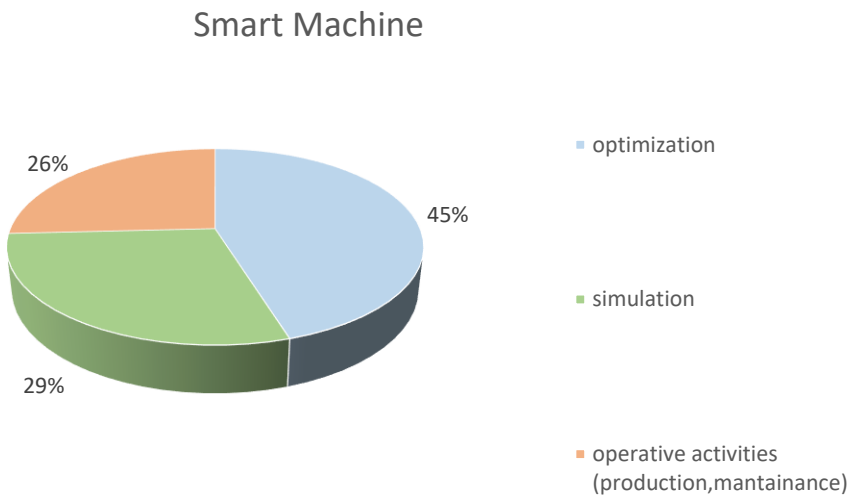

Figure 2.7

The reasons to introduce the new technology are a quite a few, this part of the analysis focuses is precisely on the following paradigm: "Why do I have to start the transaction to the Industry 4.0?". The answer is: there are a number of advantages, but everyone has a different reason depending on the global strategy of the firm and the objective for the long run. (Figure 2.8) From the data, the most popular are efficiency, real-time control and flexibility. All formers look like the principal goals of the revolution. The idea is to apply a low-cost mass production that meets the make-to-order environment with quality, production and logistics integrated across the company and create a real-time lean manufacturing eco-system that is efficient and flexible. (19)

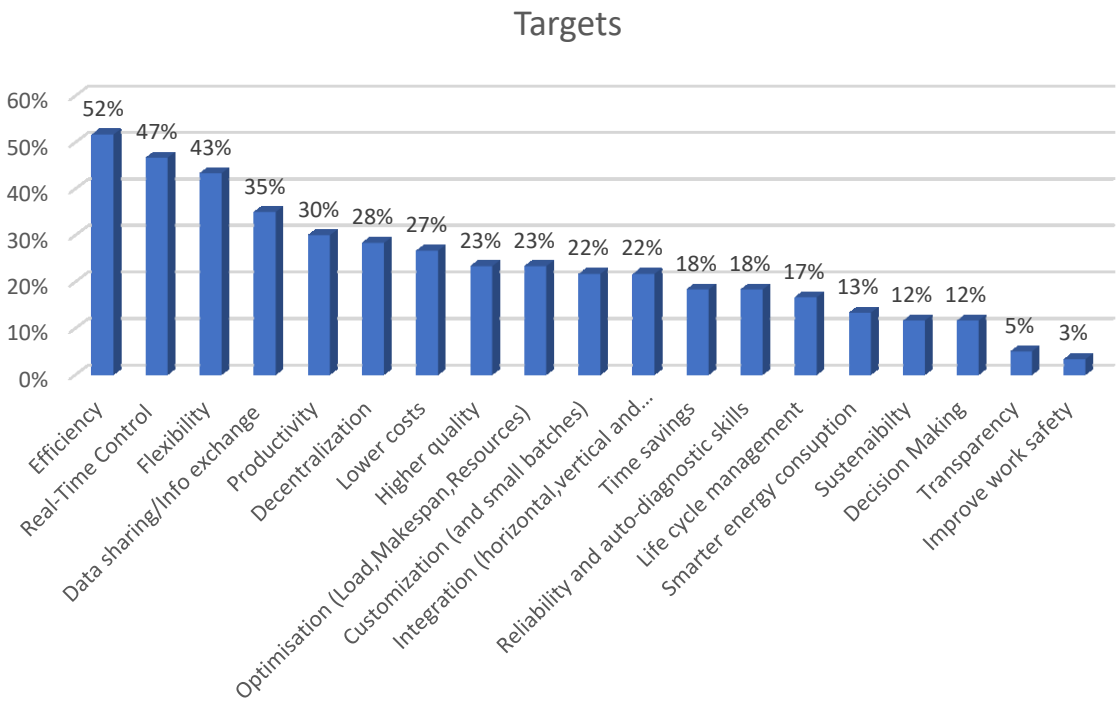

Figure 2.8

In the historical analysis (Figure 2.9), trends of 2016 almost match with 2017's ones; the differences are minimal. In considering a line of tendency also the 2015 series follows the other but there are some relevant peaks on efficiency, real-control and data exchange more highlight when confronted to the past years. The gap is probably a result of the specialisation of the article and the development of the technique during the years, which makes the documents more technic and less fuzzy.

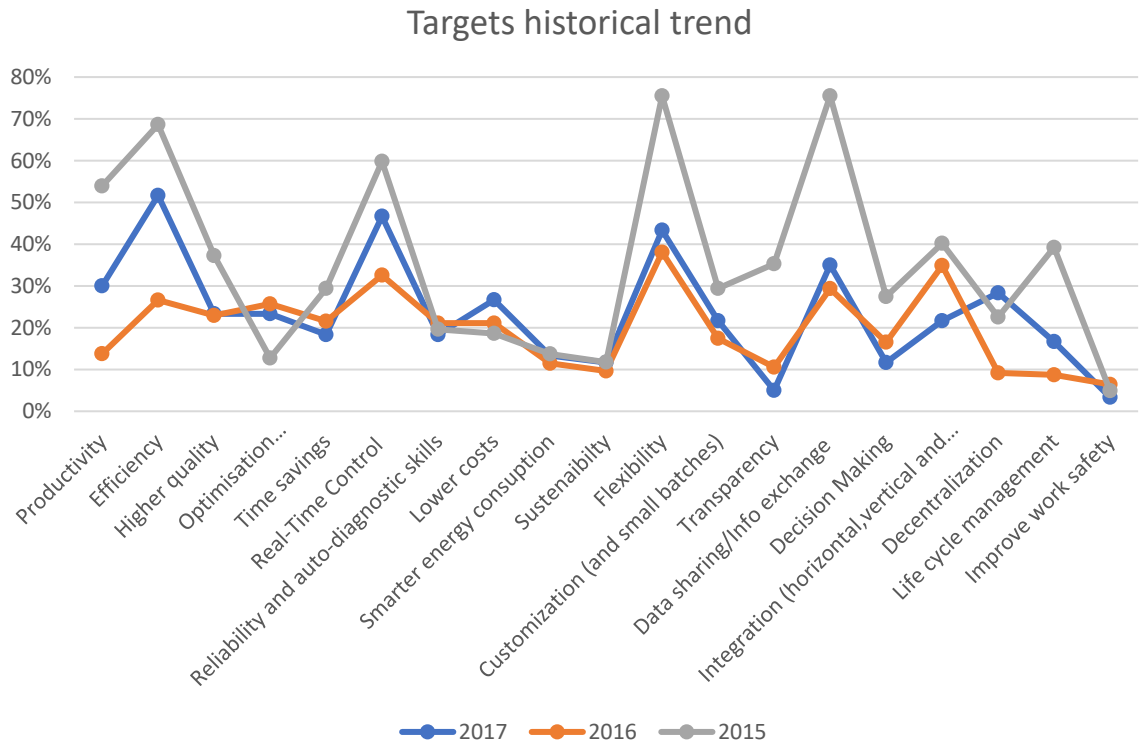

Figure 2.9

The third industrial revolution was based on the human-to-machine communication and the notion that interaction with computers helps the workers in the production of high quality and efficient output. Thinking forward, this is already obsolete, the new frontier that will revolutionise communication is a machine-to-machine connection. It will happen not only between machines in factories but also between all conceivable devices and systems, M2M applications can be directed toward individuals, companies, communities and organisations in public and private sectors. “Machine-to-machine communications (M2M) using the Internet of Things (IoT) principles will form the Cyber-Physical Systems (CPS) of tomorrow; these systems are predicted to enable new automation paradigms and improve plant operations in terms of increased Overall Equipment Effectiveness (OEE).” (20)

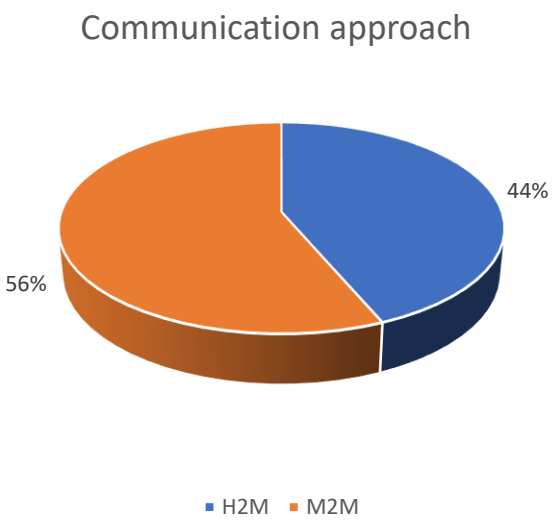

Figure 2.10

A good 56% of the articles is concerned with machine-to-machine communication directly or indirectly, the remaining part of human-to-machine (Figure 2.10). It happens for various reasons; the most important is that the shift to the new technology is in development and employees remain an essential part of the factories.

About the decision levels, there are two significant peaks: one for real-time strategy and the second for tactical strategy (Figure 2.11). The collection and elaboration of data by all the part of the system create the decentralised environment that supports real-time decision-making. Talking more in general about the adoption of the Industry 4.0, firms have based their decisions on the middle period so to be more careful in the investments and to be able to gradually adapt the production in order to avoid the problem in the normal flow.

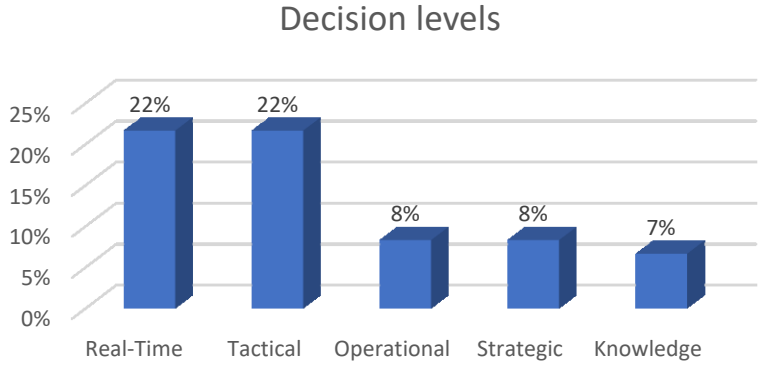

Figure 2.11

It is safe to say that mathematics is the basis of all technologies. As computers that were only an advanced calculator, after years of studies have always created a more complicated model to solve the practical problems. Thanks to the large amount and quality of data that could be collected by sensors and smart machines, to the elaboration capability of the new computer and to the storage capacity of the Clouds it is possible to find the solution of any kind of problems.

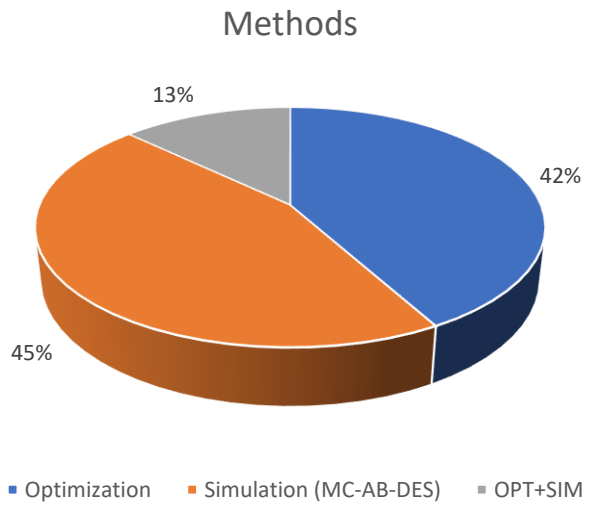

Figure 2.12

Both optimisation and simulation methods are used widely, as it is shown in the figure 2.12. Instead, the combination of the two methods is less popular. The criticism of this method is that: “there is a disconnection between research in simulation optimization—which has addressed the stochastic nature of discrete-event simulation by concentrating on theoretical results of convergence and specialized algorithms that are mathematically elegant—and the recent software developments, which implement very general algorithms adapted from techniques in the deterministic optimization metaheuristic literature.” (21)

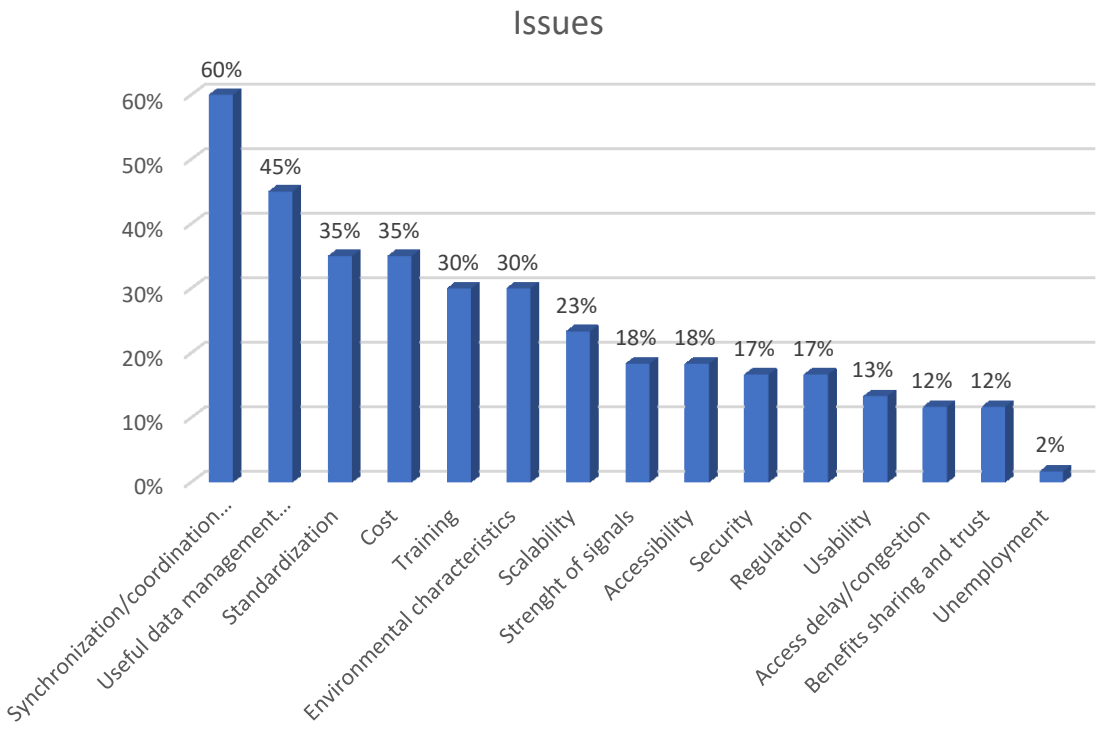

Figure 2.13

After this overview about the pros, it is only fair that we examine the cons, the principal issues that creates doubt for the implementation of the new paradigm. (Figure 2.13) From the analysis, the most troubling issues are about synchronisation and interoperability with 60%, followed by the user data management and interpretation with 45%. As usual, the shift from the old process to the new one will be slow; probably recent technologies will be applied to small parts of the production, at least at the beginning. The coordination of the system until now was always managed by humans, and since the production must continue the new technology have to work correctly also with the old one. Coordination and data management are vital process capacity as well as electrical energy. Moreover, it must be taken into account that the data management and analysis is a wholly new field and the interpretation of the result is not something that everybody can do.

Looking at the historical trend of issues (Figure 2.14), the cruel point look like the same also in the past. After the two mentioned before there are the cost and the standardisation issues. Modern technology has a cost but also the implementation of it, the adaptation of the production to the routine is a related economic disease. Industry 4.0 is a paradigm, not a standard, there is not a right way to introduce it, and innovations are continuously developing.

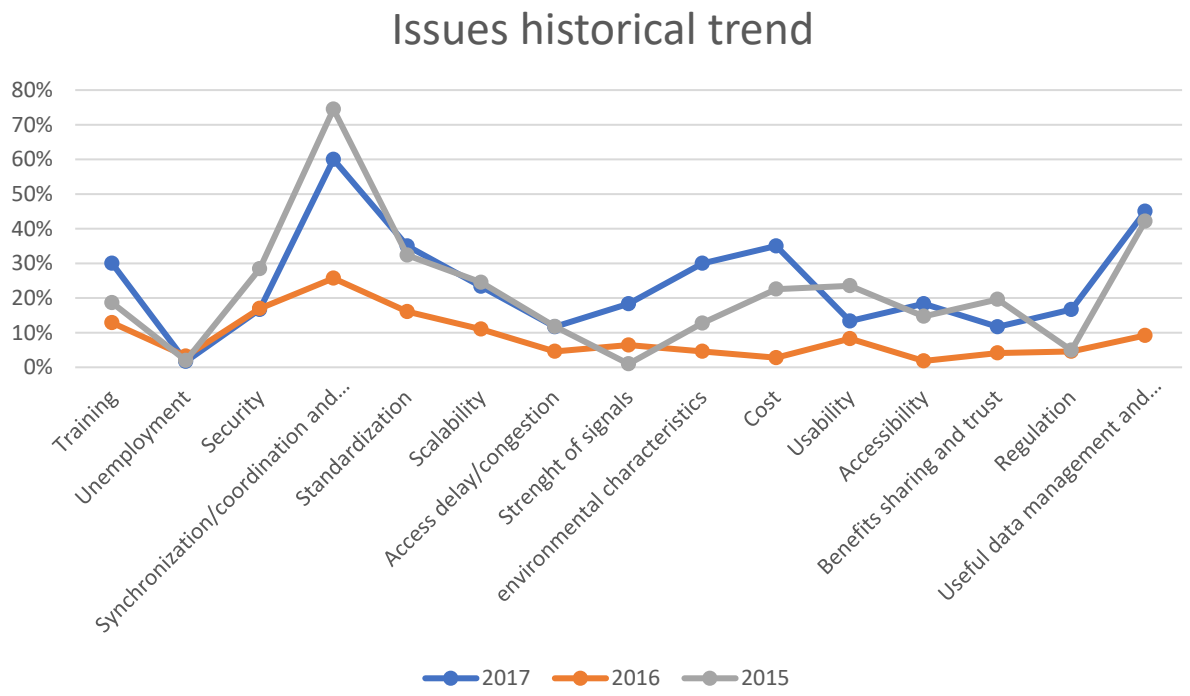

Figure 2.14

Worldwide, the topic of Industry 4.0 is becoming more and more real, the interests on it are many as are many the stakeholders impacted. In the analysis (Figure 2.15) the workers are mentioned in many articles (38%) it is clear that the impact on them will be significant. They have to manage the new technology, change their usual roles and work to keep production stable during the assessment phase. Country and Governmental agencies must regulate the innovations as well as the interest of the citizens.

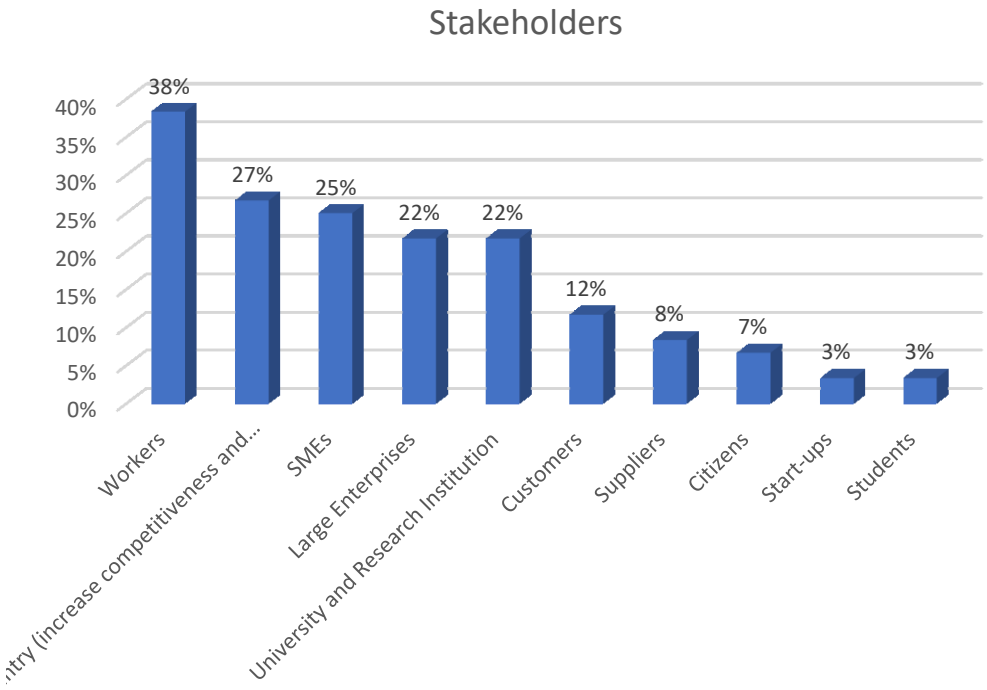

Figure 2.15

In 2015 there is a peak in University, and Research institution (Figure 2.16), 50% of the articles analysed considers them as stakeholders. This could be seen in the perspective that the most significant part of the articles were merely universities researches; in the following years, the interest of the industries became so intense that they started to conduct their own research. Many consultant companies create a line of service to help firms adopt the Industry 4.0 paradigm.

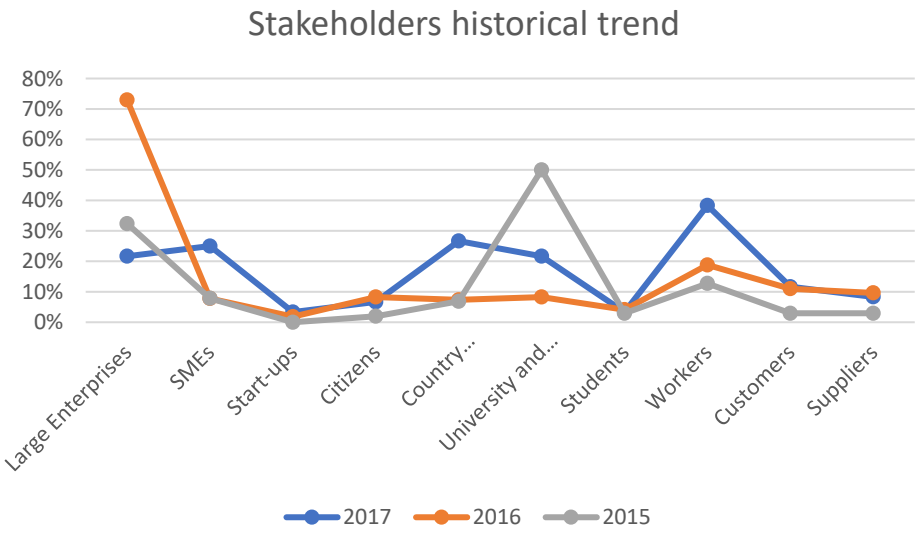

Figure 2.16

Some articles touch more than one segment of that which has been taken into consideration during the analysis (Figure 2.17). It was discovered that in general, there is a predominance of manufacturing, with the 72%, the percentage of the others are much smaller: 42% for the control, 18% for the supply chain, and only 2% is about security and logistics. The reason for it could be finding the choice of the sample because they have to respect specific technical requirement that are applied in the manufacturing fields in the first instance. The security is for sure a focal point, but this argument will be probably discussed more in specific articles or in the future when implementation phase will be completed.

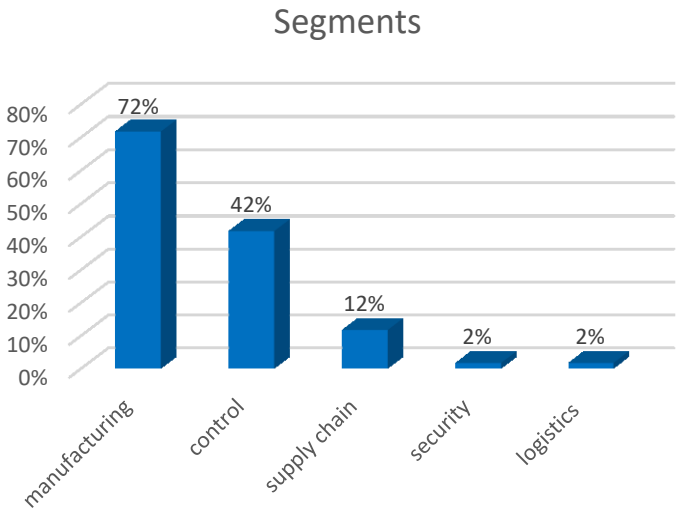

Figure 2.17

2.4 Focus on SMEs

The previous paragraph contextualised the general development and opinion about Industry 4.0. There are more than 100 definitions of this concept, but each has its focus on the new technologies used. The requirement of the firm for the introduction of such innovative equipment is a substantial investment, and a high level of expertise is required in order to have flexibility and decentralised decision-making.

In general SMEs businesses are based on flexibility, reactivity and customer proximity. For this reason, the new paradigm appears to fit well this typology of firms. However, the pre-requisites are unstable since the most of SMEs have:

- A short-term strategy that prevents long-term investment,

- Lack of expert support functions,
- Lower productivity, higher cost and less on-time delivery performance respect the large companies. (14)

To better understand the real benefits regarding this shift was extracted from the research the fifteen articles that consider the SMEs as a stakeholder and the more critical sections are re-analysed.

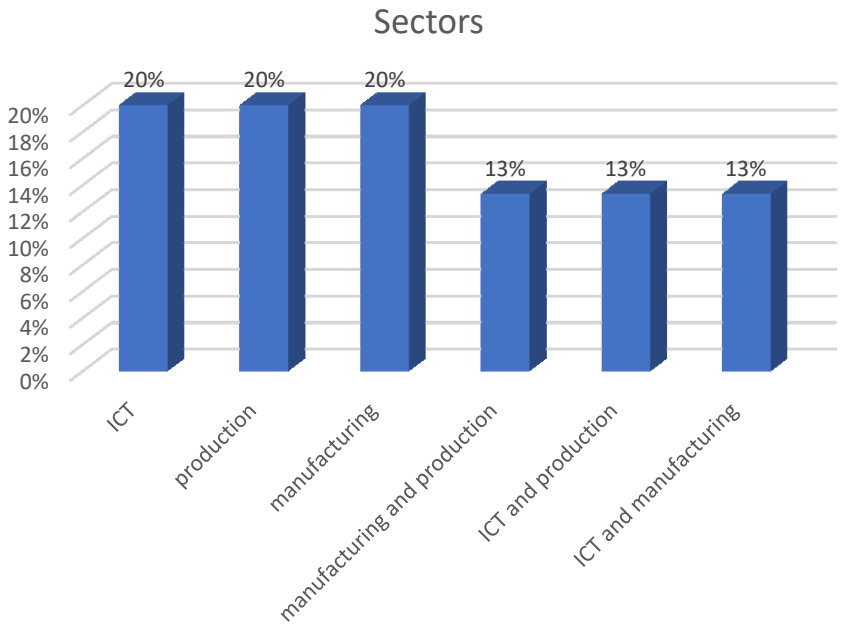

Figure 2.18

There is an equilibrium between the sectors that are argument of the paper; all sectors are explained singularly or with other in the same amount (Figure 2.18). The ICT, production and manufacturing have the same importance for the SMEs this because they are very interested in the transaction since it could be their competitive advantage over the competitors that are at adverse risk.

In focusing on the technological tools (Figure 2.19), 73% of the articles mentioned the utilisation of the CPS, this technology creates an expectation of high productivity with a stocks reduction, “personnel planning improved, logistics optimised and complexity and maintenance costs lowered. Furthermore, an increase in product quality can be expected, alongside more flexible manufacturing options. Experts even predict that maximum flexibility will be achieved with batch size one; that means that a customised product can be made for customers at the same price as a serial product today, providing a considerable boost to customer satisfaction.”

(15) Other significant points of interest are the IoX and Big Data Analytics; both techniques are complementary with the CPS to create a decentralised and autonomous system desire.

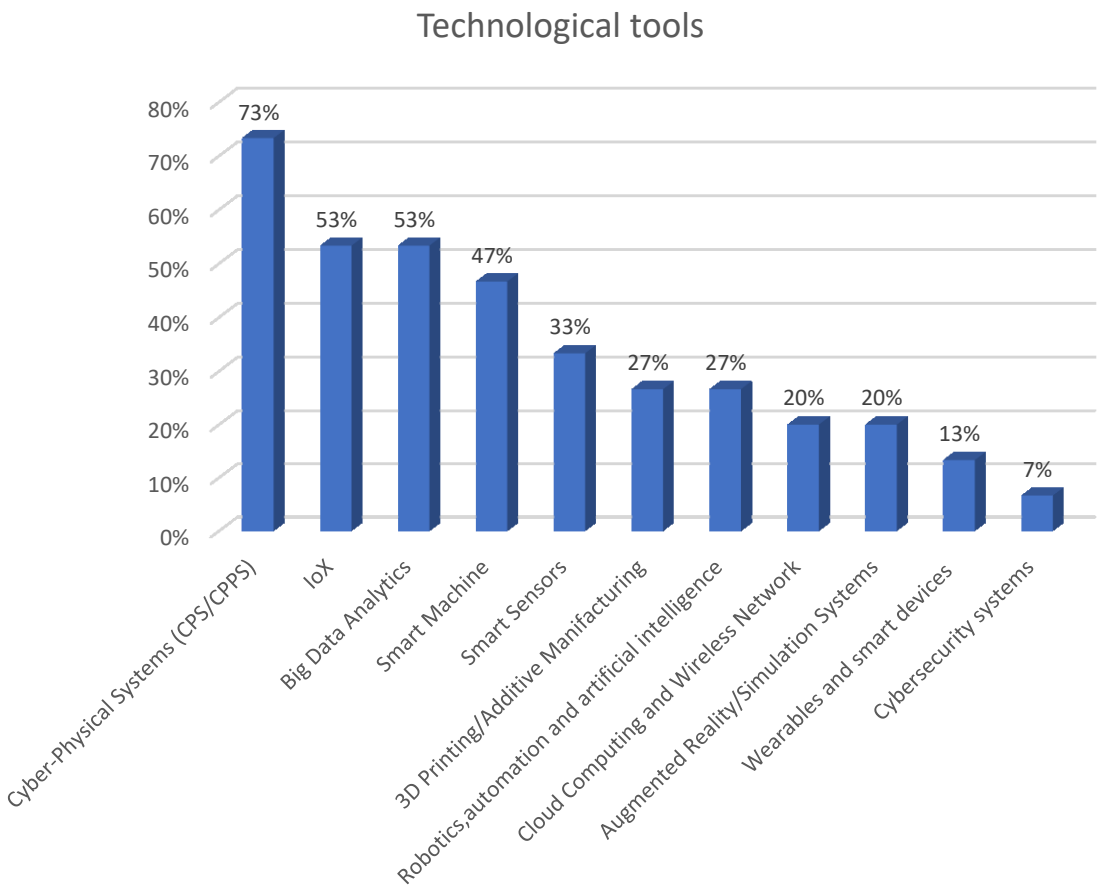

Figure 2.19

Let's analyse on what performance targets the Industry 4.0 could have an impact (figure 2.20). The 47% of the sample identifies flexibility; it is a characteristic of SMEs that allows them to be differentiated from other firms. The network created with the synchronisation of flows, with the use of IoT and Cloud Computing favours the reaction of the firm to the new demand from the market and so a better satisfaction of the client needs. With equal merit could be a highlight, also, the efficiency, uses more rational of the resources, the optimisation, to improving systems and processes, and real-time control, to reduce errors and increase the quality. (14)

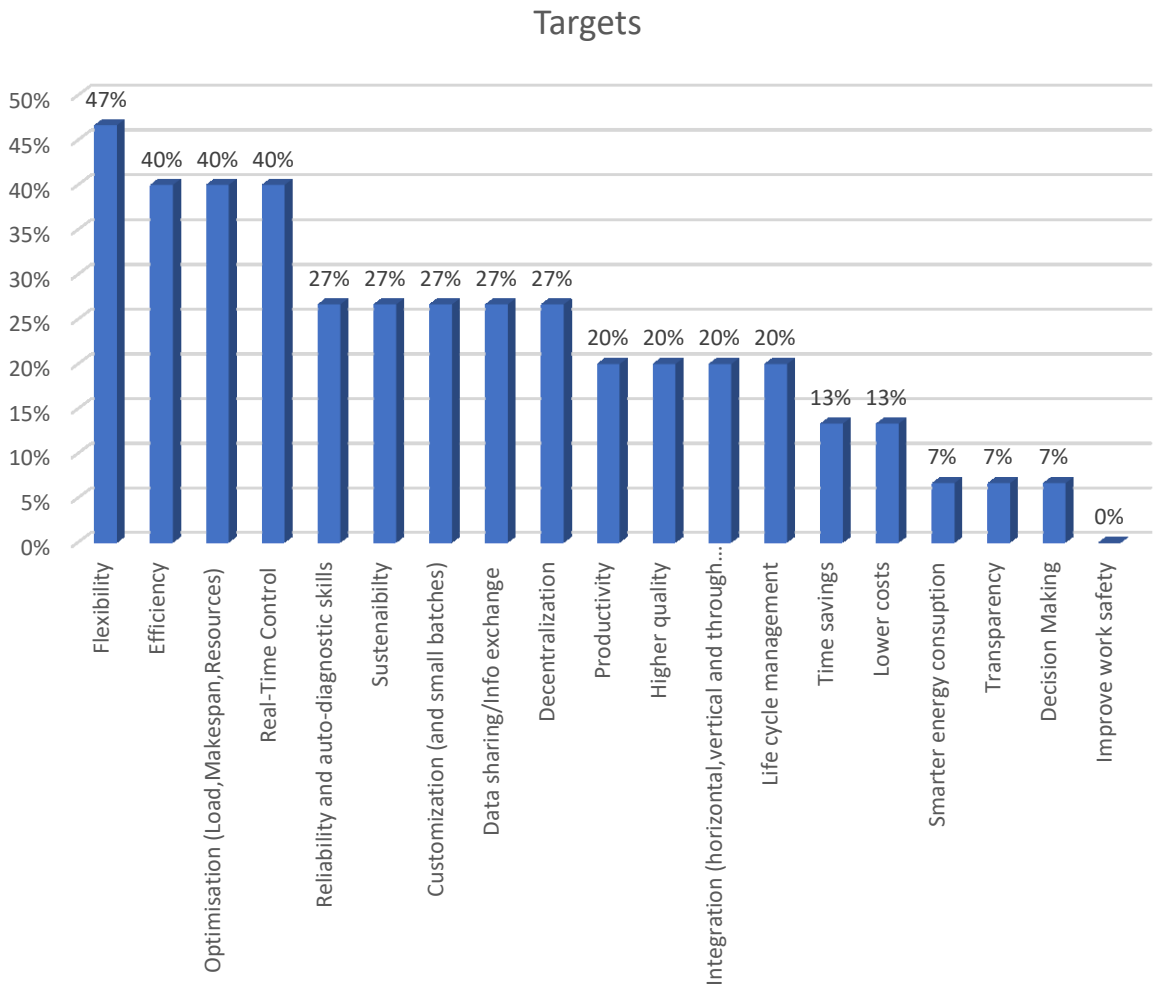

Figure 2.20

The most prominent issue for the SMEs is the high cost of implementation (Figure 2.21), but some works have shown a positive impact of Industry 4.0 in operational performance, also with little investment and little expertise (14). The regulation problem also impacts the firm, because at any time new guidelines can arise and be compliant meaning an additional cost. An example could be the GDPR (14) that imposes high-security standards for particular types of data and consequently the addition on new tools for the privacy compliance. The introduction of new technologies and practices is always risky in SMEs (14), they have to value the trade-off to take advantage of the innovation carefully.

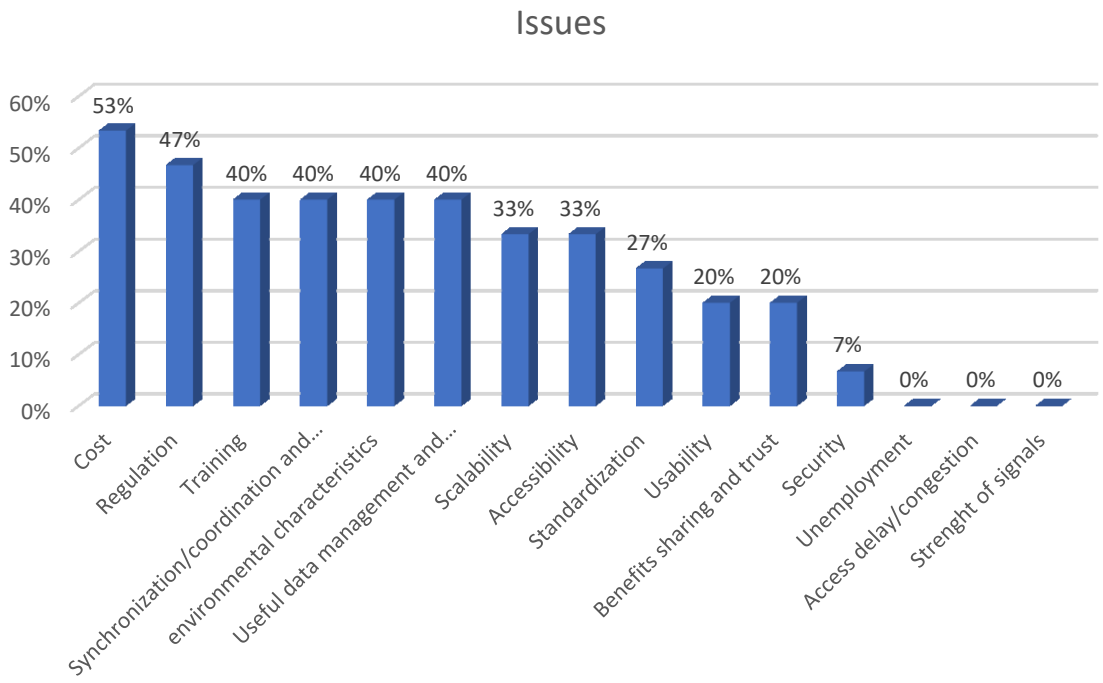
Issues
60%
50%
40%
30%
20%
10%
0%
53%
47%
40%
40%
40%
40%
33%
33%
27%
20%
20%
7%
0%
0%
0%
Cost
Regulation
Training
Synchronization/coordination and...
environmental characteristics
Useful data management and...
Scalability
Accessibility
Standardization
Usability
Benefits sharing and trust
Security
Unemployment
Access delay/congestion
Strenght of signals

Figure 2.21

3 Maturity of Italian SMEs in Industry 4.0

The previous chapter aimed to illustrate some of the findings on Industry 4.0. Research allows us to assess the evolution of interest in several subjects. Toward the end of the chapter, we will analyse the results that concern SMEs. This second chapter aims to identify the level of maturity of Italian SME on Industry 4.0.

The methodology chosen for this part of the research is an online survey or rather, a questionnaire sent to a group of firms. It is a widespread method in every field of study as it allows to reach a large population in no time and results can easily be compared. This technique is used to collect data in the various sector; the main disadvantages are the long-time of the collection, the possible lack of response, misunderstanding and errors in compilation. (22)

3.1 The questionnaire

This survey is part of one of the activities of the centre ICT for City Logistics and Enterprises (ICE) which is a laboratory of ICT technology for integrated management and smart logistics. Its scope is to promote the research and development of ICT-based solutions. (23) It was done to understand how widespread Industry 4.0 is, in Italy and if there are projects that will start to incorporate the change. Also, to discover the expectation and difficulties of the Italian's SMEs.

The questionnaire was carefully structured, so to collect the relevant data for the analysis as well as give companies the possibility to show their concerns (Attachment 1). It was divided into five sections:

1) Identification of the firm,
2) Level of knowledge about the concept of Industry 4.0,
3) Level of implementation of the paradigm,
4) Suggestion for future analysis,
5) Possibility to receive the result of the survey and/or participate in other surveys.

In the first section, the overall idea is to understand some general aspects of the firms which will allow us to contextualise the following questions. Firstly, we asked the name of the firm and the position of the writer in order to justify the perspective of the individual as well as and the reliability of the answers itself is. The other questions were about sector specialisation and market that the firm is targeting as well as its dimensions and which supply chain they belong to. The last part of this section is concerned with the interaction between firms and governmental funds, projects and initiatives.

In order to analyse the level of knowledge of Industry 4.0, the questionnaire offers its readers an abstract to introduce them to the terminology and general concept as well as a list of the leading technologies of the paradigm (explained in the subchapter 2.1.2) and questions about the level of knowledge of the tool. The choice was between:

- Very High,
- High,
- Medium,
- Low,
- Very low.

To conclude this section, we investigated the knowledge of incentive for the implementation of modern technologies correlated with the Industry 4.0.

To start the survey about the level of implementation we also created a list of needs, for each of them, therefore, the interviewee must select the level of importance being ‘low’ or ‘high’ with the possibility to select ‘not applicable’. Furthermore, some of the questions were regarding future perspectives and expectations on a potential five-year plan. The list contained:

- quality control of the product,
- preventive and predictive maintenance,
- collaboration between human and machine,
- productive process automation,
- sustainability and energy saving,
- training on the job for the new tools,
- attract professional experts,
- attract manager to manage the innovation and the digitalisation,
- collection and analysis of activities’ data
- extrapolation of information from data,

- horizontal integration,
- vertical integration,
- product design with simulations tools,
- small customised batch,
- flexibility,
- service that supports the physical product,
- allocation of resource on research and development activities,
- formalised a strategic approach based on innovation.

Following the study, we asked the level of effective implementation of the technological tools of the industry 4.0 between standards: implemented, planned, of interest and not of interest. Consequently, we investigated the willingness to adopt these technologies. Other key factors are the opinion of the firms on what are the potential 'pros' and 'cons' of the new paradigm. Their views are useful to understand the target shown in subchapter 2.1.3 and the issues of the subchapter 2.1.7. In the end, another enquiry was on weather or not a strategic plan of innovation was in motion, and if yes, who manages such projects, if it is internal, external or a combination of the two.

The 'suggestions' section aims to find out if, according to them, there are some important aspects that this survey does not cover, in case of an affirmative answer some space was left for comments. At the very end of the investigation, the person interviewed is asked to choose if he/she would like to be contacted again for future surveys and if they wished to receive the results of the study.

The questionnaire was mainly distributed in Emilia Romagna, that is situated in the north of Italy and it has an important local concentration of industries and a high level of per capita GDP, by various local industrial association as the CDO ("Compagnia Delle Opere") distributes the survey to the firms. The spread started in June 2017, up until February 2018, the completed answers received were 101, but the questionnaire is still distributed by the CDO.

3.2 Analysis of the survey

The source of data for the following report were taken from the first three sections of the questionnaire. Firstly, an overview of the participating firms and their business was given, after which the level of knowledge and implementation of the Industry 4.0 was discussed.

3.2.1 Identification of the firm

The Small Business Act for Europe is an European initiative designed to sustain small and medium enterprises in the Union and to create policies that help their development and growth. To have a better understanding the overall situation since 2011 they have performed an analysis which is referred to as the SBA Fact Sheets, where they monitor trends and effects of the policy on the SMEs in each country. (24)

Table 3.1 Estimates for 2015 produced by DIW Econ (European Commission) (24)

Class size	Number of enterprises			Number of persons employed			Value added		
	Italy		EU28	Italy		EU28	Italy		EU28
	Number	Share	Share	Number	Share	Share	Billion €	Share	Share
Micro	3 552 531	95.1 %	92.8 %	6 657 193	46.5 %	29.5 %	190.8	29.5 %	21.2 %
Small	162 263	4.3 %	6.0 %	2 910 669	20.3 %	20.2 %	138.7	21.4 %	18.0 %
Medium-sized	18 352	0.5 %	1.0 %	1 792 702	12.5 %	17.0 %	110.8	17.1 %	18.2 %
SMEs	**3 733 146**	**99.9 %**	**99.8 %**	**11 360 564**	**79.3 %**	**66.8 %**	**440.3**	**68.0 %**	**57.4 %**
Large	3 086	0.1 %	0.2 %	2 969 548	20.7 %	33.2 %	207.5	32.0 %	42.6 %
Total	**3 736 232**	**100.0 %**	**100.0 %**	**14 330 112**	**100.0 %**	**100.0 %**	**647.7**	**100.0 %**	**100.0 %**

The figure on the top is taken from the SBA Italian report for 2014, and it shows an interesting comparison between Italian and European values. Almost 70 % of the value added of Italian firm is produced by SMEs compared to the European 57.4%. In Italy, the 95.1% of the SMEs is made of Microbusinesses which, according to the European definition are firms that have less than ten employees and an annual turnover of under 2 million of euros.

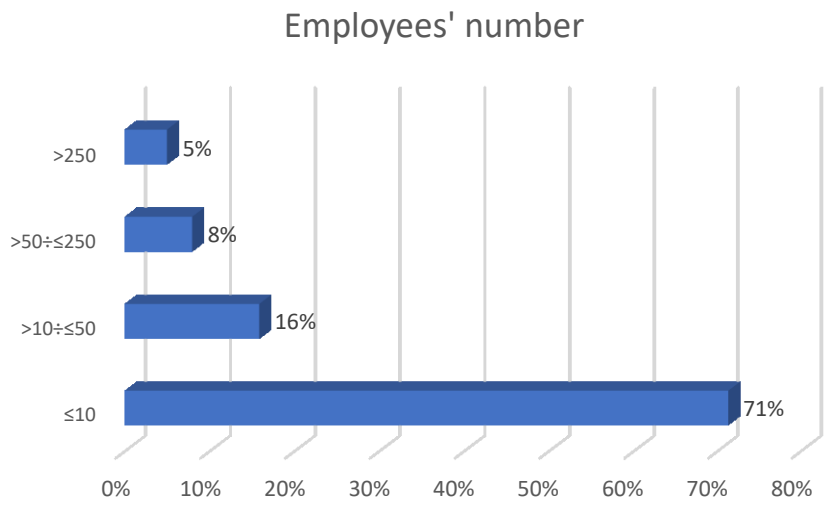

Figure 3.1

The great quantity of microenterprises also emerges from the survey (Figure 3.1): 71% of the firms interviewed has less than 10 employees, and 16% less than fifty. The turnover of the 80% of the companies analysed is under the two million euros which, as it was presented earlier, is the second identifier for a microenterprise (Figure 3.2).

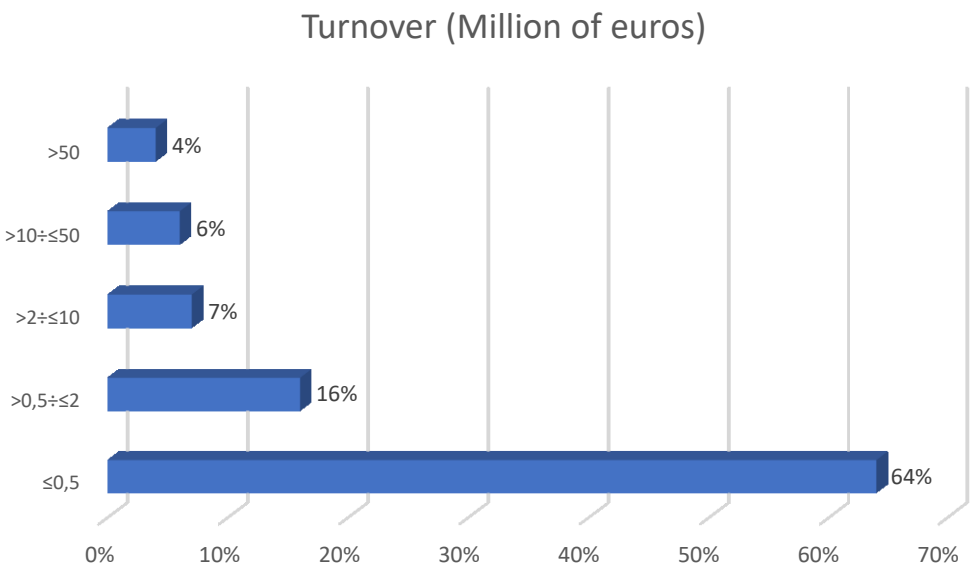

Figure 3.2

Within the analysis, 22% of the firms are part of the food and beverage sector, which together with handicraft and design cover more than half of the sample (figure 3.3). The 11% of the Emilia Romagna's enterprises operate in the manufacturing industries and the main component is the production and work of metals, followed by furniture, textile and alimentary production (25). Therefore, the sample looks well distributed in the different sectors, so the analysis could give more general results about the Italian situation.

Another question was: "What markets are supplied by the firm?" and the answer was 41% for the international market and 59% for the national. The Italian export market is in substantially growing, in 2017 it closed with a +7,3% as opposed to previous years. Overall, the "Made in Italy" is acknowledged all over the world and its connotation is usually quality and reliable products. (26)

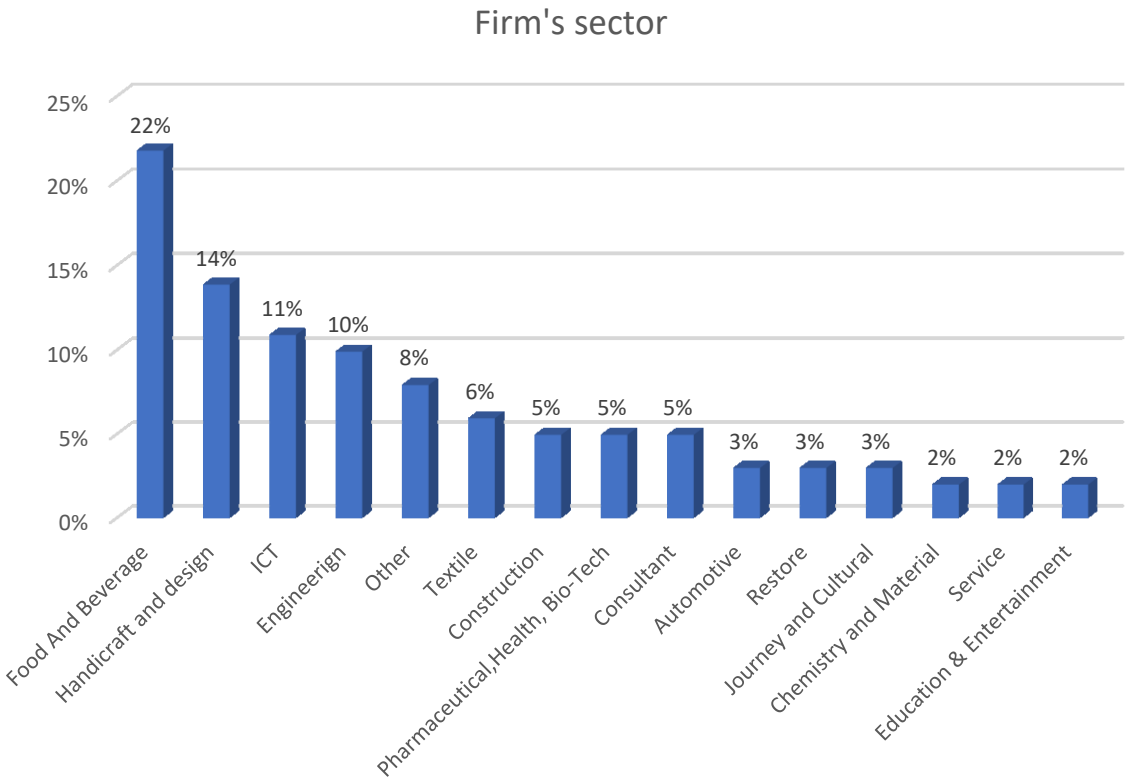

Figure 3.3

When we asked when the firms were founded the results show that it was between 1943 and 2018, almost 50% of the firms is more than ten years old, six of them are closer to 100 years old, which considering the sector in which they work it looks like they have traditional business probably of heritance nature. For regular businesses introducing new technology could prove challenging, in some more handcrafted sector their most significant selling point is human creativity, ability and experience in the field which adds value to their business.

Integration in the supply chain means studying the level of coordination between actors in the chain which, for example, could be achieved by using a shared management information system. If we were to consider a backward integration it is possible to choose a vendor from which the companies will buy almost all raw material at a set price, this could help to create trust and efficiencies based on long-term relationship. On the contrary, in the instance of forward integration the firm took the part of the vendor to a principal client, which is interesting because all single processes in the supply chain give value to the final customers, and working together along side with the whole production means having a significant impact on the cost of products manufactured in accordance with customer needs. (27)

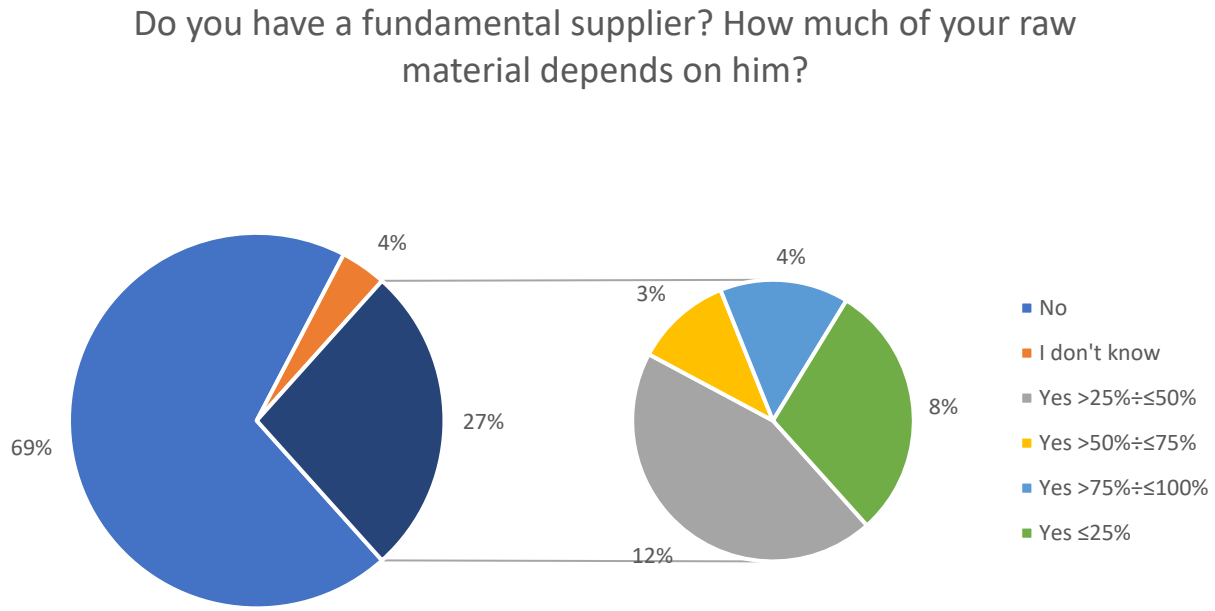

Figure 3.4

Toyota first applied the supply chain management, a car dealer in Kendari City, the fundamental pre-requisites to the benefit of the vantage of this methods is to have a mutual understanding, trust, and clear rules. This method gives firms the possibility to create an essential competitive advantage regarding price and quality of its product. (27) In figure 3.4, it is shown that only 27% of the interviewed had a fundamental supplier and of it just the 7% buy more than the 50% of their input material from the said supplier.

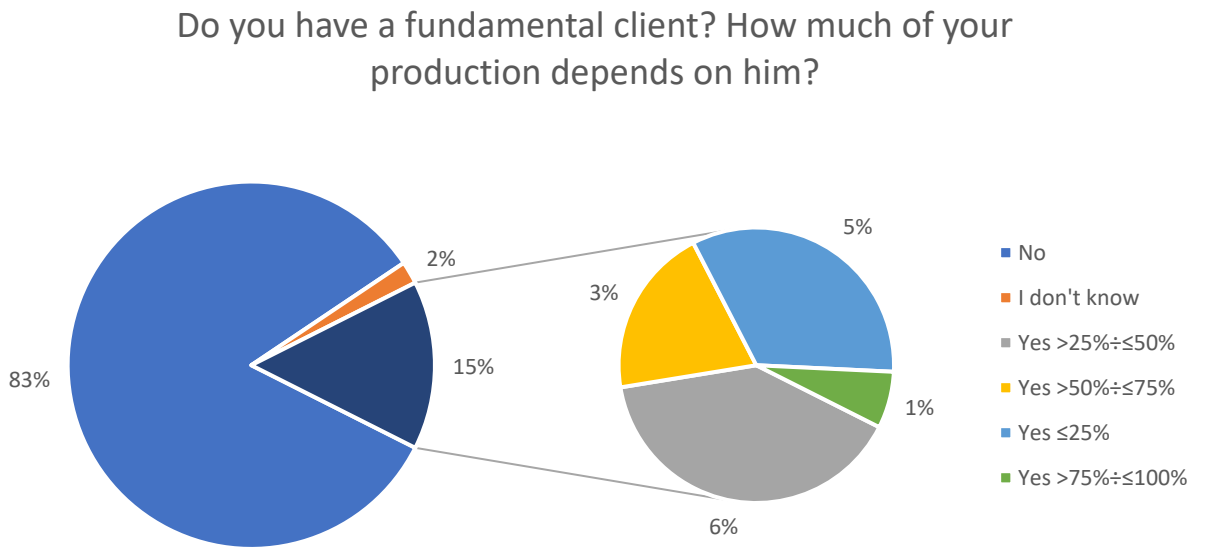

Figure 3.5

Looking at forward integration (Figure 3.5) only 15% of the firms have a fundamental client, and only 4% provides more than 50% of the production to this customer. In general, from both the analysis it appears that the supply chain of the firms that answers to the survey do not have a very integrated supply chain, it probably depends on the typology of business and from the fact that the firms came from different production sectors.

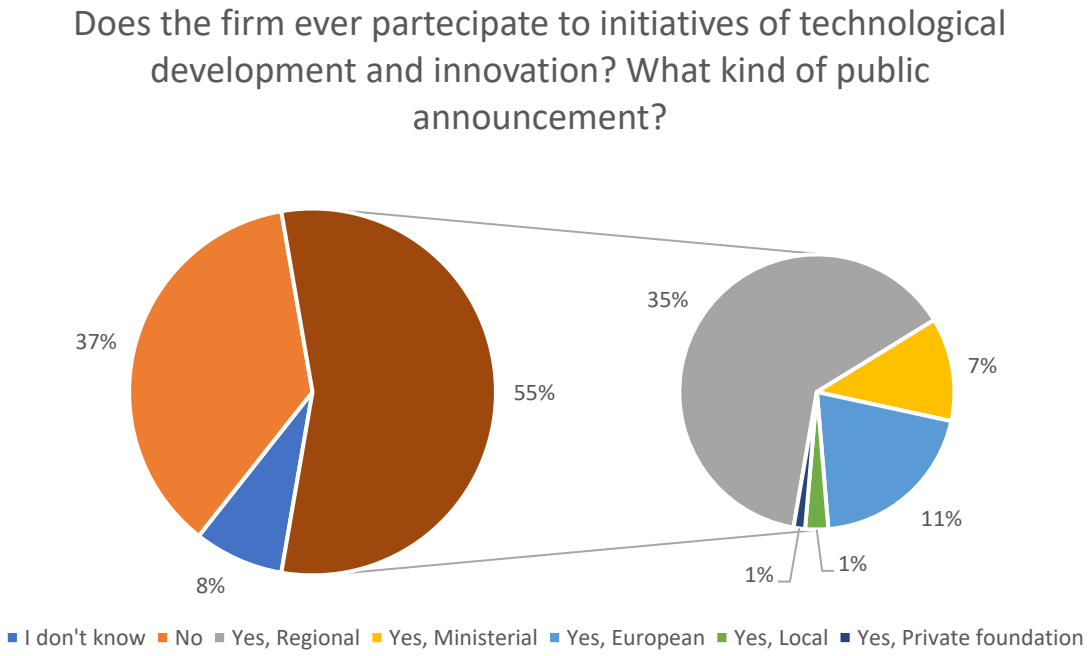

Figure 3.6

To close this section, we investigate the interest of the firm in participating in innovation initiatives; 55% of the sample had taken part in this kind of projects. The biggest slice, 35%, is announcement promoted by the Region, followed by the European and the Ministerial. Nonetheless, we must take into account that the European Union gives to the Region significant contribution to the economic growth of the territory. (28)

3.2.2 Level of knowledge about the concept of Industry 4.0

As it was shown it the previous chapter the paradigm of the Industry 4.0 is still in development, a lot of definition and research is still in progress to delimitate the perimeter of it. In Italy the firm's funds spent in research and development are important. In fact, the percentage of Italian's SMEs that introduced product or process innovations are above the average in the EU. (24)

Questioning about the term Industry 4.0 was successful, more than half of the firms interviewed have heard about the new industrial revolution. The Smart Manufacturing has a

value of 1,2 billion in Italy, but the projects started in Italy did not involve SMEs. In the whole nation, 38% of the companies have never heard of Industry 4.0, in the automotive, food and machine sectors the percentage in limited to a mere 30% but other sectors reach the 50% mark. (29)

In general, the awareness on Industry 4.0 is limited to the key stakeholders, the ones that are specifically affected in this stage of evolution such as industries, policymaker, academia and unions. In some nations of the EU, some initiatives will take place to introduce the innovation of Industry 4.0 without identifying it. (30) More than half of the firms that know about the existence of the Industry 4.0 have informed themselves on the Web and some in conference or exhibitions, meanwhile, there are a lot of smaller sources that indicate a reasonable level of diffusion of the new environment.

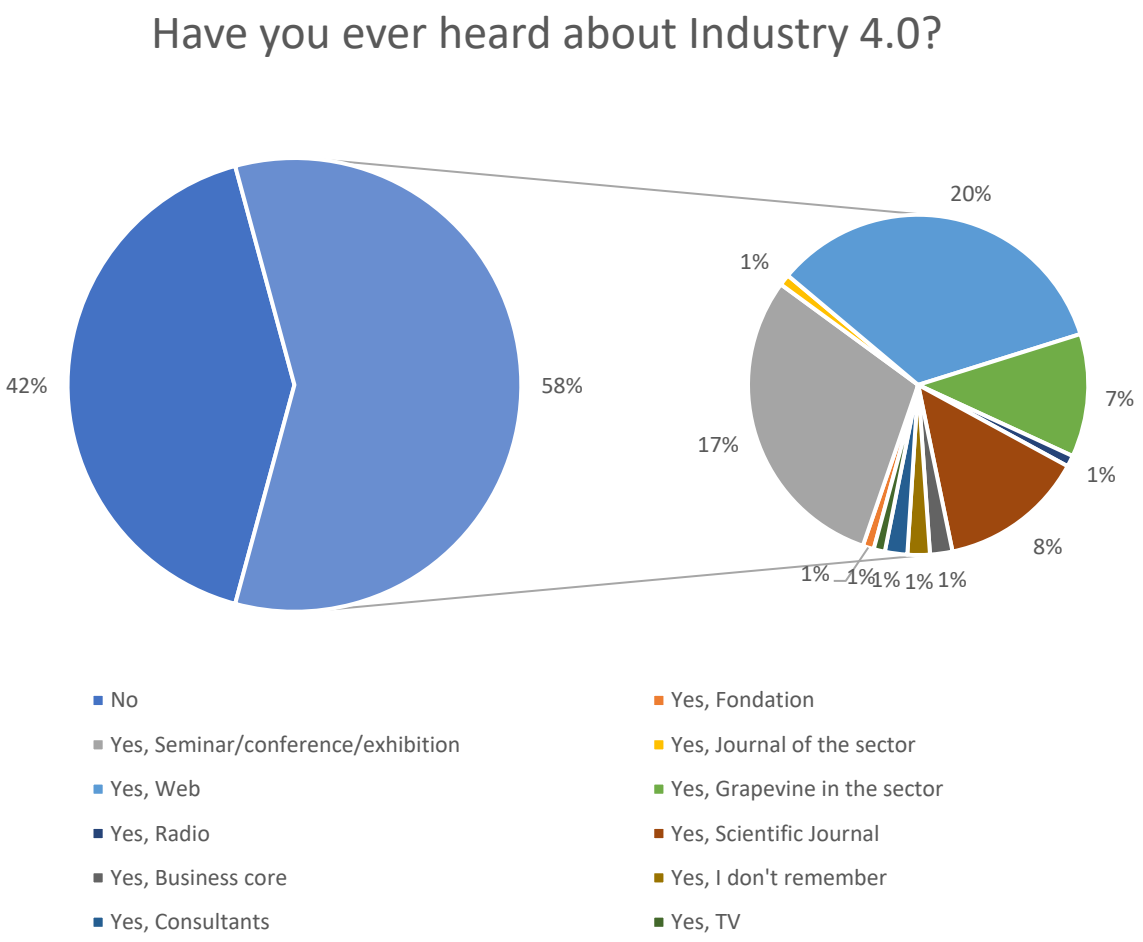

Figure 3.7

Analysing the level of knowledge about the principal technology that represents the innovation of the new system (Figure 3.8) it is evident that the average for all the technology it is medium or low. The most common technologies are the Cloud, IoT and 3D Printing, which are already part of the everyday life of citizens and their usage is widespread. The CPS is a dark horse, none of interviewed confirms to have a high level of knowledge of the technology, only 6% percent talk about a middle level, and only one out of one hundred and one said very high.

The CPS is a very complex system, both to implement and to maintain, to perform well it needs a highly integrated system, large quantities of data and an expert to manage it. Although it is safe to say that the CPS is the one technology that could give the most considerable advantage to a firm, but is also a serious investment of both capital and tenacity and a real willingness to the introduction. (31)

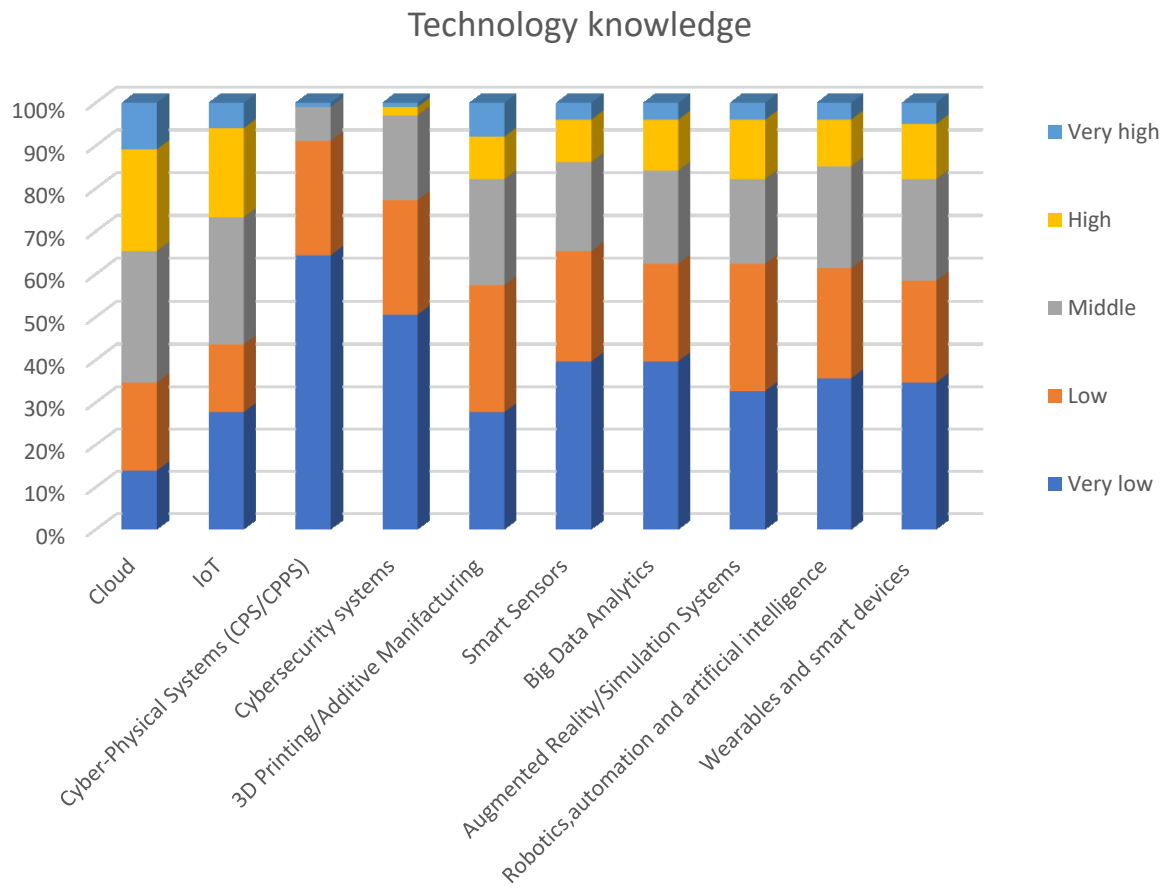

Figure 3.8

Regarding the awareness of the existence of loans and incentives for the implementation of this technology, about the 17% gave a positive answer, the most known is Horizon 2020. It is an European program for research and innovation, and it aims to develop technology and science to stimulate the economic growth of the continent. For seven years they provided 80

billion of euros to sustain scientific excellence and innovative firms and improve their competitiveness in order to create a new workplace, better lifestyle standards and gain for the community. (32)

Another initiative that is well-known is the “Iper e Super ammortamento” which is sponsored by the Government, from the Minister of economic development, and supports the firms that invest in new technologies that have to do with both materials and not (like software). Some other initiatives were mentioned both regional and national like the Smart&Start, I4MS, Startup Innovative 2017, the national plan for the Industry 4.0.

3.2.3 Level of implementation of the paradigm

Roland Berger Strategy Consultants maps report the progress of application of the new model, up until 2014, of the EU Member States regarding “ industrial excellence” (process sophistication, the degree of automation,…) and “value networks” (value added, openness,…) (33) . Using these, they create four categories for the EU Countries: “The Front Runner”, “The Potentialists”, “The Traditionalists” and “The Hesitators” (Attachment 2). Italy was positioned in the last category because apparently, it does not consider having a reliable industrial base and the presence of continuous economic problems penalise the future-orientation. (30)

To better understand the level of implementation firstly we analyse what is the point of view of the companies. It was asked to answer to the question “Given this list of requirements what the actual level of importance is today for the demand of your company?”. The scale used is the following: High importance, Important, Important on average, Low importance, Not important, Not Applicable. To the analysis was given a score from 0 (Not important) to 5 (High importance) to understand the global behaviour better. For each requirement, the percentage was considered only of the significant answers. The Not Applicable responses were considered separately.

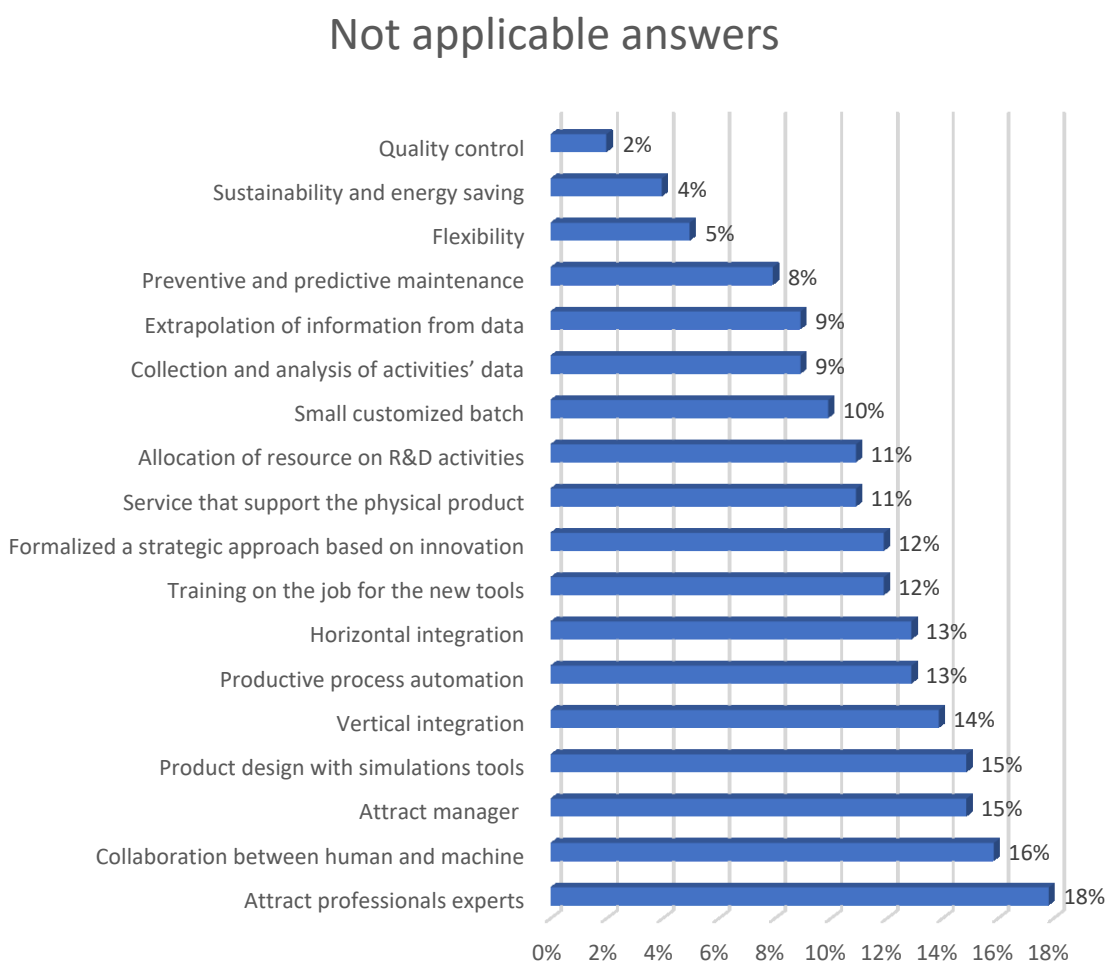

Figure 3.9

The 18% of the firms interviewed believe that the attraction of experts of innovation is not applicable to their activity (Figure 3.9). By looking at the requirements that look not suitable for the business of the sample, it seems that the introduction of the new value and the interaction between the human and machine is not very appealing. Due to the representation of various sector and different kind of firm, not all the target proposed are suitable for their activities.

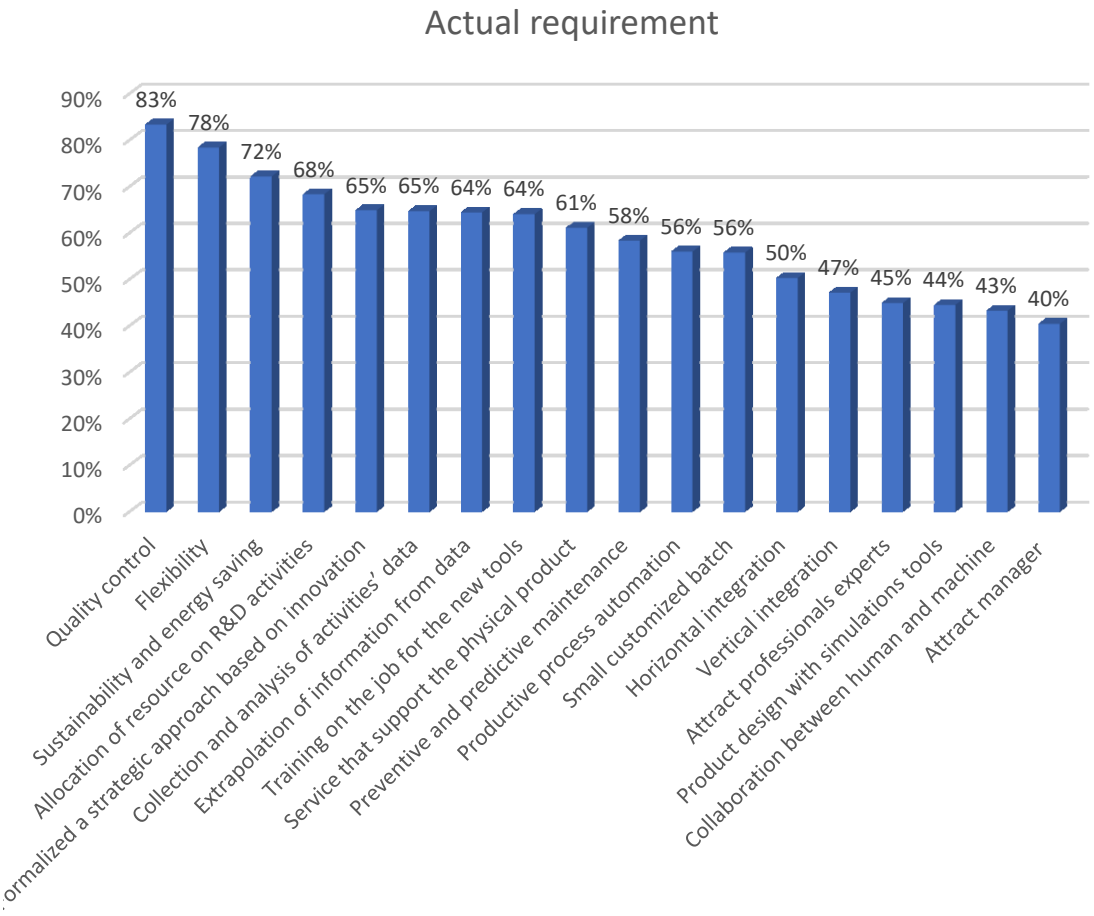

Figure 3.10

Aggregating the value of interest (Figure 3.10), the result is that the most important requirement is quality control, in general, the SMEs must produce something that is valuable to catch their customer's slice. The second most essential requirements are sustainability and energy saving. As presented earlier, another option to fire the competition in the market would be to have lower; sustainability could create added-value especially in this historical period; and flexibility. The life of the SMEs is more unstable than the one of large enterprises, being flexible means to be able to avoid great loss and exploit grain period.

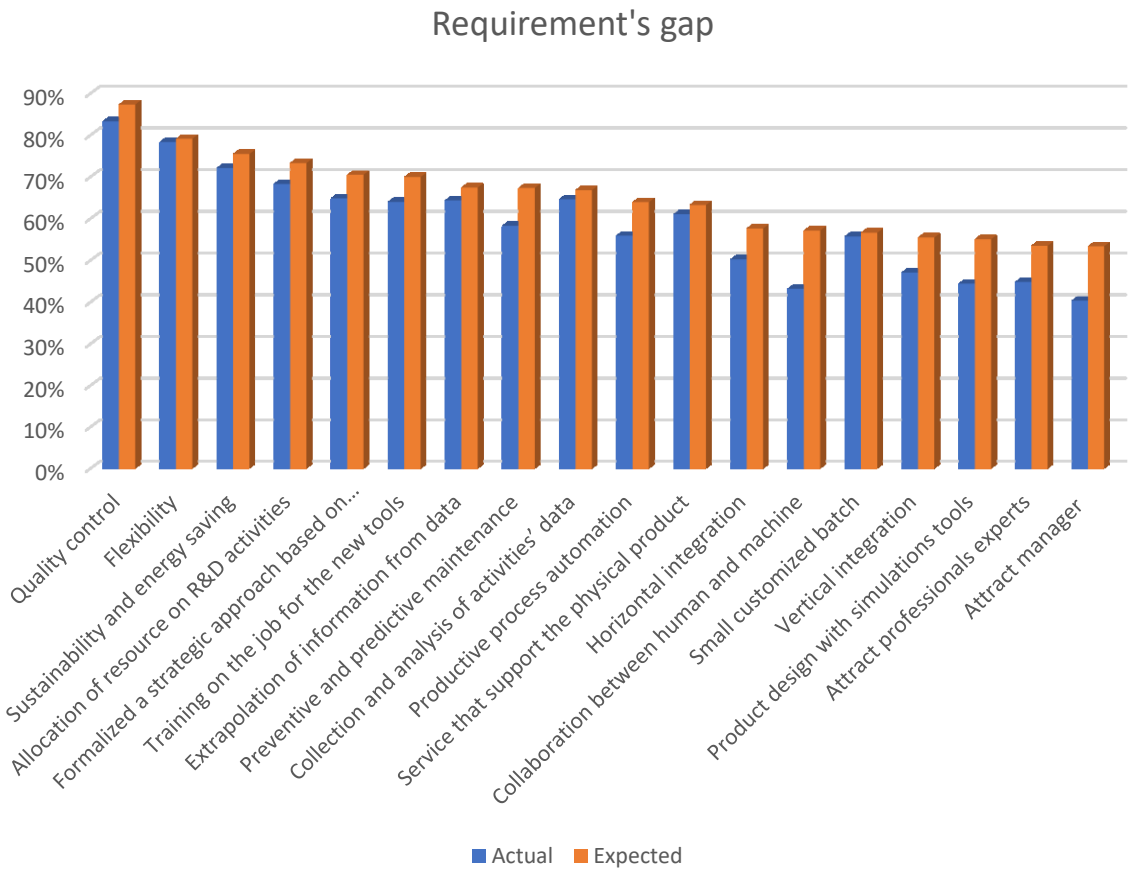

Figure 3.11

The following question was about the same requirements but more focused on the impact that they will have in the near future, the next five years. In general, the importance of the requirements does not change a lot in the future prospective (Figure 3.11). The The collaboration between human and machine has increased by 14%. Similarly, the attraction of manager and the product design with simulation has risen about the 10%. It seems that the revolution is interesting to the interviewed, since they are aware of the imminent change of the production system, in a future prospective the overall level of requirements is above the 50%. In Italy the great presence of SMEs gives the Country a different landscape to manage as opposed to the rest of Europe, it does not necessarily mean a slower adaptation as is shown from the graphic, but the situation is still in development.

After the explanation of each technology, we asked about its level of effective implementation (Figure 3.12). The most implemented is the Cloud with a percentage of 34%, the others are around 7% on the average making exception for the Simulation System, with the 1% and the CPS shows no results of usage. In general, the propensity to have a plan to adopt

the tools is about 10% for all technology and the level of interest is circa 26%. More than half of the firms interviewed confirms not to be interested in the implementation of all the technology making exception for the Cloud. It could be difficult to see the advantage of this modern technology especially if the firms that do not know them, the accessibility of this technology is not so easy and also the applicability in some kind of business, thanks to the universities and the government their knowledge of it is becoming more spread.

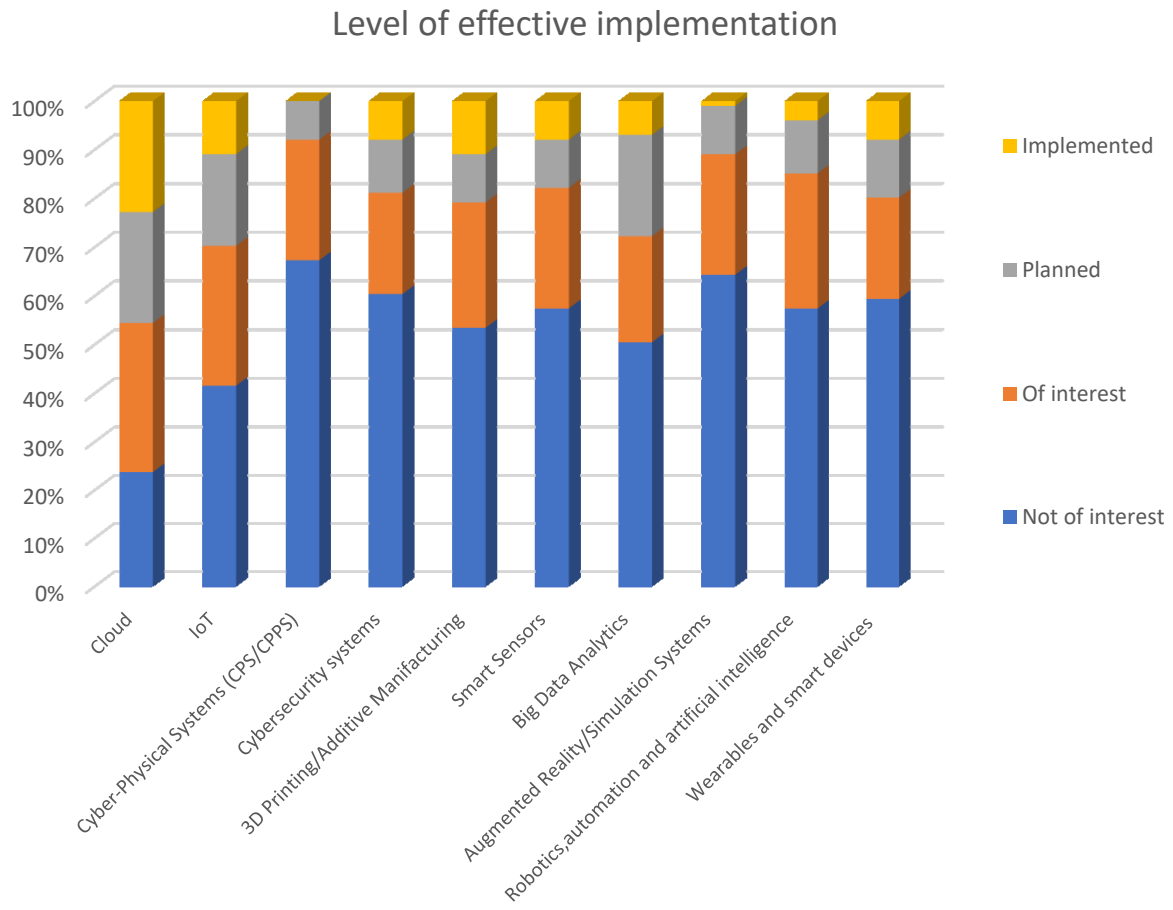

Figure 3.12

To analyse the willingness to adopt the new technology we used a scoring scale ranging from 1 (Very low) to 5 (Very high), again, with the possibility to reply "Not applicable" and the percentage does not consider this sample for the calculous (Figure 3.13). The technologies that are less applicable are CPS and 3D printing. As it was also shown from the previous analysis, it appears that technology is not the core focus of some of the firms interviewed in fact the Cloud and the Iot seems to be more applicable options because they can also be used as business support for administration, marketing and other non-production activities of the company.

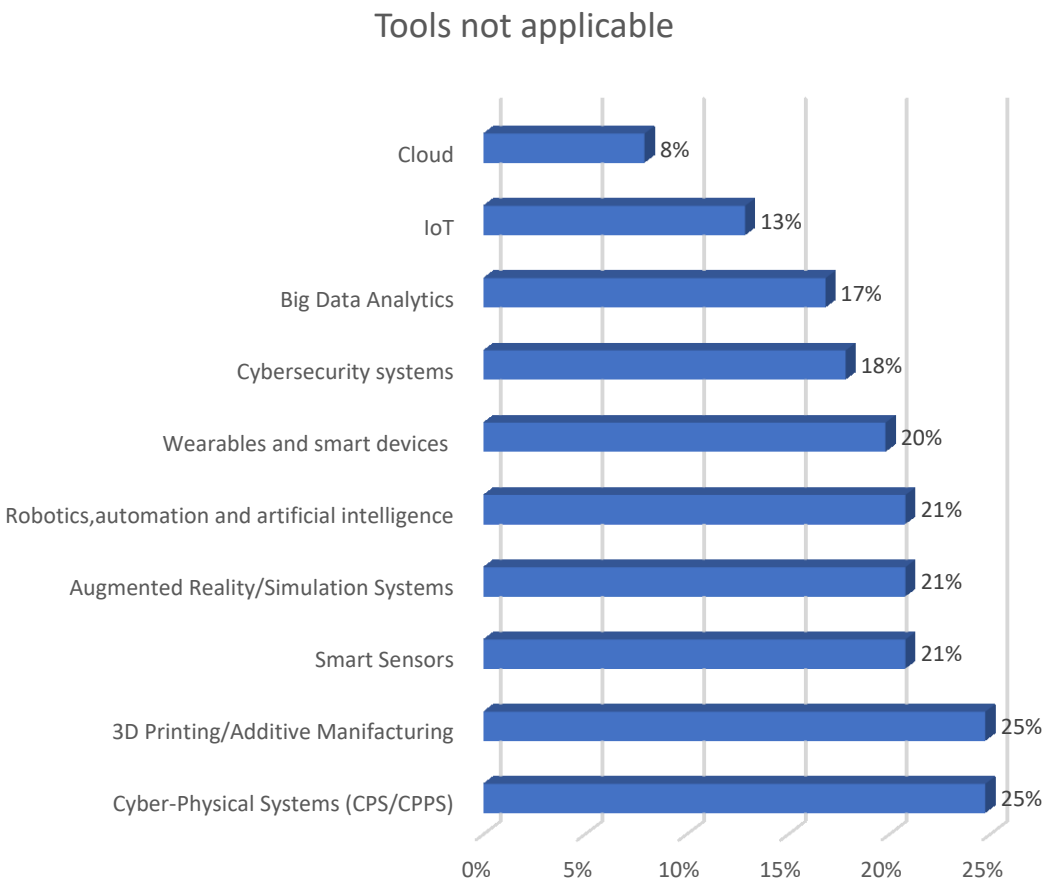

Figure 3.13

From the numerical analysis it appears that, on average, the willingness to adapt the modern technologies is between medium and low. Although we shall point (Figure 3.14) that for future perspectives, the CPS and Augmented reality are the less appealing ones. Especially the CPS has shown the lowest percentage of interest, in the analysis of acceptance gain a lot of preferences.

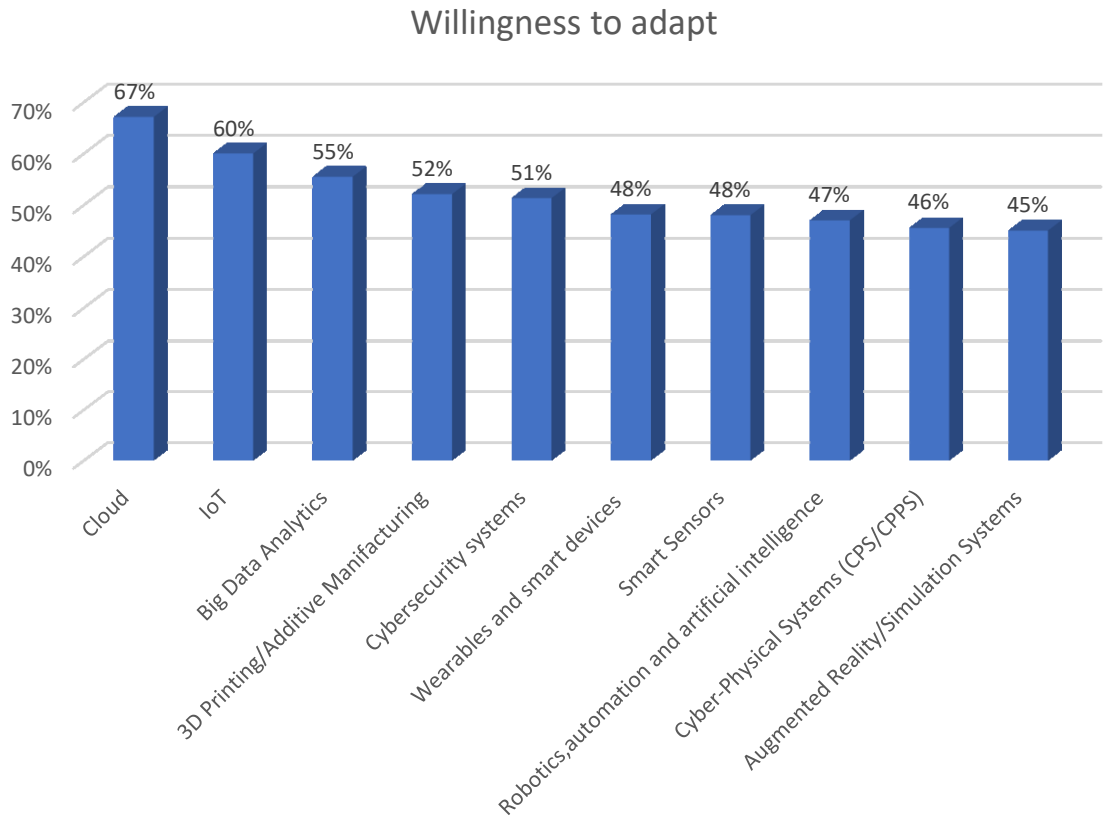

Figure 3.14

Going forward in the analysis we were concerned with what are the expected benefit of implementation of the innovations and the ones used (Figure 3.15). The first three most important things are efficiency, high quality and the productivity. The quality is significant for this kind of firm considering they cannot base their success on mass production; the impossibility of taking advantage of the so-called economy of scale pushes the companies to try to be as efficient as possible. Moreover, the data sharing/information exchange and the transparency obtain value significantly lower than efficiency that means a focus in great efficiency of the product not of the process. The implementation of these factors could increase the process efficiency but it look likes that the process is not the focus of these firms. Two of the firms interviewed affirm that these new technologies do not create any sort of benefit for their firms.

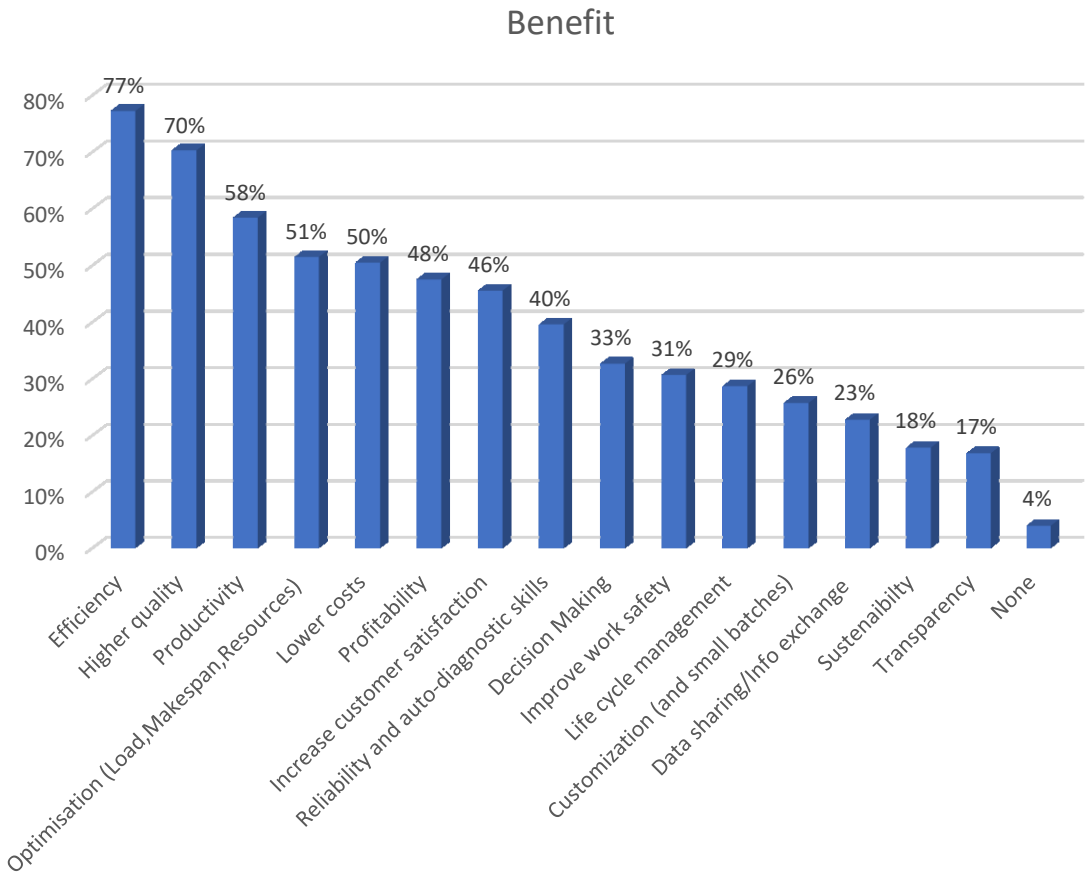

Figure 3.15

On the other hand, (Figure 3.16) cost is the most significant issue when thinking of introducing innovative technologies. Many studies show that cost reduction becomes a benefit in the long run, but the initial investment scares off same firms. The impossibility of evaluating the benefits is one of the new issues that raises from the survey. Overall, the real challenge for SMEs is to develop the right strategy that takes into account the cost-benefit of the implementation (31). Figure 3.10 clearly shows the lack of requirement to attract operational and managerial expert which is one of the reasons. Also, the training of experts is seen as a challenge for the firms. The unemployment was the less worrying element firms; probably this factor must not be analysed from the owner point of view but more from that of the employees.

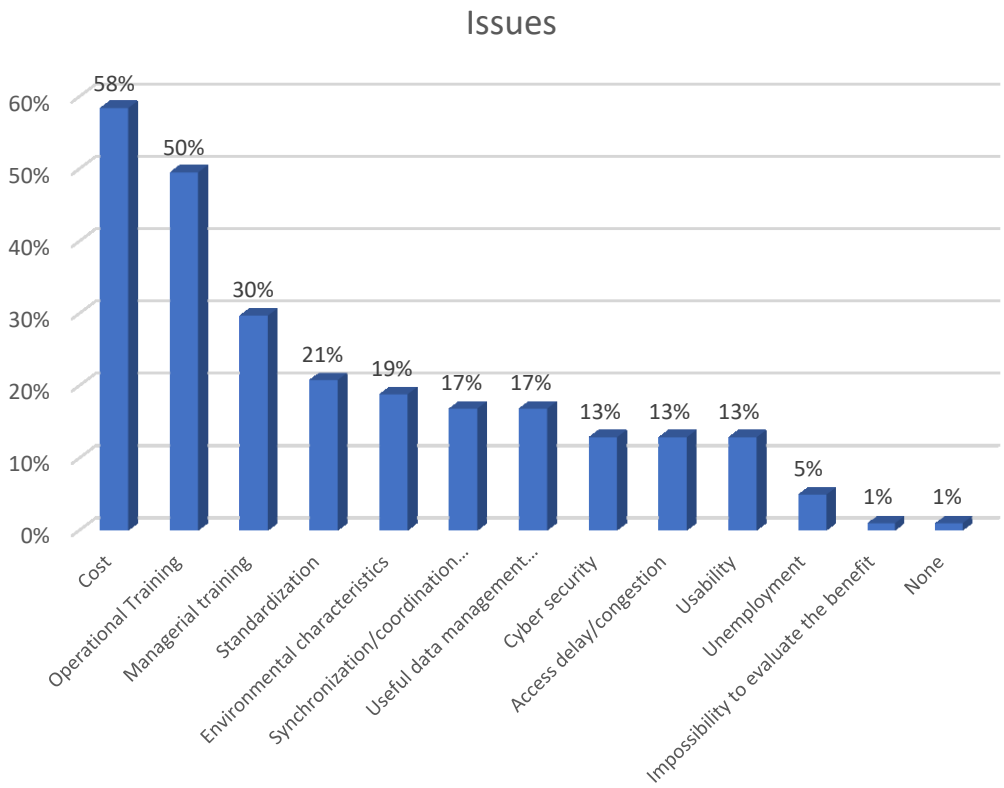

Figure 3.16

The 30% of the firms interviewed does not have any plan or strategic approach for the introduction innovation in their work activities. The remaining 60% has at least few activities planned but only 10% answered “many”. It will be interesting to repeat this questionnaire in the following years to assess the progress regarding new technologies and Industry 4.0 in particular as we firmly believe that changes will happen thanks to the huge effort that the Italian government is putting into this cause. A plan for 2017-2020 is in motion, and it aims to

incentivise the investment in the new technologies, promote the private R&D and to support innovation in start-ups and SMEs (34).

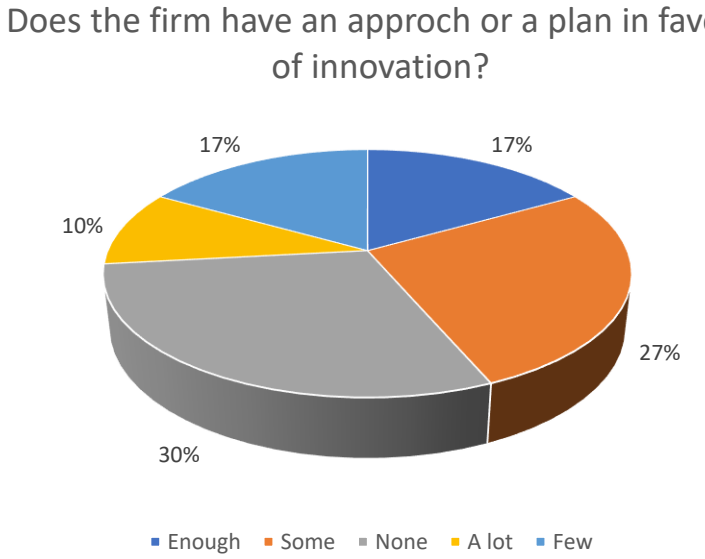

Figure 3.17

The last question of this section is about who manage the innovation projects in the firms (Figure 3.18): for the most prominent part internal staff manages them. Only 4% percent is given to external consultant, and 28% is a combination of both internal and external subjects. This is the number for now, but they must increase in order to have a significant perspective of development, as it has been shown that the firms' level of knowledge about the new technologies is very low, so it is necessary to invest in employees' training and professional growth or ask for an external contribution.

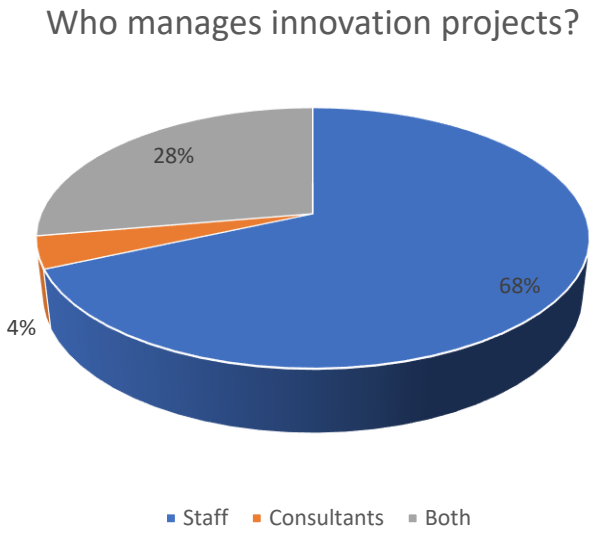

Figure 3.18

4 Conclusion

It is safe to say, following a thorough analysis that the idea of full automation and of technologically driven development, which are the principles of the Industry 4.0's paradigm, is not really applicable in the SMEs' environment. The own staff of the micro companies is what creates the economic success of the firm, with their decisively experience and knowhow. As a result, the firms could be reluctant to the adoption of the innovative technology and this is especially clear when they raise a number of social issues (35). As for all the revolutions that have occurred throughout the years, this one also will drastically change both the production process and the value chain itself as well as the organization of the firm and the way they work daily. As usual, people have very different perspectives of the outcome: the cons, whom mainly see the future rates of unemployment rise, more employee's surveillance and income insecurity; and the pros, which strongly believe in new quality jobs and the shared benefit between the company and the society. (36)

The SWOT analysis is an interesting tool that allows us to deeply understand the Industry 4.0 market scenario (Figure 4.1). The strengths of the paradigm are essentially the one considered for the analysis of the firm's benefit. The opportunities could be seen from three different prospective: Europe coldly reinforces their position in the global market creating a system of firms with an important competitive advantage; the bond between the countries of the union could help create cross national value chain and, lastly, this new environment could lower the barriers of entry for some SMEs.

Everything come with a price to pay, basing the whole business on technology means being dependent from it and, one could say, that is one of the main setbacks. Now a day, we live in a world where vulnerability is a significant issue due to data breach which happens on a daily basis. Not to mention, nature seems to be rebelling against humanity. As a matter of fact, Industry 4.0 is a worldwide phenomenon than needs to be implemented in a short-period of time and professionally, so to achieve the intended goals. The empowering of the supply chain

could create a control of the large enterprises over the SMEs and tie the destinies of all his components, but has also a huge quantity of benefits. (30)

Obviously, each country must find its own way to adapt the new paradigm depending on their needs. The strategies could differ, depend on several factors, but to catch on it must be customized. The dimension of the firms in the country is only a sub factor, as in all economic microenvironment there are six forces that influence the actors: social and cultural factor, the political situation, the economic situation, the demographic environment, and finally the natural environment and the technological environment. Even so, the fourth revolution is a global phenomenon that is taking place and in spite of all this factors will be implemented at some point.

To conclude this text, in this chapter the critical analysis of the combination of the literary review and the result of the survey it will be presented. The aim of this conclusion is to understand how Industry 4.0 in Italian SMEs is going to be adapted, which as shown above represents 99.9% of the Italian's firm. But also try to understand what are the factors that could influence the trend and shift to the adaptation.

Strengths	**Weaknesses**
• Increased productivity, (resource) efficiency, (global) competitiveness, revenue • Growth in high-skilled and well-paid jobs • Improved customer satisfaction – new markets: increased product customisation and product variety • Production flexibility and control	• High dependence on resilience of technology and networks: small disruptions can have major impacts • Dependence on a range of success factors including standards, coherent framework, labour supply with appropriate skills, investment and R&D • Costs of development and implementation • Potential loss of control over enterprise • Semi-skilled unemployment • Need to import skilled labour and integrate immigrant communities
Opportunities	**Threats**
• Strengthen Europe's position as a global leader in manufacturing (and other industries) • Develop new lead markets for products and services • Counteracting negative EU demographics • Lower entry barriers for some SMEs to participate in new markets, links to new supply chains	• Cybersecurity, intellectual property, data privacy • Workers, SMEs, industries, and national economies lacking the awareness and/or means to adapt to Industry 4.0 and who will consequently fall behind • Vulnerability to and volatility of global value chains • Adoption of Industry 4.0 by foreign competitors neutralising EU initiatives

Figure 4.1 Industry 4.0 – SWOT table (Policy Department A: Economic and Scientific Policy) (30)

In the literary review it was highlighted that the biggest sector of implementation of the Industry 4.0 environment is the ICT. The reason being is that this sector is rapidly growing, mainly because the idea of Smart Cities has become the centre of interest of numerous firms and fields of research. In the survey, 11% of the firms work in this sector which is a relatively high quantity, nonetheless the ICT technology could be applied in a wide variety of businesses since it represents all kinds of technologies that elaborate, send and receive information.

Clearly, the level of technology use is not the same in all kind of firm and the application of some technologies could be costlier than the usual cost of production. Another discriminatory factor is the kind of business the firms work for. On one hand, the industries of food-and-beverage and automotive which allow for a high variety of products can benefit from Industry 4.0 as it would grant them a higher level of flexibility. On the other hand, the businesses that focus more on high-quality as the pharmaceutical and the handcraft are extremely concerned with reducing the error margin in their products. (30)

Although the word about Industry 4.0 paradigm must be widely spread, it is a common belief that too much publicity could raise unrealistic expectation. The reality is that a lot of things must still be defined and if the first full models were expected to appear in 2016, on the large scale, realization will take place no earlier than 2025. In order to achieve this goal a lot of action has to take place to realise a long term strategical plan of implementation. (30)

From a theoretical perspective, the biggest part of the research and the experiments about the new paradigm involve the application of CPS, IoX, smart machine and Big Data Analytics. In contrast, the real application of this technology in the SMEs in Italy is very poor especially for the CPS that is not implemented in any firm. Although, when asking about the willingness to adopt we were please to find that IoX is the second most implemented tool, followed by Big Data Analytics which is the second preference.

When looking at the graph illustrating levels of knowledge of each tool (Figure 3.8) we can easily understand and justify this discrepancy. The CPS is the less known tool and the degree of knowledge is a fundamental variable to consider as it directly influences the willingness of manufacturers to adopt the new technology as well as their perception about the relevance or irrelevance, advantages and disadvantages of the new environment. (30)

The advantage of the Digital Twin is not sufficiently known in the SMEs, probably due to the lack of competence in the firms. The IT environment in this kind of firms is often fractionally implemented, but in a context of digitalization and data managing it is becoming

more and more significant, SMEs have to familiarize with the technology, the implementation effort and advantage that could arise from this technology, like for example flexible, easy to use, scalability and service oriented digitization (37). The CPS are of their infancy, and to make the fourth industrial revolution the new reality we firstly have to address the several challenges and gaps. (38)

Majority of SMEs does not have a manager that looks ahead, beyond the regular production and product, investing in the wrong technology could surely imply a loss of money and so they tend to avoid the risk. They do not want to be the first adopters of the recent technologies because is not the safe route. The key concept that they should take into consideration is that firms need to be fully trained in the demanding technology and they need to look for skilled professional in order to be competitive in this globalized environment. (39)

In the literary review, the most important benefits and advantages addressed for the implementation of Industry 4.0 are efficiency, real time control, flexibility and data sharing. All these beneficial components aim to improve the production process. In the survey there was a consistent focus on the product, the principal requirement is quality, followed by flexibility and energy saving, at the last position the attraction of new professional figures. As mentioned above, the lack of a professional figure is one of the most significant problem of the SMEs and this is probably the explanation to why, in the survey, many firms have clearly stated that the new technologies are not applicable to their business.

Again, when analysing all benefits, efficiency, quality and productivity are on the top of the list despite transparency, sustainability and information exchange. These elements are the ones to look forward to when integrating the supply chain in which firms are bounded with each other. As it was shown, the firms are not so integrated in the supply chain, because one of the most important characteristic of SMEs is their independence but this behaviour could create a prohibitive entry barrier for a market that is in digital transformation (30).

The literary review highlights how much of a problem missing a strong integrated supply chain is, in fact in the collection of the issues were identified as a problem the synchronization, the useful data management and the standardization. On the other side the opinion of Italian SMEs raises three different kind of issues more focused on self-implementation which are cost and the training of manager and employees. Both issue raised are truly an issue of the new paradigm.

The policy department of Economic and Scientific policy of the European Parliament has found six obstacles to the participation of SMEs to the Industry 4.0 supply chain:

1) *Lack of awareness*, both about innovative technologies and their benefit in the production;
2) *Ability* to invest in research and new technologies and consequently of management ability to finance this kind of investment;
3) *Lack of capacity to run a pilot project*;
4) *Attraction of skilled labour ad specialised IT staff* to integrate and use advanced technologies;
5) Big companies could benefit from their test and take advantage *to raising entry barriers*;
6) *Increasing of dependency of SMEs from bigger firms* due to the internationalization of the product.

However, they could overcome this issues with the integration of the existing supply chain and by taking advantage of the experience of big firms and therefore create a more international niche market with a dispersed production system, by embracing technologies that make it easier for the production and help the decentralization of it and by analysing and collecting the data from customer and production that usually remain unutilized (30).

As previously stated, the problem arising from both the analysis could be solved by the mutual implementation of the new techniques. In order to help Italian SMEs in the industrial change, the Italian Ministry of Economic Development is promoting various measures to incentivise investments in innovation, technology and skill development to address the principle of the Industry 4.0.

The program' goal is to turn public investment into fiscal condition that may encourage the private sector to invest in the innovation. The scope of the program is to support research and development as well as to promote the investment in venture capital or in technological tools and pilot projects. In addition, the Ministry would contribute to the growth of skills by creating "I4.0 educational programmes" to increase the knowledge and the awareness about this paradigm, which is important just as much as the investment in innovation tools but, of course, it does not give short-term benefit (40).

To sum up what has been said so far, Industry 4.0 is becoming more and more established in the industrial scene and with it all the changes that it implies. The digitalization

becomes the driver throughout the whole of the value chain, but many businesses are not prepared for it, especially among the SMEs. There are issues that concern the implementation, such as risk and cost, and problems that will arise after it, such as data security and unemployment. Large firms are more inclined to the Industry 4.0 but the union remains suspicious, in fact there is very little awareness outside the group of the key stakeholders which from the literature analysis appear to be the Government and the large firms. There is a huge demand for digital specialists in order to compensate the great gap of skill that are required to better develop the adjustment due to the new technologies (30).

During the survey the biggest problem that arise is the limited level of knowledge and awareness about the Industry 4.0, more than half of the interviewee had heard about the topic but when we asked about the technological tools the level of knowledge was mostly low. There is a lack of partnership between the educational system and the firms, the increasing of this type of relationship could significantly increase the familiarity of the companies with the modern technology and they could have a better understanding of what are the potential benefits for their business. Despite all the worries, the new paradigm is essentially based on the "quality of human factor", the training and the involvement of human resources in the transit process is what could make the difference between failing and succeeding. (41)

The process of adopting Industry 4.0 must be gradual but as it is required for any evolution process, it will be disruptive on some prospectives, but it will also create new opportunities and standards. Moreover, research shows that there are a number of benefits that come with the new environment and we are not only referring to the product itself, but also to the production process, value chain and continental economies. The analysis performed shows that in Italy the process of changing has somewhat started, there are a lot of gap and difficulties but there are also a lot of positive signals. New firms base their business on Industry 4.0, the consultant companies make research and offer service to help firm with the implementation and the EU with the Government are trying to incentivize the innovation in the country.

As a matter of fact, the role of the EU, the Italian Government and the Regional initiatives is fundamental to lower the entry barriers for the SMEs in the Industry 4.0 market. Sharing the research and creating assistance in terms of money, advice and qualification is a glorious starting point, but when it comes to focusing on technology it is important to help the firm in creating a long term strategy based on their own economic realities and create a new business paradigm that will imply potential benefits as well as new challenges for the firms (30).

Following to the institutional program, it would be interesting to repeat the analysis in a couple of years to compare the result and evaluate the effect of all the initiative that started during these years. Although, we must keep in mind that the survey mainly took into consideration some of the firms located in Emilia Romagna, so it would be interesting to extend the survey to a greater number of firms all around Italy and see if there is a difference in the perception of the new industrial revolution, even just to understand if the results are representative for all the country. Another point of improvement could be the integration of all the firms' suggestions to create a much more extended questionnaire and study more aspects of the diffusion of the Industry 4.0.

6 Attachments

6.1 Attachment 1

Questionario Industria 4.0

POLITECNICO DI TORINO

Questionario Industria 4.0

Il presente questionario si inserisce all'interno delle attività del Centro ICT for City Logistics and Enterprises (ICE). ICE mira a farsi promotore di azioni di ricerca (sia pura sia applicata) per la creazione di soluzioni ICT-based per la gestione della città, focalizzandosi in particolare sull'integrazione delle attività industriali nella e per la città e nella progettazione di sistemi intelligenti per la gestione del traffico merci e persone.

Il questionario mira ad identificare il livello di maturità del paradigma Industria 4.0 nelle imprese italiane.

Esso è composto da 5 sezioni:

1. Identificazione dell'Azienda rispondente;
2. Livello di conoscenza dei concetti afferenti al paradigma Industria 4.0;
3. Livello effettivo di implementazione dei concetti di Industria 4.0 in Azienda;
4. Suggerimenti e spunti al fine di migliorare le indagini future;
5. Recapiti dell'Azienda rispondente nel caso si desiderasse essere ricontattati per ulteriori indagini o per la condivisione di informazioni.

Il contributo della Sua Azienda è fondamentale per comprendere se Industria 4.0 sia realmente conosciuta in Italia, se siano già stati mossi i primi passi in questa direzione o se siano state riscontrate difficoltà nella sua implementazione e se i benefici attesi ed un generale clima di fiducia ed ottimismo superino le perplessità e le minacce potenziali insite nei grandi cambiamenti che il paradima propone.

Ci sono 28 domande all'interno di questa indagine.

INFORMAZIONI AZIENDA RISPONDENTE

1 [1]Nome dell' Azienda rispondente: *

Scrivi le tue risposte qui:

2 [2]Posizione del rispondente nell'organigramma aziendale: *

Scrivi le tue risposte qui:

3 [3]Settore di appartenenza dell'Azienda: *

Scegli **solo una** delle seguenti:

- ○ Edilizia
- ○ Consulenza
- ○ Elettronica
- ○ Education and Entertainment
- ○ Utilities (energia, gas, acqua)
- ○ Automotive
- ○ Logistica, trasporti e stoccaggio
- ○ Metalmeccanico
- ○ Farmaceutico, sanitario, bio-tech
- ○ Chimica e materiali
- ○ ICT
- ○ Tessile
- ○ Food and Beverage
- ○ Commercio e finanza
- ○ Altro

4 [4]Dimensione aziendale (numero di dipendenti) : *

Scegli **solo una** delle seguenti:

- ○ ≤10
- ○ >10÷≤50
- ○ >50÷≤250
- ○ >250

5 [5]Mercati serviti: *

Scegli **solo una** delle seguenti:

- ○ Nazionali
- ○ Internazionali

6 [6]Anno di fondazione: *

Scrivi le tue risposte qui:

7 [7]Fatturato (espresso in milioni di euro): *

Scegli **solo una** delle seguenti:

- ◯ ≤0,5
- ◯ >0,5÷≤2
- ◯ >2÷≤10
- ◯ >10÷≤50
- ◯ >50

8 [8]Grado di integrazione della filiera: *

Scegli la risposta appropriata per ciascun item:

	Sì	Non so	No
Esiste un fornitore principale?	◯	◯	◯
Esiste un cliente principale?	◯	◯	◯

9 [8.a]

Quante materie prime, semilavorati, componenti in % dipendono da questo fornitore chiave?

*

Rispondi solo se le seguenti condizioni sono rispettate:
° ((**8_SQ001.NAOK** == "Y"))

Scegli **solo una** delle seguenti:

- ◯ ≤25%
- ◯ >25%÷≤50%
- ◯ >50%÷≤75%
- ◯ >75%÷≤100%

10 [8.b]

All'incirca quanta % del fatturato dipende da questo cliente chiave?

*

Rispondi solo se le seguenti condizioni sono rispettate:
° ((**8_SQ002.NAOK** == "Y"))

Scegli **solo una** delle seguenti:

- ◯ ≤25%
- ◯ >25%÷≤50%
- ◯ >50%÷≤75%
- ◯ >75%÷≤100%

11 [9]

L'azienda ha mai partecipato ad iniziative sullo sviluppo tecnologico ed innovazione (quali bandi, progetti, finanziamenti ecc.)?

*

Scegli **solo una** delle seguenti:

- ○ Sì
- ○ No
- ○ Non so

12 [9.a]Che tipo di bandi? *

Rispondi solo se le seguenti condizioni sono rispettate:
° ((**9.NAOK** == "A1"))

Scegli **solo una** delle seguenti:

- ○ Regionali
- ○ Ministeriali
- ○ Europei
- ○ Altro

LIVELLO DI CONOSCENZA

13 [1]Ha mai sentito parlare di Industria 4.0? *

Scegli **solo una** delle seguenti:

- ○ Si
- ○ No

14 [1.a]Dove ne ha sentito parlare? *

Rispondi solo se le seguenti condizioni sono rispettate:
° ((**1.NAOK** == "A1"))

Scegli **solo una** delle seguenti:

- ○ Riviste scientifiche
- ○ Seminari/conferenze/fiere
- ○ Passaparola di settore
- ○ Web
- ○ Non ricordo
- ○ Altro [ ]

15 [2]Indichi per ciascuna delle seguenti tecnologie il suo livello di conoscenza: *

Scegli la risposta appropriata per ciascun item:

	Molto basso	Basso	Medio	Alto	Molto alto
Cloud	○	○	○	○	○
Internet of Things	○	○	○	○	○
Sistemi Ciberfisici (CPS,Cyberphysical Systems)	○	○	○	○	○
Sistemi di sicurezza cibernetica (Cybersecurity Systems)	○	○	○	○	○
Stampa 3D, Additive Manufacturing	○	○	○	○	○
Sensori smart	○	○	○	○	○
Big Data Analytics	○	○	○	○	○
Realtà virtuale	○	○	○	○	○
Robotica e intelligenza artificiale	○	○	○	○	○
Wearable e dispositivi smart	○	○	○	○	○

16 [3]È a conoscenza di bandi/finanziamenti rogati da enti/fondi a favore dello sviluppo tecnologico e dell'implementazione delle tecnologie coerenti con il paradigma di Industria 4.0? *

Scegli **solo una** delle seguenti:

- ○ Sì
- ○ No

17 [3.a]Di quali è a conoscenza? *

Rispondi solo se le seguenti condizioni sono rispettate:
° ((**3.NAOK** == "A1"))

Scrivi le tue risposte qui:

IMPLEMENTAZIONE EFFETTIVA CONCETTI DI INDUSTRIA 4.0

18 [1]Indichi dalla seguente lista di esigenze qual è il livello attuale di importanza che ciascuna esigenza riveste oggi per la Sua impresa: *

Scegli la risposta appropriata per ciascun item:

	Per nulla importante	Poco importante	Mediamente importante	Importante	Molto importante	NA
Controllo qualità dei prodotti	○	○	○	○	○	○
Manutenzione preventiva e predittiva	○	○	○	○	○	○
Collaborazione uomo-macchina/uomo-robot	○	○	○	○	○	○
Automatizzazione dei processi produttivi	○	○	○	○	○	○
Sostenibilità ambientale e risparmio energetico	○	○	○	○	○	○
Formazione sul campo dei dipendenti su utilizzo e gestione dei nuovi strumenti digitali	○	○	○	○	○	○
Attrarre risorse esperte di meccatronica integrante meccanica,elettronica,informatica e controlli automatici	○	○	○	○	○	○
Attrarre manager per governare innovazione e digitalizzazione	○	○	○	○	○	○
Raccolta e analisi di dati sulle attività in essere	○	○	○	○	○	○
Estrapolazione di informazioni dai dati	○	○	○	○	○	○
Integrazione orizzontale (cioè espansione delle attività dell'impresa a prodotti,processi,know-how affini alla filiera già esistente) tramite protocolli standard di comunicazione	○	○	○	○	○	○
Integrazione verticale (cioè internalizzazione delle fasi a monte/a valle della filiera in cui già opera l'impresa) tramite protocolli standard di comunicazione	○	○	○	○	○	○
Progettazione dei prodotti assistita da calcolatore/strumenti di simulazione	○	○	○	○	○	○
Produzione di piccoli lotti fortemente customizzati	○	○	○	○	○	○
Flessibilità organizzativa e predisposizione al cambiamento	○	○	○	○	○	○
Offerta di servizi in supporto ai prodotti fisici	○	○	○	○	○	○
Allocazione di risorse ad attività di ricerca e sviluppo	○	○	○	○	○	○
Formalizzazione di un approccio strategico per incentivare l'innovazione	○	○	○	○	○	○

NA: Non Applicabile alla propria Azienda

19 [2]Indichi dalla seguente lista di esigenze qual è il livello <u>atteso</u> di importanza che ciascuna esigenza rivestirà nel <u>futuro prossimo (prossimi 5 anni)</u> per la Sua impresa: *

Scegli la risposta appropriata per ciascun item:

	Per nulla importante	Poco importante	Mediamente importante	Importante	Molto importante	NA
Controllo qualità dei prodotti	○	○	○	○	○	○
Manutenzione preventiva e predittiva	○	○	○	○	○	○
Collaborazione uomo-macchina/uomo-robot	○	○	○	○	○	○
Automatizzazione dei processi produttivi	○	○	○	○	○	○
Sostenibilità ambientale e risparmio energetico	○	○	○	○	○	○
Formazione sul campo dei dipendenti su utilizzo e gestione dei nuovi strumenti digitali	○	○	○	○	○	○
Attrarre risorse esperte di meccatronica integrante meccanica,elettronica,informatica e controlli automatici	○	○	○	○	○	○
Attrarre manager per governare innovazione e digitalizzazione	○	○	○	○	○	○
Raccolta e analisi di dati sulle attività in essere	○	○	○	○	○	○
Estrapolazioni di informazioni dai dati	○	○	○	○	○	○
Integrazione orizzontale (cioè espansione delle attività dell'impresa a prodotti,processi,know-how affini alla filiera già esistente) tramite protocolli standard di comunicazione	○	○	○	○	○	○
Integrazione verticale (cioè internalizzazione delle fasi a monte/a valle della filiera in cui già opera l'impresa) tramite protocolli standard di comunicazione	○	○	○	○	○	○
Progettazione dei prodotti assistita da calcolatore/strumenti di simulazione	○	○	○	○	○	○
Produzione di piccoli lotti fortemente customizzati	○	○	○	○	○	○
Flessibilità organizzativa e propensione al cambiamento	○	○	○	○	○	○
Offerta di servizi in supporto ai prodotti fisici	○	○	○	○	○	○
Allocazione di risorse ad attività di ricerca e sviluppo	○	○	○	○	○	○
Formalizzazione di un approccio strategico per incentivare l'innovazione	○	○	○	○	○	○

NA: Non Applicabile alla propria Azienda

20 [3]Indichi dalla seguente lista di tecnologie il grado di effettiva implementazione di ciascuna di esse, facendo riferimento alla relativa definizione: *

Scegli la risposta appropriata per ciascun item:

	Non di interesse	Di interesse, ma non ancora implementata	È nei piani	Implementata
Cloud	○	○	○	○
Internet of Things	○	○	○	○
Sistemi ciberfisici (Cyber-Physical Systems, CPSs)	○	○	○	○
Sistemi di sicurezza cibernetica (Cybersecurity Systems)	○	○	○	○
Stampa 3D, additive manufacturing	○	○	○	○
Sensori smart	○	○	○	○
Big Data Analytics	○	○	○	○
Realtà virtuale	○	○	○	○
Robotica ed intelligenza artificiale	○	○	○	○
Wearable e dispositivi smart	○	○	○	○

Internet of Things:è un network di prodotti fisici integrati con componenti elettronici, software e sensori capaci di connettersi alla rete, in modo da poter raccogliere e scambiare dati.

I Cyber-Physical Systems sono tecnologie che fondono il mondo fisico con quello virtuale, ossia macchine e componenti fisici connessi e dotati di software e capacità computazionali.

I Cybersecurity Systems sono quelle tecnologie che permettono alle imprese di proteggersi da possibili attacchi cibernetici ai propri sistemi ciberfisici tra cui crittografia e blockchain.

Per stampa 3D si intende la realizzazione di oggetti tridimensionali, mediante produzione additiva, partendo da un modello 3D.

Per Big Data Analytics si intendono quelle tecnologie che permettono la raccolta, il processamento e l'analisi di grandi moli di dati.

La realtà virtuale fa riferimento a quei dispositivi che permettono di generare una realtà simulata e l'interazione in un ambiente virtuale.

I wearable sono dispositivi indossabili dotati di molteplici funzionalità, tra cui si annoverano smartwatch e smart glasses.

21 [4]Indichi il livello di predisposizione all'adozione delle seguenti tecnologie, facendo riferimento alle medesime definizioni della domanda precedente: *

Scegli la risposta appropriata per ciascun item:

	Molto basso	Basso	Medio	Alto	Molto alto	NA
Cloud	○	○	○	○	○	○
Internet of Things	○	○	○	○	○	○
Sistemi ciberfisici (Cyber-Physical Systems, CPSs)	○	○	○	○	○	○
Sistemi di sicurezza cibernetica (Cybersecurity Systems)	○	○	○	○	○	○
Stampa 3D, additive manufacturing	○	○	○	○	○	○
Sensori smart	○	○	○	○	○	○
Big Data Analytics	○	○	○	○	○	○
Realtà virtuale	○	○	○	○	○	○
Robotica ed intelligenza artificiale	○	○	○	○	○	○
Wearable e dispositivi smart	○	○	○	○	○	○

NA: Non Applicabile alla propria Azienda

22 [5]Indichi i benefici attesi dall'implementazione delle tecnologie già in uso e di quelle che si è predisposti ad adottare:

Scegli **tutte** le corrispondenti:

- ☐ Aumento di produttività
- ☐ Aumento di efficienza
- ☐ Aumento della qualità dei prodotti/processi
- ☐ Riduzione delle tempistiche (es. time-to-market,set-up)
- ☐ Aumento di affidabilità dei prodotti/processi
- ☐ Aumento della sicurezza dei lavoratori
- ☐ Riduzione dei costi
- ☐ Aumento dei profitti
- ☐ Livellamento dei carichi energetici e riduzione utilizzo di energia
- ☐ Maggiore soddisfazione dei consumatori
- ☐ Realizzazione di prodotti customizzati in piccoli lotti
- ☐ Aumento della trasparenza nelle attività svolte dai vari attori della filiera
- ☐ Interoperabilità tra i vari attori, sincronizzazione e scambio di informazioni
- ☐ Miglioramento del processo di controllo del ciclo di vita del prodotto
- ☐ Miglioramento del processo decisionale
- ☐ Altro: _____

23 [6]Indichi le difficoltà e le sfide già riscontrate o attese nell'implementazione delle tecnologie precedentemente contrassegnate:

Scegli **tutte** le corrispondenti:

- ☐ Risorse umane non preparate a livello operativo
- ☐ Risorse umane non preparate a livello gestionale/manageriale
- ☐ Spiazzamento/Disoccupazione
- ☐ Sicurezza cibernetica
- ☐ Coordinamento ed interoperabilità con altri attori
- ☐ Standardizzazione dei protocolli di comunicazione
- ☐ Congestione della rete/ritardi nell'accesso alle informazioni
- ☐ Problematiche a livello di ambienti di lavoro non idonei alle nuove tecnologie
- ☐ Costo delle attrezzature
- ☐ Usabilità e problemi di interfaccia uomo-macchina
- ☐ Capacità di interpretare correttamente i dati durante il processo decisionale
- ☐ Altro:

24 [7]Esistono in Azienda un piano di azione per il lancio di nuove attività e un approccio strategico formalizzato al fine di favorire l'innovazione? *

Scegli **solo una** delle seguenti:

- ○ Per nulla
- ○ Pochi
- ○ Qualcuno
- ○ Abbastanza
- ○ Molti

25 [8]Chi si occupa dei progetti di innovazione? *

Scegli **solo una** delle seguenti:

- ○ Personale interno
- ○ Consulenti esterni
- ○ Sia personale interno che consulenti esterni

SUGGERIMENTI

26 [1]C'è qualche aspetto che Lei giudica significativo e che non è stato trattato in questo questionario? *

Scegli **solo una** delle seguenti:

- ◯ Sì
- ◯ No

27 [1.a]Quale/i? *

Rispondi solo se le seguenti condizioni sono rispettate:
° ((**1.NAOK** == "Y"))

Scrivi le tue risposte qui:

RECAPITI

28 [1]Si fornisca un recapito se si desidera essere contattati in futuro per ulteriori indagini o per ricevere i risultati della nostra ricerca:

Scrivi le tue risposte qui:

Grazie per il tempo speso a favore della conoscenza!
1970.01.01 – 01:00

Invia il tuo questionario.
Grazie per aver completato il questionario.

6.2 Attachments 2

The RB Industry 4.0 Readiness Index is a combination of the "industrial excellence" and "value network". The scale used for each criteria was from 1 to 5 where “5” indicate a country that is excellently prepared for the Industry 4.0 paradigm. In the horizontal axis the manufacturing share of the GDP in the traditional industry. (33)

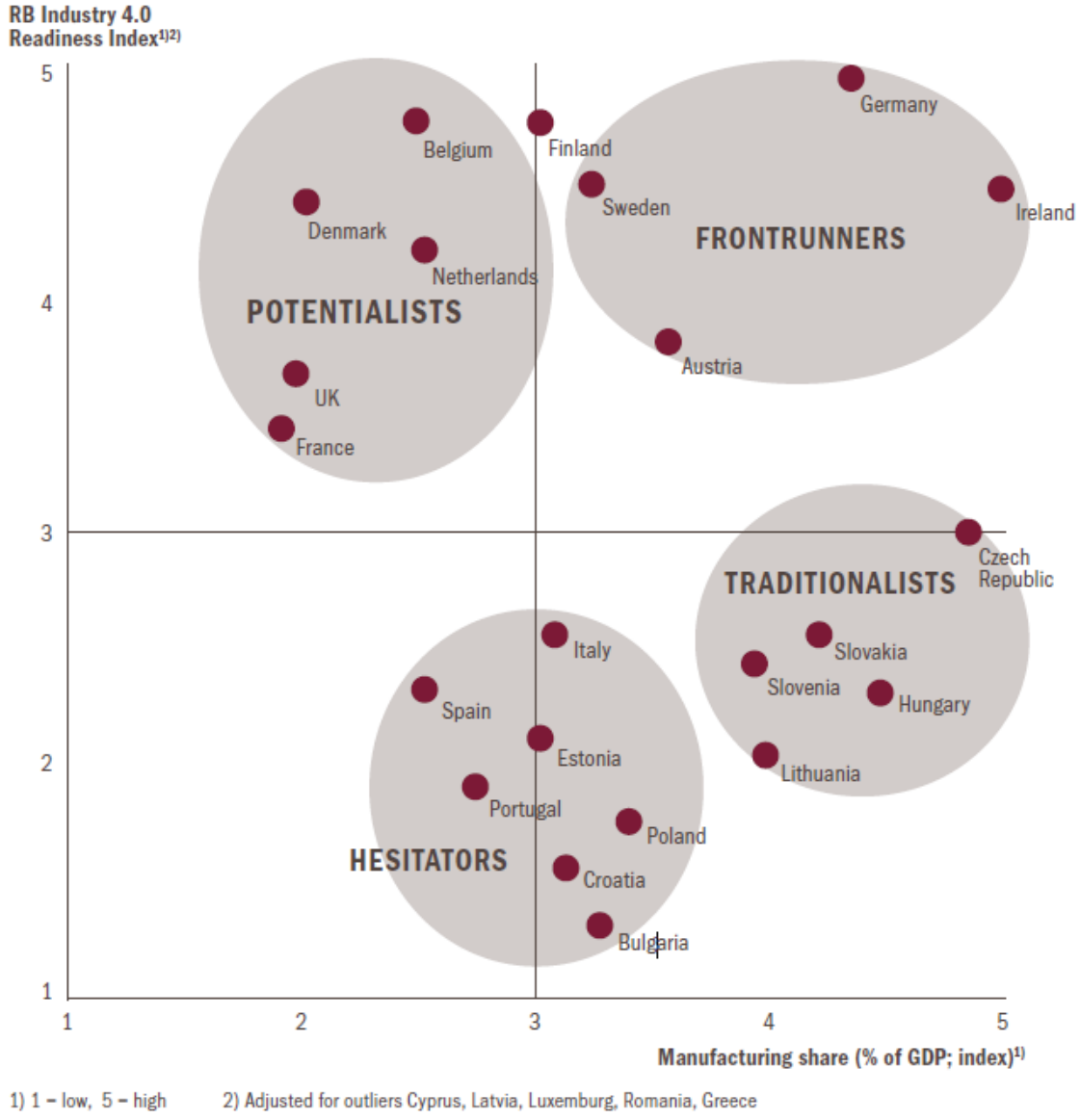

Figure 6.1 THINK ACT INDUSTRY 4.0 The new industrial revolution: How Europe will succeed (Roland Berger Strategy Consultants) (33)

7 Bibliography

1. **Press, Oxford University.** English Oxford Living Dictionaries. [Online] https://en.oxforddictionaries.com/definition/revolution.

2. *A review of the roles of Digital Twin in CPS-based production.* **Negri, Elisa, Fumagalli, Luca and Macchi, Marco.** Modena : s.n., 2017.

3. *THE FOURTH INDUSTRIAL REVOLUTION INDUSTRY 4.0.* **STĂNCIOIU, Alin.** s.l. : Academica Brancusi, 2017.

4. **Enisa.** *Looking into the crystal ball.* 2018.

5. **Martin.** Industry 4.0: Definition, Design Principles, Challenges, and the Future of Employment. *CLEVERISM.* [Online] https://www.cleverism.com/industry-4-0/.

6. **Ward, Susan.** SME Definition (Small to Medium Enterprise). *the balance.* [Online] https://www.thebalance.com/sme-small-to-medium-enterprise-definition-2947962.

7. **OECD.** *Financiling SMEs and Enterpreneurs 2016:An OECD Scoreboard.* Paris : OECD Publishing, 2016.

8. *Cloud Computing.* **Rajaraman, V.** Bangalore : R Ramaswamy, 2014.

9. *Industry 4.0 as a Part of Smart Cities.* **Lom, Michal, Pribyl, Ondrej and Svitek, Miroslav.** Prague : s.n., 2016.

10. **Rouse, Margaret.** WhatIs.com. *TechTarget.* [Online] March 2016. http://whatis.techtarget.com/definition/human-machine-interface-HMI.

11. **RAY, BRIAN.** What is M2M? *Link Labs.* [Online] November 2015. https://www.link-labs.com/blog/what-is-m2m.

12. **Rothlauf, Franz.** Design of Modern Heuristics. Berlin : Springer, 2011.

13. *SIMULATION OPTIMIZATION: METHODS AND APPLICATIONS.* **Carson, Yolanda and Anu, Maria.** Binghamton : s.n.

14. **GDPR Portal. [Online] https://www.eugdpr.org/.**

15. **Raab, Charles and Szekely, Ivan.** Data protection authorities and information. *Computer Law & Security Review.* 2017.

16. **Baskerville, Peter.** What's the difference between a startup and an SME (small medium enterprise)? *Quora.* [Online] September 2015. https://www.quora.com/Whats-the-difference-between-a-startup-and-an-SME-small-medium-enterprise.

17. **Commission, European.** User guide to the SME Definition. *European Commission.* [Online] Febrary 2016. http://ec.europa.eu/regional_policy/sources/conferences/state-aid/sme/smedefinitionguide_en.pdf.

18. Welcome to the 27th International Conference on Flexible Automation and Intelligent Manufacturing. *FAIM 2017.* [Online] **University of Modena and Reggio Emilia.** http://www.faim2017.org/.

19. *Industry 4.0: Intelligent and flexible production.* **Lydon, Bill.** 2016, InTech Magazine .

20. **Bloem, Jaap, et al.** The Fourth Industrial Revolution. *VINT | Vision • Inspiration • Navigation • Trends.*

21. **Fu, Michael C.** Feature Article: Optimization for simulation: Theory vs. Practice. *INFORMS Journal on Computing.* 2002, Vols. 14(3):192-215.

22. **Secondi, Luca.** *Statistica per le ricerche di mercato.* Viterbo : s.n.

23. Laboratorio di tecnologie ICT per la gestione integrata ed intelligente. ***ICELAB.*** [Online] http://www.ice-lab.online/.

24. **European Commission.** *2016 SBA Fact Sheet - Italy.* 2016.

25. **Servizio Statistica e informazione geografica della Regione Emilia-Romagna**. *Analisi territoriali dal Censimento industria, servizi,.* 2011.

26. **Lillo, Nicola**. L'export in Italia cresce più che in Germania, boom in Cina. *La Stampa Economia.* 2017.

27. **Hatani, La**. Integrated Supply Chain Management Practices in the Flow. *The International Journal Of Engineering And Science* . 2017.

28. **Regione Emilia-Romagna**. Programma operativo regionale - Fondo europeo di sviluppo regionale. [Online] http://fesr.regione.emilia-romagna.it/.

29. **Balabio, Barbara**. LA DIGITALIZZAZIONE DELL'INDUSTRIA: ITALIA, WORK IN PROGRESS. *Osservatori.net digital innovation.* [Online] Politecnico di Milano, June 2016. https://www.osservatori.net/it_it/osservatori/executive-briefing/la-digitalizzazione-dell-industria-italia-work-in-progress.

30. **Policy department A: Economic and Scientific policy**. *Industry 4.0.* s.l. : European Union, February 2016.

31. **Schröder, Christian.** The Challenges of Industry 4.0 for Small and Medium-sized Enterprises. *Division for Economic and Social Policy.* 2016 .

32. **European Commission.** *HORIZON 2020 in breve.* 2014.

33. *THINK ACT INDUSTRY 4.0 The new industrial revolution: How Europe will succed.* **Roland Berger Strategy Consultants**. 2014.

34. **Ministero dello sviluppo economico**. *Piano Nazionale Industry 4.0.* Roma : s.n., 2017.

35. **Wulf, Thomas Ludwig · Christoph Kotthaus · Martin Stein · Hartwig Durt · Constanze Kurz · Julian Wenz · Thorsten Doublet · Maximilian Becker ·Volkmar Pipek · Volker**. Working in Industry 4.0 - SME in the Field of Tension of Digital. *HMD Praxis der Wirtschaftsinformatik.* 2016.

36. *Industry 4.0 and representative participation in innovation in manufacturing industries.* **Ramioul, Monique**. Naples : s.n., 2017.

37. *The Digital Twin: Demonstrating the potential of real time data.* **Uhlemanna, Thomas H.-J.**, et al. 2017.

38. *Enabling Connectivity of Cyber-Physical Production Systems: A Conceptual Framework.* **Rojasa, Rafael A.**, et al. Modena : s.n., 2017.

39. *Industry 4.0 Learning Factory for regional SMEs.* **Faller, Clemens and Feldmüller, Dorothee.** 2015.

40. **Demetrius Klitou, Johannes Conrads & Morten Rasmussen, CARSA and Laurent Probst & Bertrand Pedersen, PwC**. *Italy:"Industry 4.0".* s.l. : European Commission, 2017.

41. **Santis, Sabrina De and Monetti, Matteo**. *COUNTRY REPORT Italy.* Rome : FEDERMECCANICA, 2017.

42. **Londra, Ambasciata d'Italia a**. [Online] http://www.amblondra.esteri.it/Ambasciata_Londra/resource/doc/2016/11/industria_4.0_national_plan.pdf.

43. **Alexandre Moeuf, Robert Pellerin, Samir Lamouri, Simon Tamayo-Giraldo, Rodolphe Barbaray**. The industrial management of SMEs in the era of. *International Journal of Production Research.* 2017.

44. **Kotler, Philip and Armstrong, Gary.** *Principles of Marketing.* s.l. : Pearson Education, Inc.,, 2012.