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"FASHION 4.0: AN EMPIRICAL ANALYSIS OF HOW NORTHERN ITALIAN FIRMS COPE WITH INDUSTRY 4.0 TECHNOLOGIES."

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INTRODUCTION

In this document we will present an empirical analysis conducted by a research group of the "Marco Fanno" Department of Economics and Business Science of the University of Padua (DSEA), coordinated by Prof. Eleonora Di Maria and Prof. Marco Bettiol. The research concerns Industry 4.0 and the related technologies.

The first part of the thesis will deeply analyse the historical path towards the ongoing fourth industrial revolution. The main peculiarity of Industry 4.0 regards the massive amount of information created through the interconnection of the technologies adopted, not only in manufacturing process, but also in the R&D function, prototyping, and sale & marketing function.

In the second part we will examine the main national plans carried out by Italy, Germany, USA and China. We will highlight the guidelines scheduled by each Country and lastly we will compare the main aspects of the plans proposed by the governments of these Countries.

In the third and last part, we will report the data analysis, based on a sample of companies geographically located in the North of Italy. The macro-sectors subject to the analysis are apparel-fashion (including apparel, sport goods, and leather goods and shoes), automation / mechanics (including automotive, electric and lighting equipment, and rubber goods), furniture, and other sectors like jewellery and glasses and lens. The first three macro-sectors have been classified following the 4As of the Made in Italy. The research has been conducted through an online survey, composed by 38 questions submitted to the companies by the researchers. The questions investigate different aspects: the non-adoption reasons, the motivations that pushed companies to invest in technologies 4.0, the main difficulties faced during implementation, the customisation level necessary for integrating the technologies, the impact on production and innovation, and, lastly, the results achieved.

The contribute of this thesis to the aggregate research consists in the examination of two specific branches of the apparel-fashion macro-sector: the footwear and the tanning sectors. Throughout the analysis we often compare the aggregate results to those ones of the footwear and tanning sector, whenever discrepancies have been found among them.

CHAPTER ONE

1 THE PATH TOWARDS INDUSTRY 4.0

1.1 Introduction: The Industrial Revolution

It was the 1799 when Louis-Guillaume Otto, a French diplomat, coined the term "Industrial Revolution" (Anderson, 2012), referred to the disruptive change that steam-powered machines brought to the economic and social environment. In particular, the production changed from home-based activity to industrial business, from simple instruments to power-driven machineries. The period in which this revolution took place was from the second half of 18th century to the first half of the 19th century.

The industry, as appears nowadays, namely the great capitalistic industry focused on mass production rather than quality production, based on efficient and technically perfect machines rather than skilled men, is a historically recent phenomenon. Until 18th century, industry did not practically have history. Product manufacturing had been artisanal for centuries: machines usage was sporadic, their basic structure and the driving force used was supplied by man, animals or natural forces. The labour was being held in small mills or more often at home and in the countryside, enterprises were self-employed or family-based, artisanal business was bound by corporations. The industrialisation process began in the second half of the 18th century and it had its origin in the so called "Industrial Revolution", which led to a series of technological, economic and social transformations in Great Britain (since 1760 according to Toynbee), and then spread in other countries during the 19th century. The factors that allowed to Great Britain to be the cradle of industrialisation were several: capital savings, financing development, low interest rates, increasing prices, demand and trade expansion, presence of entrepreneurial skills, raw materials, energy resources and workforce availability, the liberal ideas establishment. Fundamental causes of the phenomenon are the particularly rapid increase of the population and of the production of goods and services, this latter was exceptional in respect with the past trends. The factory system, based on the use of the machine as support or in substitution of human labour, became dominant: workforce was more specialised and gained more mobility. The majority of population abandoned agriculture in order to commit, as workers, to production of goods and services, by grouping in cities, where factories arose. New social classes were born, new human and working relationship were established, new ideas and ideas movements were developed.

1.1.1 Innovation and industrialization

The most salient and evident characteristic of the "Industrial Revolution" was the introduction of a lot of technical innovations that allowed never seen productivity growth. The branches of industry in which the first radical technology transformations occurred, were the cotton and iron ones. After 1700, English cotton industry, traditionally rural, was hit by an increasing demand, previously satisfied by textile imports from India. On one hand, the backwardness of the production systems, and on the other hand, the request to satisfy a larger market, were the reasons that pushed textile industry innovation. The first significant innovation was applied to weaving and was John Kay's fly-shuttle (1733). It overruled around 1760, accelerating operations to such an extent to make even more clear the slowness of weaving. An immediate success was obtained by J. Hargreaves's spinning-jenny and R. Arkwright's water-frame, crucial for the spinning transformation. The former, widely adopted in cottage industry, was a machine that enabled an individual to produce multiple spools of threads simultaneously, whereas the latter, more complex, fostered the work concentration in factories. Cotton industry transformation was completed by two other inventions: S. Crompton's mule-jenny (patented in 1779) and E. Cartwright's power loom (1784). The last innovation that characterized the "Industrial Revolution" was the substitution, in the iron industry, of the hydropower with J. Watt's steam engine.

"In 1712, Englishman T. Newcomen developed the first practical steam engine (which was used primarily to pump water out of mines). By the 1770s, the Scottish inventor J. Watt had improved on Newcomen's work, and the steam engine went on to power machinery, locomotives and ships during the Industrial Revolution. In the early 18th century, Englishman A. Darby discovered a cheaper, easier method to produce cast iron, using a coke-fuelled (as opposed to charcoal-fired) furnace. In the 1850s, the

British engineer H. Bessemer developed the first inexpensive process for mass-producing steel. Both iron and steel became essential materials, used to make everything from appliances, tools and machines, to ships, buildings and infrastructure." (Hystory.com, 2018)

1.1.2 Transportation

During this period, also the transportation industry was improved by innovative technology. Before steam engine, raw materials and finished goods were distributed via horse-drawn wagons, and by boats along canals and rivers. The first commercially successful steamboat was built by the American R. Fulton in 1807, and by the mid-19th century, steamships were carrying freight across the Atlantic.

In February 1804, the first locomotive-hauled railway's journey took place, thanks to the creativity of Richard Trevithick, which built the first high-pressure steam engine, and then built the first full-scale working railway steam locomotive. In 1830, England's Liverpool and Manchester Railway became the first to offer regular, timetabled passenger services. By 1850, Britain had more than 6,000 miles of railroad track.

Lastly, in 1830, a new process for road construction was developed by the Scottish engineer J. McAdam: thanks to this technique, known as macadam, roads were smoother, more durable and less muddy.

1.1.3 Communication and banking

In 1837, two Englishmen, W. Cooke and C. Wheatstone, patented the first commercial electrical telegraph. By 1840, railways were a Cooke-Wheatstone system, and in 1866, a telegraph cable was successfully laid across the Atlantic. Over the period, banks and industrial financiers, along with a factory system dependent on owners and managers, caught on. In the 1770s, a stock exchange was established in London, as well as the New York Stock Exchange in the 1790s.

1.1.4 Quality of life

Economic and social consequences of the "Industrial Revolution" were, from almost one century, subject of study and discussion. Despite they were difficult to quantify, the economic consequences had been mostly positive. Instead, social consequences, in particular those related to workers, were more difficult to evaluate. Worth mentioning were man's enslavement to the machine and the unemployment created by the adoption of them, an extremely burdensome working hours, the continuous peril of injuries and fatal accidents, the shortage of homes caused by a sudden and massive urbanisation. Wages were low and working conditions could be dangerous and monotonous. Additionally, urban, industrialized areas were unable to keep pace with the flow of arriving workers from the countryside, resulting inadequate, overcrowded housing, polluted and unsanitary living conditions in which diseases were rampant. At the same time, from 1750 to 1850, pro capite English GDP increased of twice and a half. It increased the living standard of the majority of the population: in fact, the goods that industrial revolution provided in large quantity, were those predominantly intended for mass consumption, such as imported food (cereals, sugar, tea, coffee) in exchange for those industrial exported. Furthermore, by the later part of the 19th century, Britain's working-class began to gradually improve its living conditions, as the government instituted various labour reforms and workers gained the right to form trade unions.

1.1.5 Industrialization moves beyond Britain

In the first half of the 19th century, Great Britain was the most prosperous nation in the world and the most advanced in the industrial technology. The "Industrial Revolution" took place in other countries (France, Belgium, Netherlands, Germany, United States, etc.) only in 1850. For those countries, shortage of capital, raw materials, workforce and initiative were the primary causes of the delay. Instead, in Italy the main cause was the lack of a political unity. Worth mentioning was the law related to the prohibition of exporting technology and skilled workers that Great Britain enacted; it was useless, as history has taught us. In fact, by the early 20th century, the U.S. became the world's leading industrial nation.

1.2 The Technological Revolution

From 1870 till the beginning of the First World War there was a rapid industrial development that involved US, Britain, Germany, France, Italy and Japan. A very close connection arose among science, technology and industry: production, communication and transport technology revolutionized, new sources of energy were used, concentration and restructuring industrial processes intensified, companies dimension were growing, and the relations between industry and banking system were changing. From 1875 to 1913, worldwide manufacturing production increased by 378% and population by 126%. Below it’s possible to quote some examples of the remarkable number of breakthroughs, as results of the major developments concerning science and technology:

- steel-making process renewal;
- construction of: the first generation plant, the first car, the first combustion engine city bus;
- realisation of: the first film, the first radiography, the first airship, the first airline flight, the first radio broadcast;
- invention of: the first telephone, the first fridge, the first combustion engine, the first light bulb, and Coke;

Scientific research was more geared towards its potential industrial applications; Indeed, inventors such as scientists, technicians and researchers became high specialized professions. Most of them, such as Siemens, Edison, Bayer, Solvay, Dunlop and Bell, became tycoons and embodied the very close link between science and industry.

In this period there was an astonishing expansion of the rail road that allowed people to move easily, however the most relevant developments concerned chemical, electromechanical and steel-making sectors. The chemical sector was fundamental because its progresses were applied to several field: production of paper, glass, soap, colouring agents and synthetic fibres, concrete, explosive, rubber, medicinal products, and many others. The electromechanical sector was revolutionised by electricity and by combustion engine, whereas the steel-making sector by new production techniques (Bessemer method and then Gilchrist-Thomas).

In order to sustain the higher costs and enormous investments of chemical or steel-making facilities, new business property forms and new way of fund raising were fundamental in the more and more structured financial market controlled by banks. The financial and banking institutions channelized clients deposits towards production investments; gradually, they specialized in different branches and aimed to cluster. A strict relationship between industry and banks began, giving birth to a period called “financial capitalism”, underlying the fact that the financial capital guides and rules economy. The needs of reducing the risks of costly investments, limiting a greater competition and setting a stronger control over the market strengthened the trend of firms’ concentration (horizontal and vertical mergers). In some production sectors these big industrial structures controlled the market, fixing prices and the number of products produced, establishing an oligopoly, and in some cases a monopoly. It was the sunset of the free competition capitalism that characterized a part of the 19th century.

Really important was the production rationalisation: industrial production organisation was hit by relevant innovations aimed at facilitating production flow (using conveyor belts, lifters, freight elevators, etc.) or at increasing work productivity. In 1911 F. W. Taylor published *The principles of scientific management*, whose well-known principle was the “one best way”, based on the breakdown of the production cycle various phases in operations as basic as possible, scientifically measured and planned. This theory was pretty similar to the Fordism. Henry Ford tested it in his car manufacturing industry in Detroit, in 1913 and this new way of producing was centred on the assembly-line, which drastically reduced unitary production time and costs. This new production method widespread across industries and launched an innovative circuit among mass production, mass market and mass consumption, allowing an increase in middle class, and in particular an increase in salaries of million people. (Treccani)

The Second Industrial Revolution was also known as the “Technological Revolution”, but it is also called “Industry 2.0”.

1.3 The Digital Revolution

Post-industrial society was the result of the most recent economic transformation – the so called Third Industrial Revolution – occurred in the second half of the 20th century in the most developed countries. The most significant characteristic of the new era was the primary role of the tertiary sector in the economy, namely of services: transport, school, healthcare, bank, culture and free time. Already in 1956 the number of employees, technicians, managers, professionals overcame that of workers in the U.S. In 1995 the tertiary sector occupied more than 70% of the work force. With the old assembly-line the products were standardized, whereas the modern technologies allow a diversified and flexible production, capable of satisfying the different preferences of a customer more and more demanding. Besides differently from the past different capabilities and skills are requested to the workers: firms require more and more specialized workers, such as researchers, engineers, technicians, managers, namely very qualified employees.

Knowledge, competences and design and innovation capabilities acquired more and more relevance in the post-industrial economy. Also workplace changed: old facilities left the place to laboratories, research centres, schools, universities, free time structures. Industries changed their organization: they did not produce internally anymore, in the huge facilities where thousands of workers were employed, but tended to outsource part of the production to third companies. These latter are more flexible and suitable to a variable and ever-changing production. So, a network-based business model established, made by several firms coordinated by a single leader. It is also important to specify that the traditional industrial system did not disappear, it was relocated in developing countries, where employees' salaries are still very low. Often, firms of the most powerful countries, multinationals, have delocalised production facilities where there is cheap labour. This is the so called globalization, another typical characteristic of post-industrial era. (Parmentola, 2006)

From an innovation point of view, in 1970, when microprocessor was invented, a new industrial revolution began. In particular, the term ICT (Information and Communication Technologies) was introduced. It is related to computers and communications' equipment, but also services linked to them. The disruptive fact was the passage from analogue to digital, which allowed a simpler and faster communication of electric devices. The consequences of informatics and electronics in the factory environment, were a faster and better automation level of production and organizational processes. There were obviously also broad social impacts and widespread lifestyle changes. The ‘80s saw the arrival of computer in film production, of robots in industry production and of automated teller machines (ATMs) in banks. In 1991 internet was made available to the public and analog mobile phones were replaced by digital ones. At the beginning of the 21st century, the cell phone became a common device and the high-definition television replaced the analog one. The “boom effect” of these new products made the other ones obsolete and antiquated: the fax machine, typewriters, analog radio, VHS tapes, etc. This was the “Digital Revolution”, which could be renamed as “Industry 3.0”.

1.4 Industry 4.0

Recently, over 6.000 entrepreneurs from 67 countries met in order to present to over 240.000 visitors their products, projects and ideas, in April 2011 at the Hannover Fair. In this edition there were 13 topics, among them industrial automation and digital factory. In this context the term “Industry 4.0” originated, at the beginning just used as an embryonic stage project, but then, in 2012, a team operationally started the project and the “Industry 4.0 Plan” was submitted to the German Federal Government. In 2013 the final report was disclosed at the Hannover Fair and it contained a forecast concerning the investments on schools, industries, infrastructures and energy systems needed to modernise the German production system. Then, this plan was a source of inspiration for many countries.

In the following page the Figure 1 summarizes the four industrial revolutions in a time perspective: the first one was triggered by a revolutionary machinery of the textile industry, the steam-powered loom, designed and built in 1784 by Edmund Cartwright; the second one was pushed by the introduction of electrically-powered mass production, in particular by the first production lines of a Cincinnati slaughterhouse, dating back to 1870; the third one began when the first programmable logic controller (PLC) was built by Bedford Associates in Massachusetts in 1969; the fourth and last one started in 2011 thanks to a futuristic project which included the basis for the modernisation of a country production system, not only considering the industry point of view, but also education, infrastructure and suitable energy systems point of view.

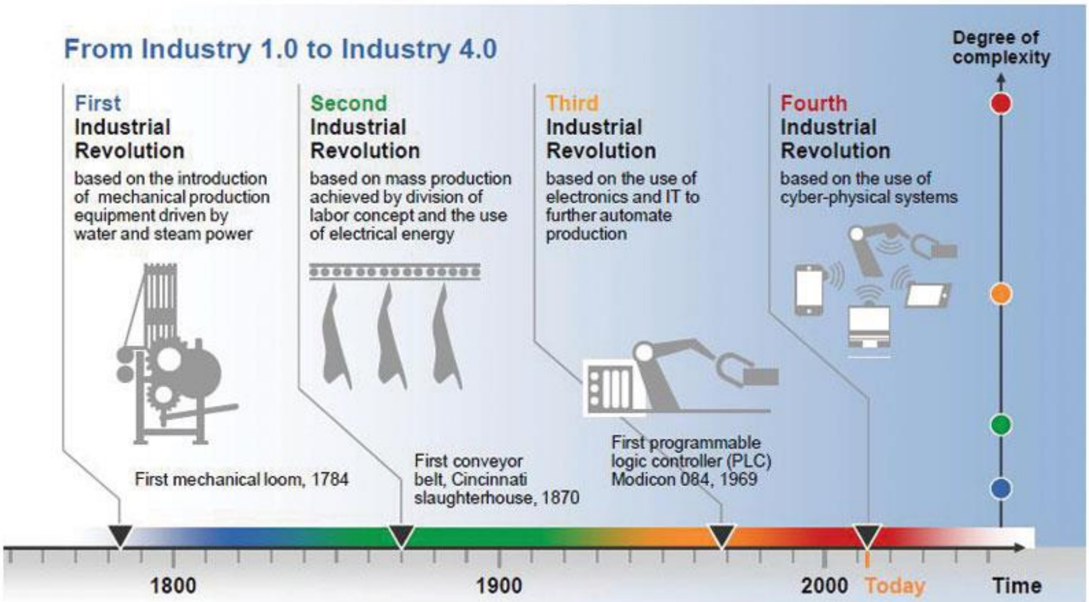


Figure 1.1: From Industry 1.0 to Industry 4.0 (Condor, 2017)

Making a simple calculation, there have been four industrial revolutions in 234 years; the first three approximately 100 years apart, whereas the last one is only 40 years apart from the previous one. Since we are actually living this last industrial revolution, someone could be sceptical about the real consequences of it: will it be a revolutionary innovation or not? Then, it is impossible to answer, in the meantime we must analyse this phenomenon because something is changing, and the result of this change could be impressive.

After this brief historical parenthesis, it is useful to define the concept of Industry 4.0: it is a combination of new technologies, new production factors and new work organisations which are deeply modifying the way of producing and the relationships among economic players, consumers included, with relevant effects on the labour market and on the social organisation. Moreover, this term is linked with many expressions that underline the several shades and heterogeneous characteristics, namely «smart manufacturing», «factory of the future», «industrial internet», and others. (Magone, 2016)

Why should an entrepreneur adopt technologies 4.0? Mainly the reasons behind such investment are: better working condition and improved productivity and quality production of facilities. Two fundamental aspects to reach these goals are automation and interconnection. Automation is given by robotics, control system, monitoring tools and sensors. Interconnection means that production equipment, production lines, facilities, suppliers, customers and products are linked together. The point of junction of these aspects is the human being, which must necessary have specialized skills given by proper education and experience. Hence, ultimately an innovative and high-tech robot requires the human being, either to control it or to fix it.

1.5 Technologies and machineries part of Industry 4.0

What is relevant in this revolution, is the different way in which new and updated technologies and machineries connect and communicate among themselves. In order to understand better how these innovations can improve production efficiency, in term of time-saving and quality-level, exploit production flexibility to customize products and services, collect countless data and draw up reports that works as a feedback for manager at different level, we will highlight the relevant aspects and the possible utilisation of the following technologies: robotics, artificial intelligence (AI), 3D printing and additive manufacturing, laser cutting, big data, the cloud, 3D scanning, augmented and virtual reality (AR and VR), IoT and also social media and marketing.

1.5.1 Robotics

When we hear the term robotics we could think about different types of robot: one-harm robot, two-harm robot, or humanoid robot; basically what we can see during advertising, news on TV or in a TV program where they show the inside of a production facility. However, this theme is more complex than it seems. First of all, we have to define the term "robot" and the International Standard Organization (ISO) provides it.

ISO 8373:2012:

> *"It is an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks. A robot includes the control system and interface of the control system. The classification of robot into industrial robot or service robot is done according to its intended application." (ISO, 2012)*

However, it is useful to focus our attention to robots that are used into production facilities, which are used for arc welding, spot welding, material handling, machine tending and other applications. Below we summarize several robotic application

WELDING ROBOT APPLICATIONS: increase the efficiency of welding processes allowing the firm to produce more parts in less time, while minimizing scrap, increasing quality and improving the working environment. (ABB, Robotic Solutions for Welding Applications, s.d.)

Figure 1.2: ABB Robot IRB 1600ID (ABB, 2018)

- Arc Welding Robots
- Electron Beam Welding Robots
- Flux Cored Welding Robots
- Laser Welding Robots
- MAG Welding Robots
- MIG Welding Robots
- Orbital Welding Robots
- Oxyacetylene Welding Robots
- Plasma Cutting Robots
- Plasma Welding Robots
- Resistance Welding Robots
- Shielded Metal Arc Welding Robots
- Spot Welding Robots
- Submerged Arc Welding Robots
- TIG Welding Robots
- TIP / TIG Welding Robots
- Welding Automation Robots

MATERIAL HANDLING ROBOT APPLICATIONS: increase the efficiency in terms of time-saving, simplest capability of objects transportation, accuracy of movements and unlimited weight capability.

Figure 1.3: Fanuc packaging robot (Pathrotkar, 2018)

- Collaborative Robots
- Dispensing Robots
- Injection Molding Robots
- Machine Loading Robots
- Machine Tending Robots
- Material Handling Robots
- Order Picking Robots
- Packaging Robots
- Palletizing Robots
- Part Transfer Robots
- Pick and Place Robots
- Press Tending Robots
- Vision Robots

OTHER ROBOT APPLICATIONS: complete the utilization of robots in the most disparate fields, from the pharmaceutical to the food processing one.

Figure 1.4: ABB Yumi Robot (ABB, IRB 14000 YUMI, 2018)

- 3D Laser Vision Robots
- Appliance Automation Robots
- Assembly Robots
- Bonding / Sealing Robots
- Cleanroom Robots
- Coating Robots
- Cutting Robots
- Drilling Robots
- Foundry Robots
- Grinding Robots
- Laser Cutting Robots
- Material Removal Robots
- Meat Processing Automation Robots
- Milling Robots
- Paint Robots
- Polishing Robots
- Refueling Robots
- Sanding Robots
- Thermal Spray Robots
- Waterjet Robot

Leaving aside robot applications, there are six main types of industrial robots:

1. Articulated: this robot design features rotary joints and can range from simple two joint structures to 10 or more joints. The arm is connected to the base with a twisting joint. The links in the arm are connected by rotary joints. Each joint is called an axis and provides an additional degree of freedom, or range of motion. Industrial robots commonly have four or six axes.

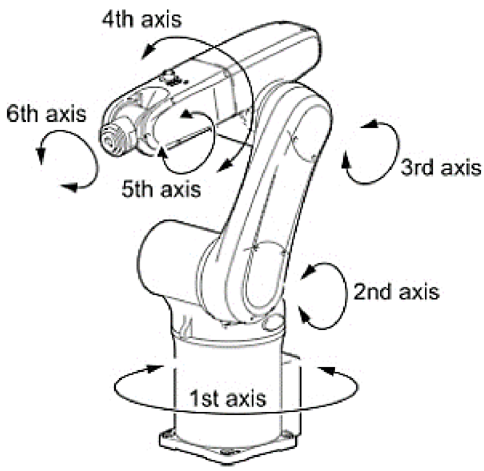


Figure 1.5: An articulated robot with 6 axes (Roboticsbeta, 2017)

2. Cartesian: these are also called rectilinear or gantry robots. Cartesian robots have three linear joints that use the Cartesian coordinate system (X, Y, and Z). They may also have an attached wrist to allow for rotational movement. The three prismatic joints deliver a linear motion along the axis.

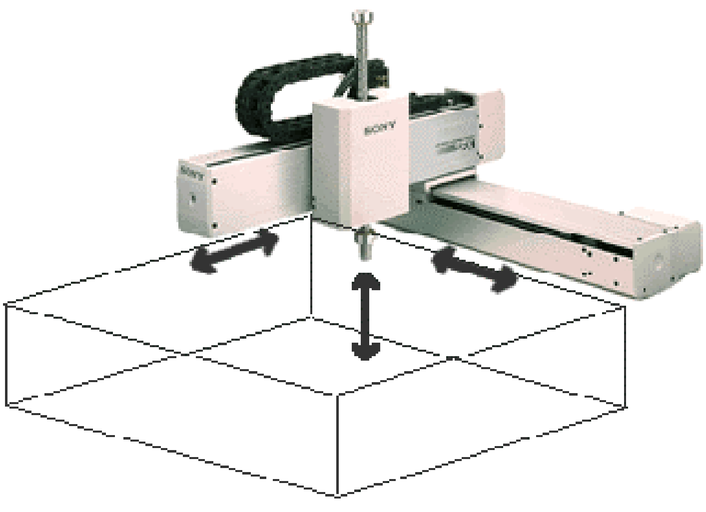


Figure 1.6: Cartesian Robot (Arbotist, 2017)

3. Cylindrical: the robot has at least one rotary joint at the base and at least one prismatic joint to connect the links. The rotary joint uses a rotational motion along the joint axis, while the prismatic joint moves in a linear motion. Cylindrical robots operate within a cylindrical-shaped work envelope.

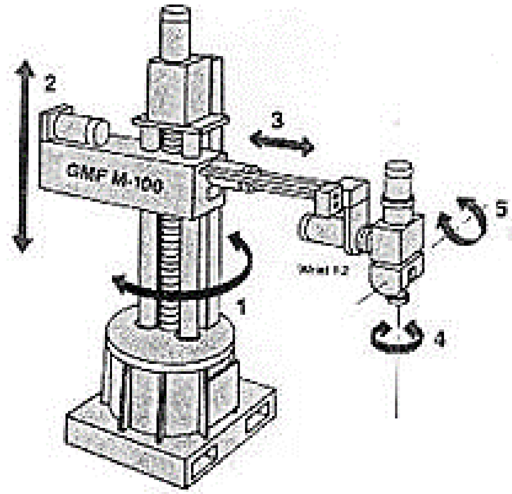


Figure 1.7: Cylindrical Robot (Society of Robots, 2014)

4. Polar: also called spherical robots, in this configuration the arm is connected to the base with a twisting joint and a combination of two rotary joints and one linear joint. The axes form a polar coordinate system and create a spherical-shaped work envelope.

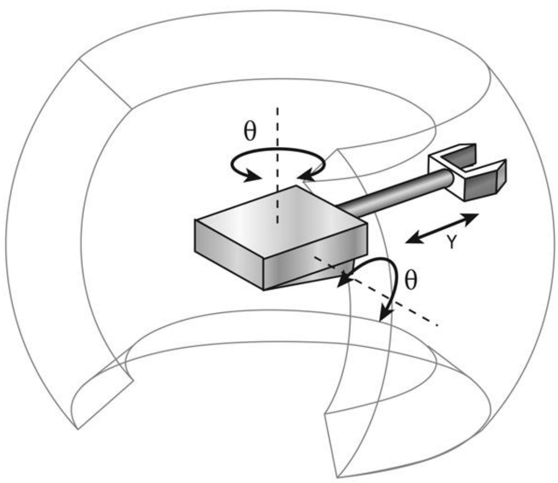


Figure 1.8: Polar Robot (Machine Design, 2016)

5. SCARA: commonly used in assembly applications, this selectively compliant arm for robotic assembly is primarily cylindrical in design. It features two parallel joints that provide compliance in one selected plane.

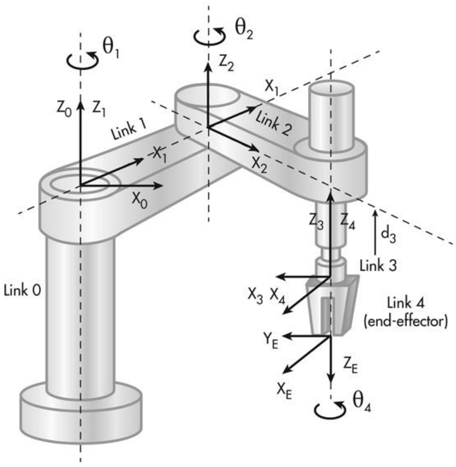


Figure 1.9: SCARA Robot (Machine Design, 2016)

6. Delta: these spider-like robots are built from jointed parallelograms connected to a common base. The parallelograms move a single EOAT in a dome-shaped work area. Heavily used in the food, pharmaceutical, and electronic industries, this robot configuration is capable of delicate, precise movement. (RobotWorx, 2018)

Figure 1.10: ABB Delta Robot IRB 360 FlexPicker (ABB, IRB 360 FlexPicker, 2018)

After listing the applications and the types of robots, we can better understand the ISO definition of industrial robot.

ISO 8373:2012:

> *"An automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation application" (ISO, 2012)*

In order to better analyse the Industry 4.0 phenomenon, it is relevant to summarize the reason why a company should implement industrial robots in its production facilities. Basically, robots can offer many benefits from their implementation:

- thanks to their peerless precision, in terms of reliability and consistency, the final products result of a higher quality that is worth the investment;
- due to the fact that robots do not require breaks, vacation, or sick leave, like all human workers, companies save a lot of money and doing so they quickly recover the initial cost;
- robots avoid waste production due to their precision and accuracy, saving valuable materials. Moreover, companies adopt industrial robots because they expect fewer mistakes;
- robots can be installed on walls, shelves, pedestals, wheels, crawler or rails, hence they can be very efficient in term of space;
- in term of production, they can reduce the manufacturing time, allowing the company to increase profits;
- some working environments are really dangerous, because of gases, dust particles or sparks; however, robots can easily operate in those risky environments without consequences, keeping the working environment safer.

Lastly we provide some numbers concerning the quantity produced by the top 10 of robot producers worldwide. The top three is composed by Fanuc, Yaskawa Motoman and ABB, which together hold the 66% of market. In fact, they respectively produce 400.000, 360.000 and 300.000 robots, over a total of 1,6 million robots. Their numbers are almost three times those of their competitors, highlighting a sort of oligopoly.

Here below a summary of the Top 10 worldwide robot producers, in the first chart we highlight the market percentage, in the second one we show the number of robots produced by each company:

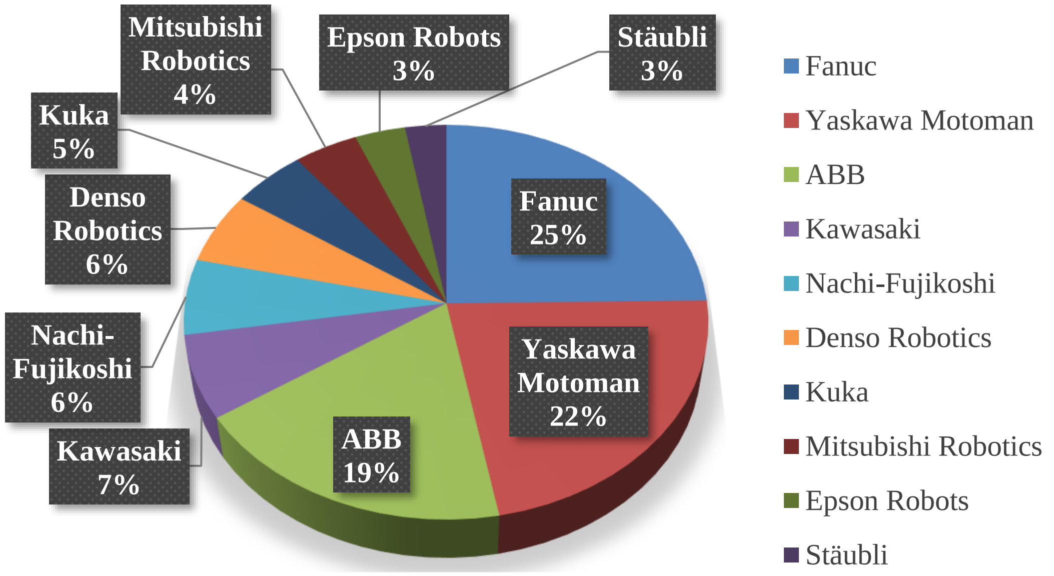


Chart 1.1: Top 10 Worldwide Robot Manufacturers (Francis, 2018)

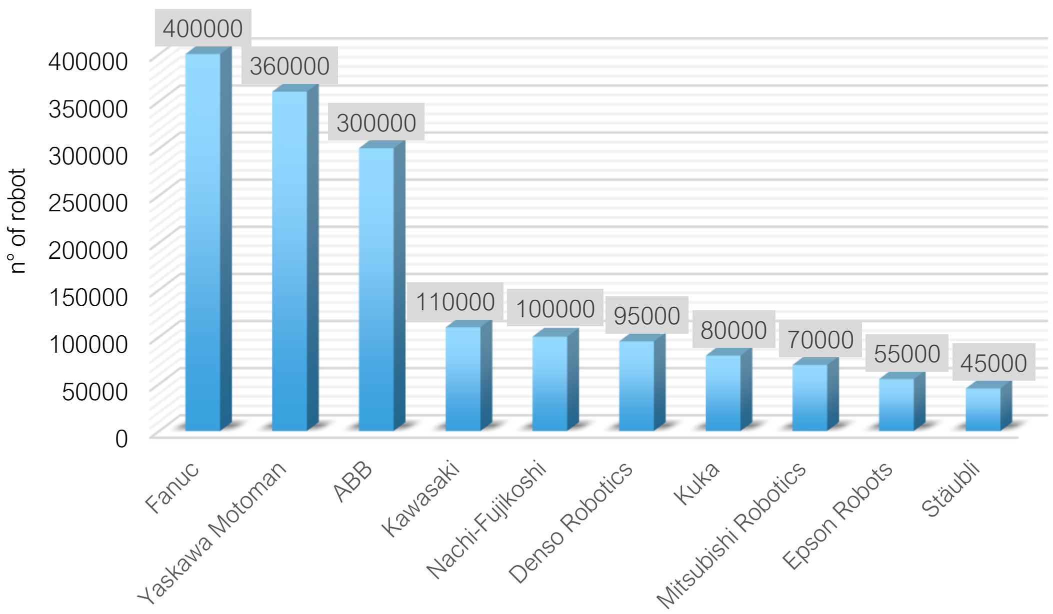


Chart 1.2: Top 10 Worldwide Robot Manufacturers (Francis, 2018)

Concerning the Italian industry, every 62 manufacturing workers there is a robot, according to the research “ADP 5.0: how digitalisation and automation change how the way of working", carried out by The European House – Ambrosetti, on behalf of ADP Italia. The research has highlighted how, in the last decade, there have been several changes in the international competitive scenario, not only because of the Great Recession effects, but also for the arrival – and the growing availability at competitive prices – of new digital technologies. In the chart below we can see how much Italian firms has invested in digital transformation.

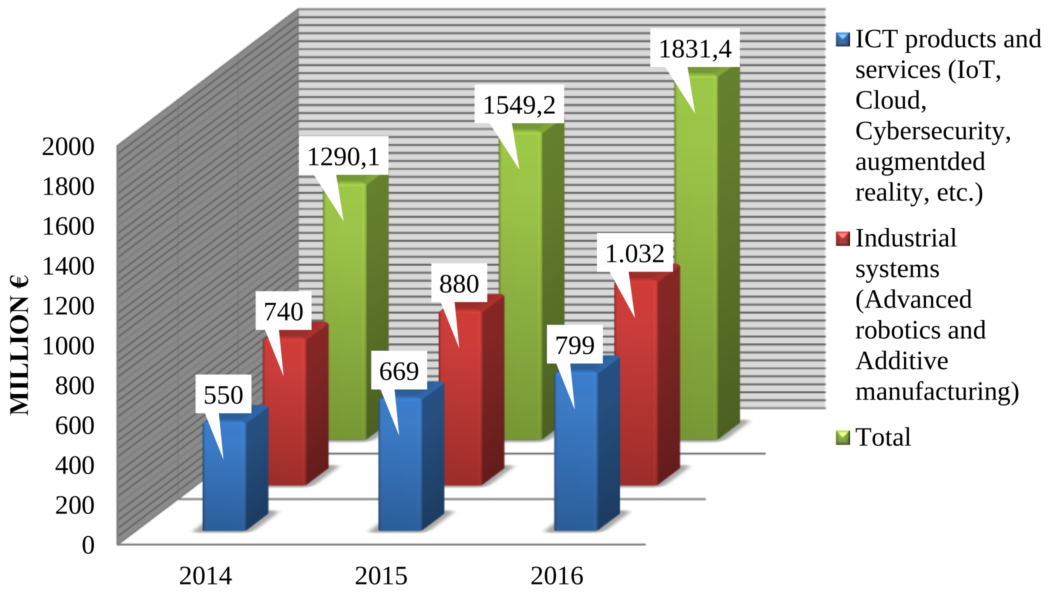


Chart 1.3: Italian firms' investments in Industry 4.0 (Biagio, 2017)

Basically, Industry 4.0 market has reached a turnover of 1,83 billion € in 2016 and the 2017 perspective is estimated on the increase, in a range from 10% to 20%, namely from 2,01 to 2,19 billion €. Focusing our attention to the international scenario (see Chart 4), Italy is ranked 10th, with 160 robots every 10.000 workers on average. Italy exceeds countries like UK, France and Spain, but it is far from Germany and Japan, which almost double it, and incredibly far from Singapore and South Korea, which respectively have two and a half times and almost three and a half times the value of Italy. (Biagio, 2017)

Obviously these differences may be caused by many factors:

- the level of development of the country;
- the government incentive policies;

- the types of industry that prevail in the secondary sector;
- or the different distribution in each country's sectors: primary, secondary and tertiary.

For example, in 2017 Italy's economic sector distribution is: 2,1% in the agriculture sector, 24% in the industry sector and 73,9% in the services sector; whereas South Korea's economic sector distribution is respectively: 2,2%, 38,8% and 59,1%. There is a substantial difference in terms of percentage point in the industry sector, where robots are adopted, in fact we notice that South Korea has almost 15% more in respect with Italian industry sector. (Wikipedia, 2017)

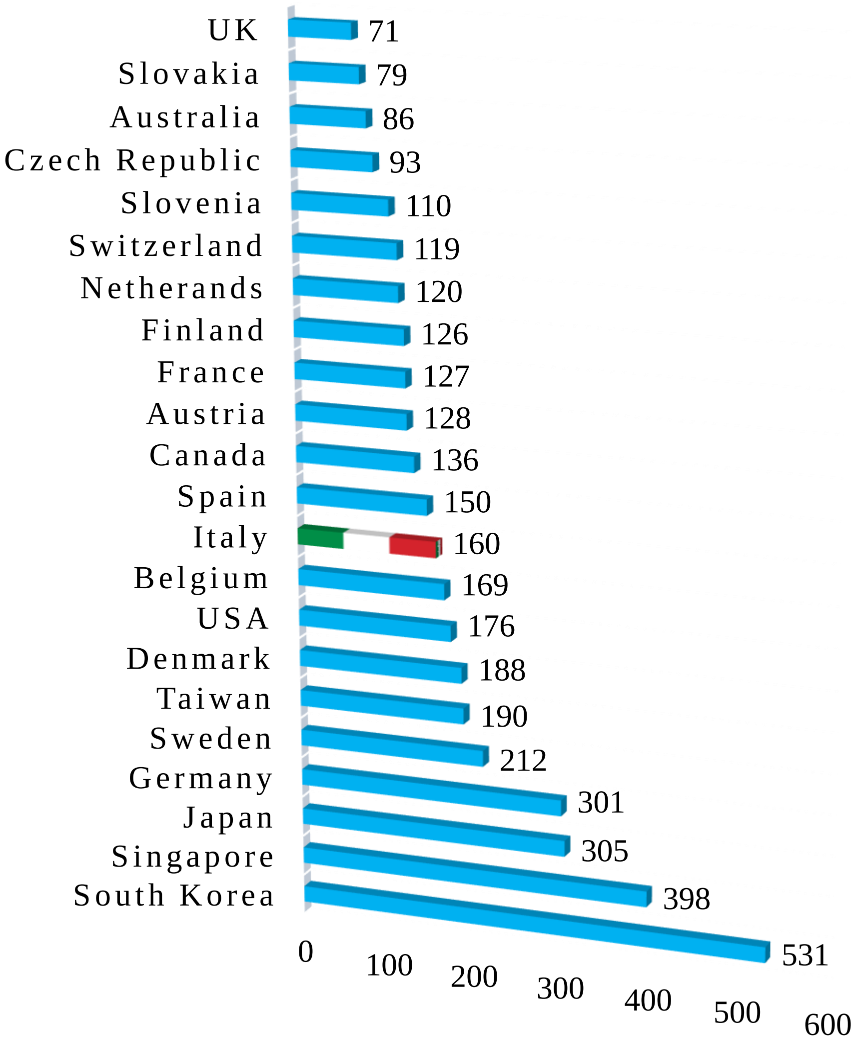


Chart 1.4: List of Top worldwide robot adopter countries (Biagio, 2017)

1.5.2 Artificial Intelligence

Another relevant technology is the Artificial Intelligence (hereafter referred to as AI), defined by the ISO/IEC 2382-28:1995 as:

> *"The capability of a functional unit to perform functions that are generally associated with human intelligence such as reasoning and learning."*
>
> *(ISO, 1995)*

AI can be classified in four main types:

1. Reactive machines: this type is the most basic one because it is purely reactive. A typical example is the IBM's chess-playing supercomputer.
2. Limited memory: this type of AI can look into the past, but these simple pieces of information about the past are only transient. For instance, self-driving cars do some of this already.
3. Theory of mind: this AI not only form representations about the world, but also about other agents or entities in the world. In particular, if AI systems will ever walk among us, they'll have to be able to understand our thoughts and feelings, and adjust their behaviour accordingly.
4. Self-awareness: the last step is to build systems that can form representations about themselves. In practice we refer to machines that have consciousness, self-awareness. (Hintze, 2016)

It is important to highlight the fact that what many companies are calling AI today, aren't necessarily so. A true AI system is one that can learn from its own, can improve on past interactions, getting smarter and more aware, allowing it to enhance its capabilities and its knowledge. That type of A.I., the kind that we see, for instance, in HBO's powerful and moving series, Westworld, or Alex Garland's, Ex Machina. We're not talking about that. At least not yet. Here below we list three examples of AI in use today:

- Siri: is a pseudo-intelligent digital personal assistant. It uses machine-learning technology to get smarter and better able to predict and understand our natural-language questions and requests.

- Tesla: electric-car with predictive capabilities, self-driving features and over-the-air updates which improve its smartness.
- Nest: a learning thermostat that uses behavioural algorithms to predictively learn from your heating and cooling needs, thus anticipating and adjusting the temperature in your home or office based on your own personal needs. (Adams, 2017)

1.5.3 Additive manufacturing and 3D printing

This type of technology is based on a geometrical representation from which a 3D printer creates physical objects by successive addition of material. The general definition of additive manufacturing (AM) is provided by the 2015 Standard ISO/ASTM 52900:

> *"Additive manufacturing is a process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies." (ISO, 2015)*

The definition of 3D printing, given by the Standard, is:

> *"fabrication of objects through the deposition of a material using a print head, nozzle, or another printer technology." (ISO, 2015)*

First of all, it is useful to specify that there is a difference between additive manufacturing and 3D printing in terms of using the word. Typically, the term additive manufacturing is used by the people in the industry sector, whereas the term 3D printing is preferred by the people of maker communities. However, in strictly way, we can consider 3D printing as the operation at the heart of the additive manufacturing, and so additive manufacturing entails more than 3D printing. (Zelinski, 2017)

The typical additive manufacturing process is made up of six basic steps, as we can see in Figure 11. It starts from a 3D CAD model of the object from which we obtain a ".stl" file, and then using a slicing software we made the layer slices and the tool path useful for the 3D printer to create the object.

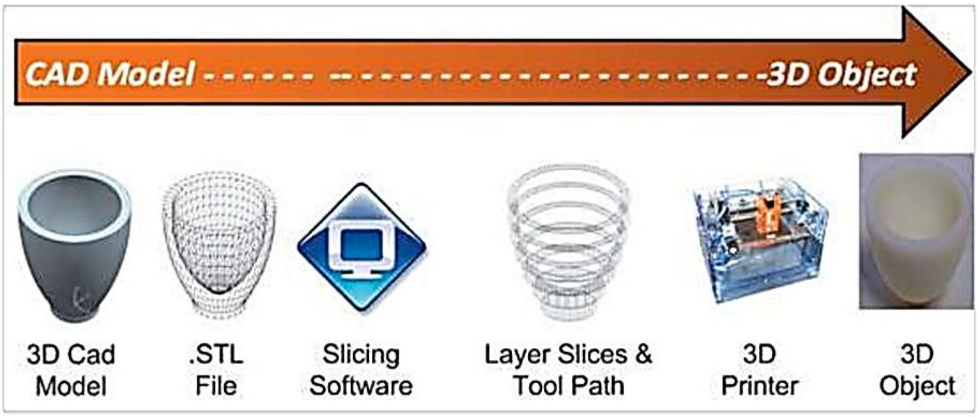


Figure 1.11: Additive Manufacturing process (Magnaghi, 2016)

Concerning the 3D printing world, we recognize six major 3D printing technologies (Frost & Sullivan, 2014), which differ on the types of material and techniques used:

1. Stereolithography (SLA): a stereolithographic apparatus uses liquid plastic, a perforated platform, and UV laser to print 3D objects.

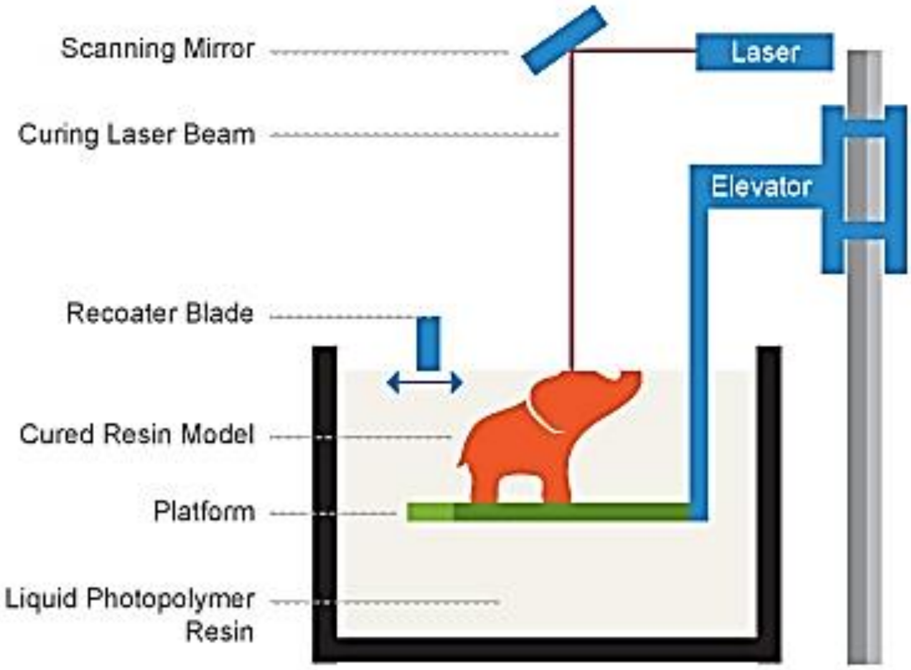


Figure 1.12: Stereolithography (Printspace3D, 2012)

2. Selective Laser Sintering (SLS): it is like SLA with one main exception, it uses fine powder instead of a liquid photopolymer resin. The powder can be made out of a variety of material including metal, plastic, glass or ceramic.

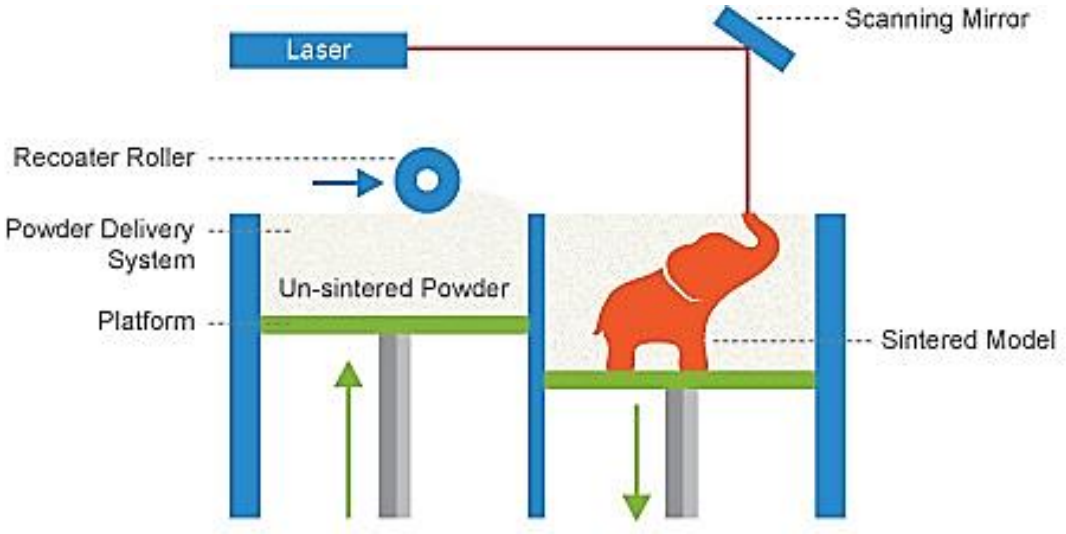


Figure 1.13: Selective Laser Sintering (Printspace3D, 2012)

3. Laminated Object Manufacturing (LOM): layers of adhesive-coated paper, plastic or metal laminates are fused together using heat and pressure and then cut to shape with a computer controlled laser or knife.

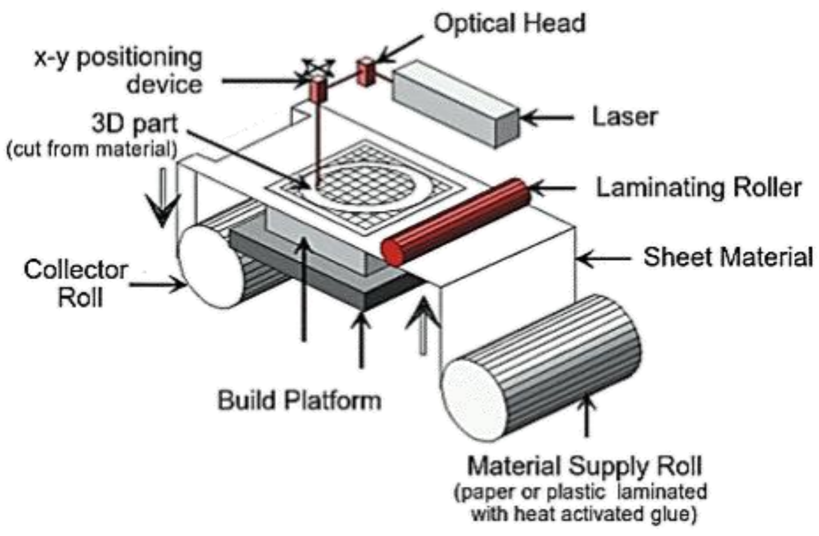


Figure 1.14: Laminated Object Manufacturing (Scanandmake.com)

4. Selective Laser Melting (SLM): it is a technique that uses 3D CAD data as a source and forms 3D objects by means of a high-power laser beam that fuses and melts together metallic powders. Metals that can be used for SLM include stainless steel, titanium, cobalt chrome and aluminium. SLM is widely spread among manufactures of aerospace and medical orthopaedics because it is suggested for complex geometries and structures with thin walls and hidden voids or channels.

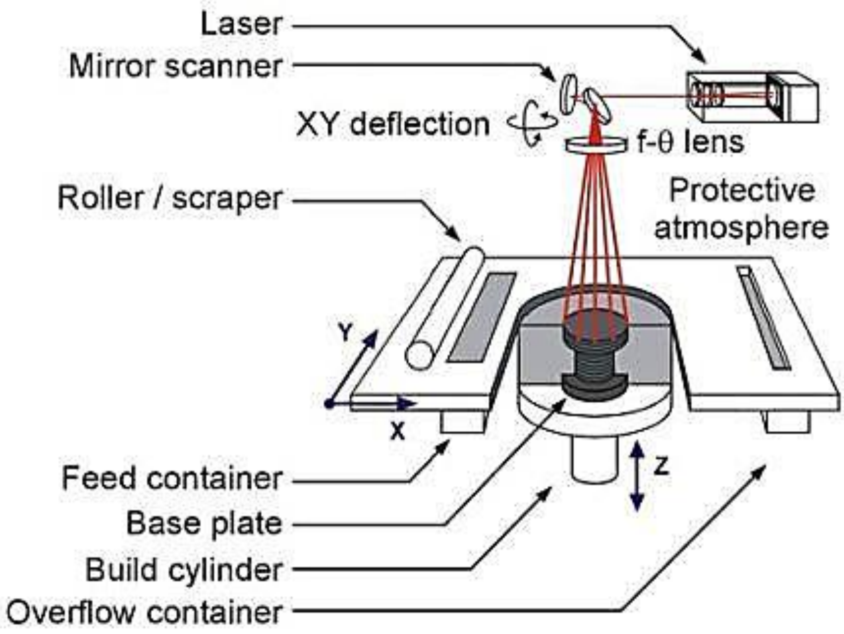


Figure 1.15: Selective Laser Melting (Scanandmake.com)

5. Electron Beam Melting (EBM): it is a powder bed fusion technique similar to SLM. This latter uses high-power laser beam, whereas EBM uses an electron beam. This expensive process is mainly focused on medical implants and aerospace area.

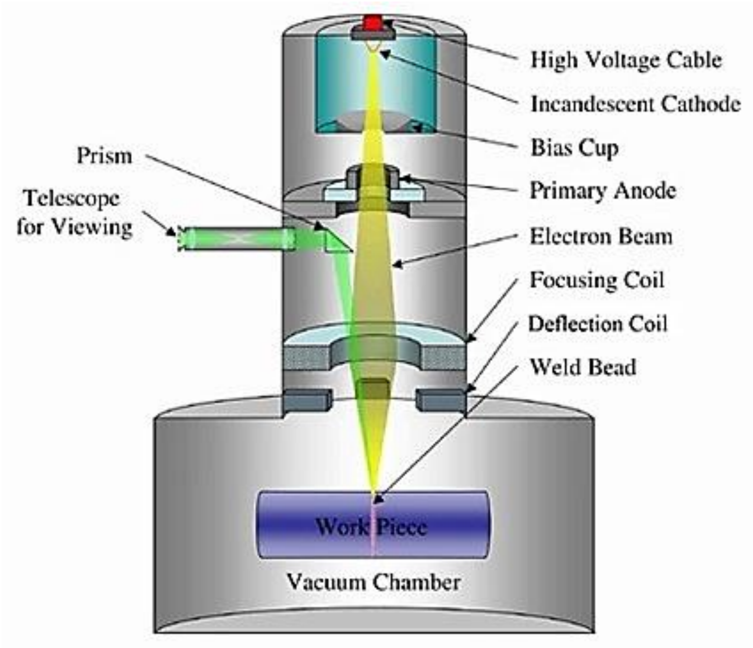


Figure 1.16: Electron Beam Melting (Scanandmake.com)

6. Fused Deposition Modelling (FDM): thys system uses thermoplastic material which is melted to a semi-liquid state and extruded according to computer-controlled paths.

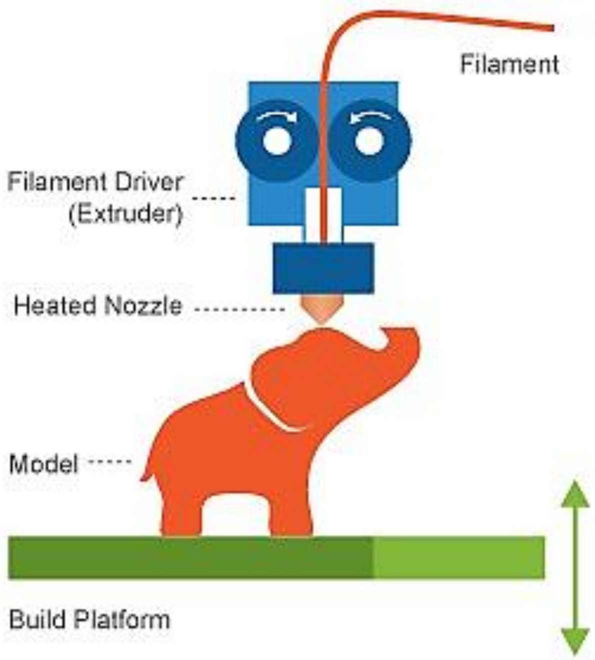


Figure 1.17: Fused Deposition Modelling (Printspace3D, 2012)

1.5.4 Laser Cutting

This technology is based on high-power laser beam that is focused and intensified by a lens or a mirror to a very small spot in order to cut materials including titanium, stainless steel, mild steel, aluminium, plastic, wood, engineered wood, wax, fabrics, paper and ceramic. (Wikipedia, 2018) Laser cutting allows to obtain high-quality and dimensionally accurate cuts, the whole thing is controlled by a computer which transform the information from a CAD file into computer-controlled parameters that guides the laser cutter. The reasons why a producer should implement a laser cutting machine in the manufacturing process shall take into account: the automation of the process, the user-friendliness, the reliability, the service level provided, the numerical control and the 360-degree management of the manufacturing process.

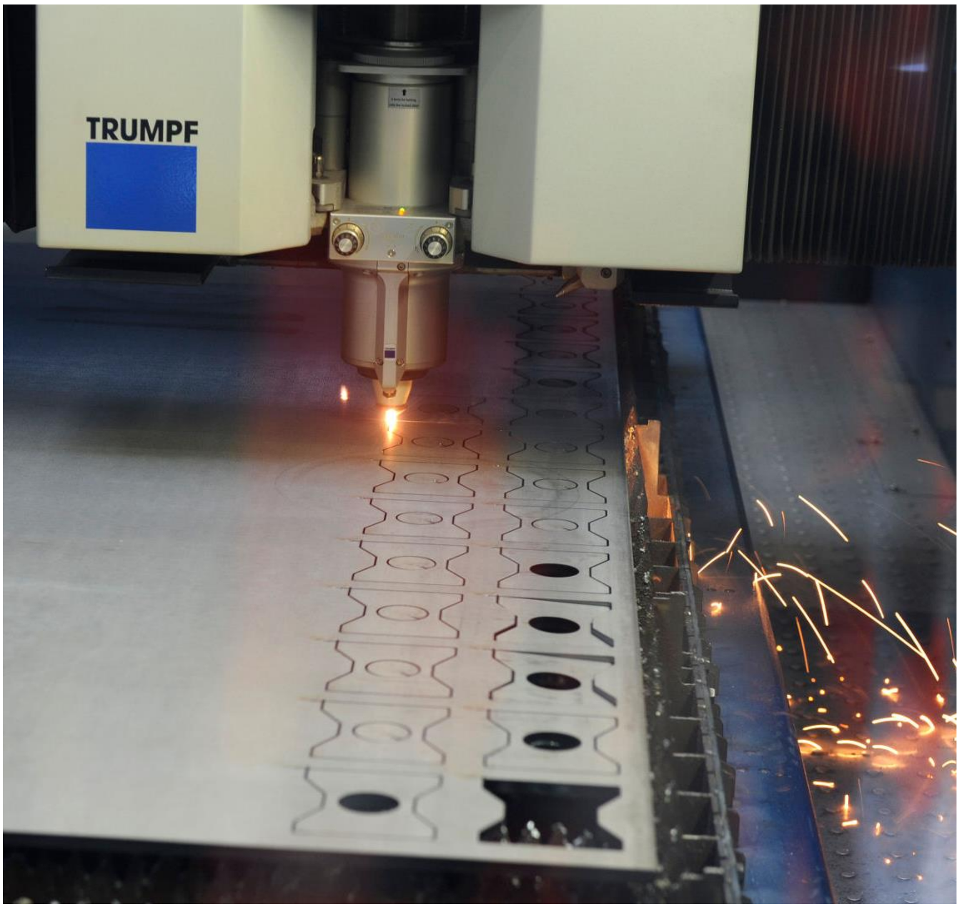


Figure 1.18: Laser Cutting process (Global Metal srl)

There are four types of lasers used in laser cutting and each one can be used in specific case:

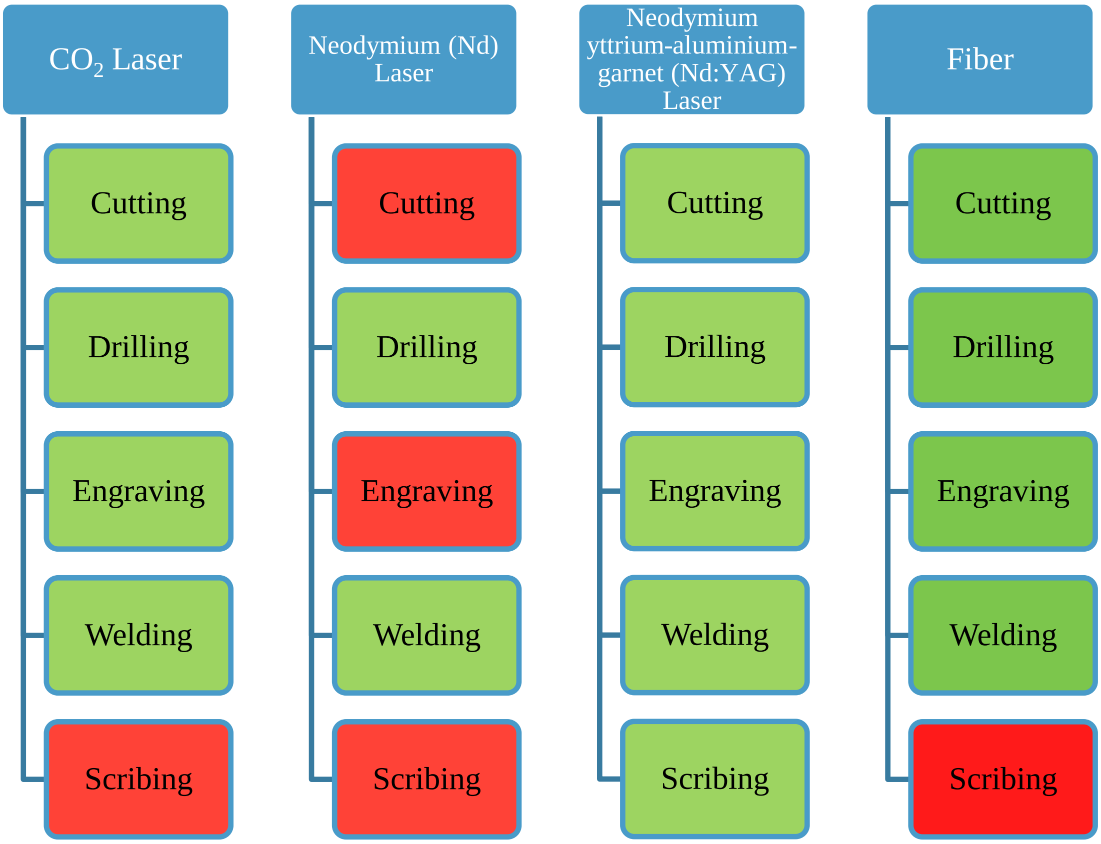


Figure 1.19: Types of lasers and their applications (Wikipedia, 2018)

1.5.5 Big Data

First of all, we have to define the term Big Data using the definition provided by ISO, in particular we refer to ISO/IEC JTC 1/SG 2:

> *"Big Data is a data set(s) with characteristics that for a particular problem domain at a given point in time cannot be efficiently processed using current/existing/established/traditional technologies and techniques in order to extract value"* (ISO, 2014)

The key characteristics of Big Data are:

- volume: nowadays in different industries firms require data volumes in terms of terabytes, petabytes, and beyond;

- variety: today data applications are creating, consuming, processing, and analysing data in a wide range of formats from diverse application domains;
- velocity: it is the speed at which data are created, stored, analysed and visualised. Currently firms have started to highlight the need for real-time, streaming, continuous data discovery, extraction, processing, analysis and access, creating new challenges to enable real-time data usage;
- variability: it refers to the changes in data other characteristics that impact the analytic system;
- veracity: it is the trustworthiness, applicability, noise, bias, abnormality and other quality properties of the data.

The most relevant aspect concerning Big Data is the analysis of the data, which allows people to have insights about their business and their customers, useful to take the right decisions.

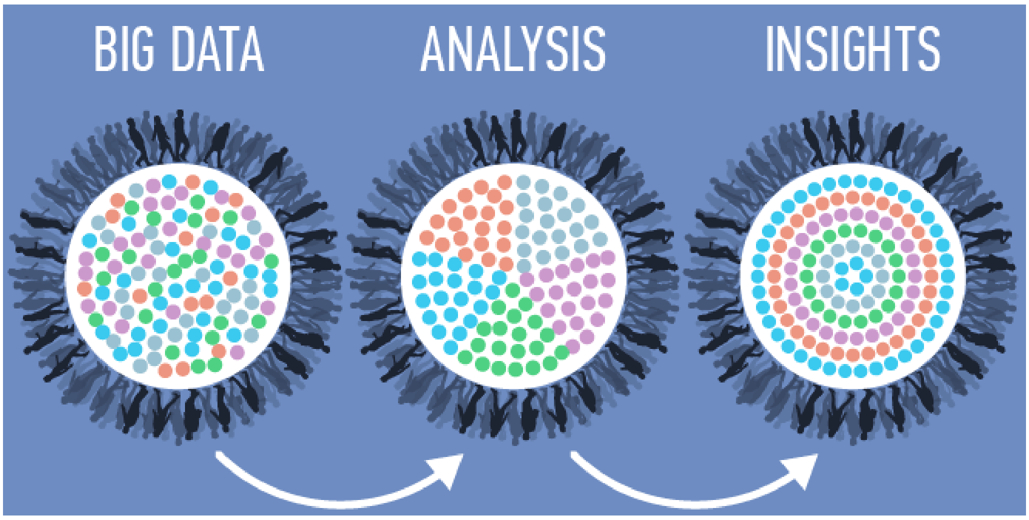


Figure 1.20: From Big Data to insights through analysis (Bekker, 2017)

From an economic point of view, Big Data market had, have and will have a positive trend which highlights the potential of this technology and the related data services to businesses. In fact, a 2015 analysis of Wikibon (Kelly, 2015) shows that in 2018 this market should reach $50 billion, starting in 2011 from less than one fifth of today forecast. We can see the detailed forecasts in the next figure.

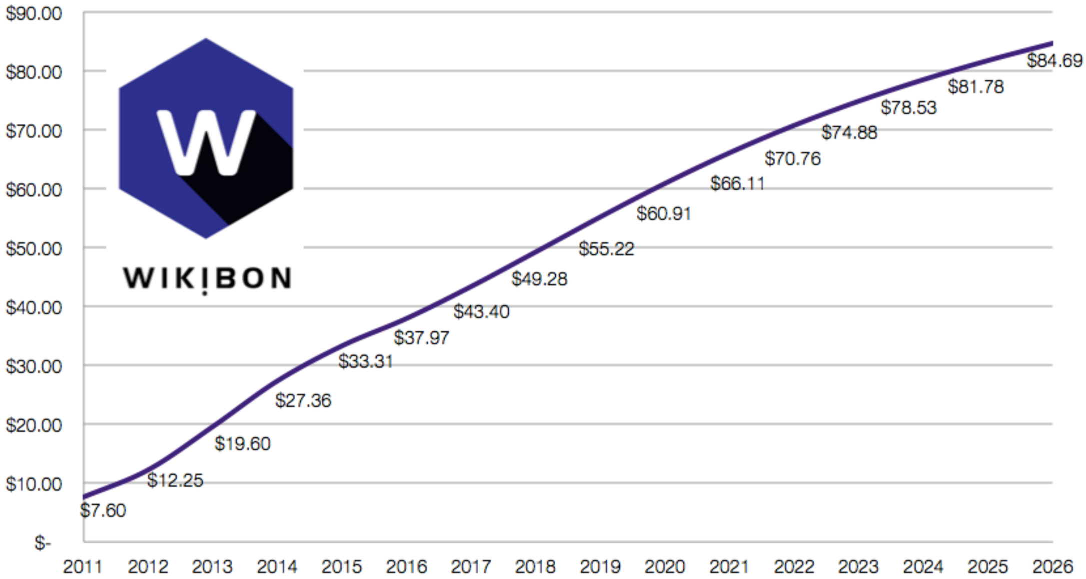


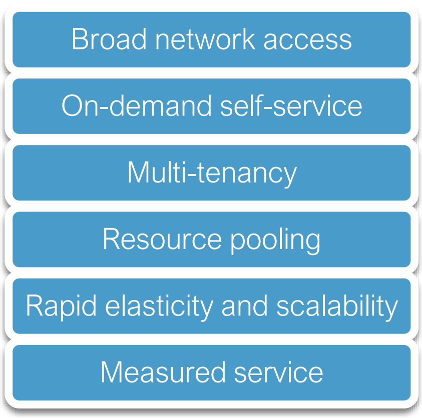
Figure 1.21: Big Data Market Forecast, 2011-2026 ($US B)

1.5.6 The Cloud

When we hear or talk about the Cloud we are technically referring to the term Cloud Computing, defined by the ISO in ISO/IEC 17788 as:

> *"the paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with on-demand self-service provisioning and administration." (ISO & Qavami, 2014)*

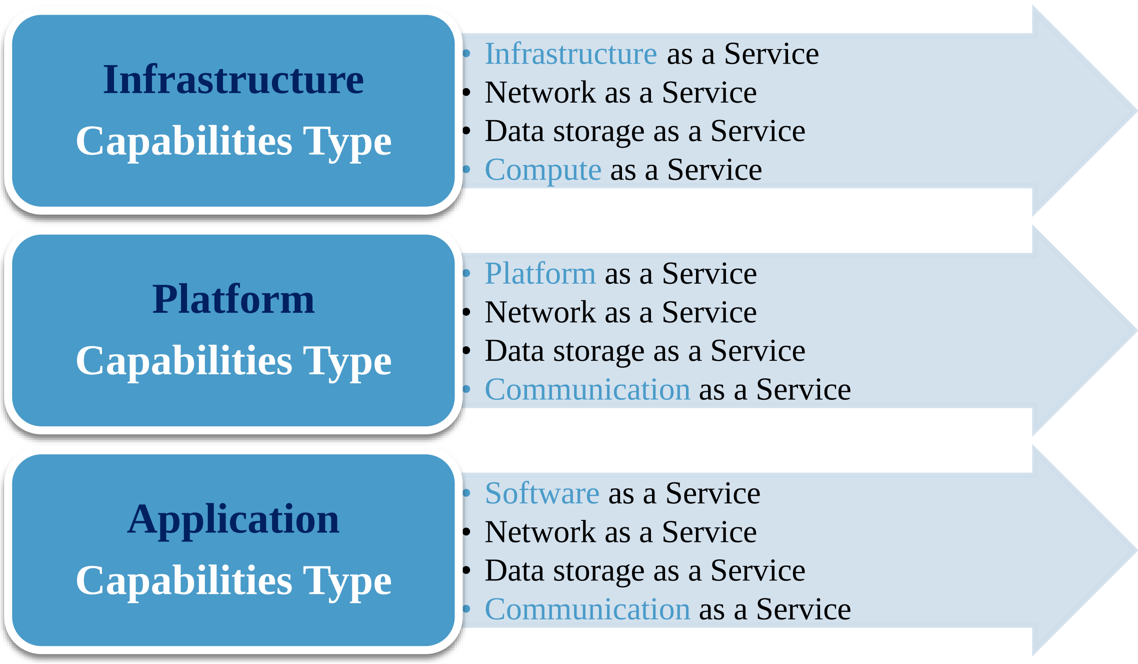
The document provided by ISO underlines the existence of six key characteristics of the Cloud:



Moreover, we can distinguish among four deployment models (ISO, 2014):

1. public cloud: cloud deployment model where cloud services are potentially available to every cloud-based customer.
2. private cloud: cloud deployment model where cloud services are exclusively used by only one cloud service customer.
3. community cloud: cloud deployment model where cloud services are shared among several organizations from a specific community that have common interests.
4. hybrid cloud: cloud deployment model that consists of at least two different types of cloud deployment models.

Lastly we consider that there are three cloud capabilities types (ISO & Qavami, 2014):



An interesting research made by Gartner, the world's leading research and advisory company, forecasts the revenues of worldwide public cloud services till 2020 and underlines through numbers that the total market will almost double in four years, starting from 219,6$US billions of 2016 and reaching 411,4$US billions of 2020. In particular, the total market grew by 18,5% in 2017, and will increase by 17,5% in 2018, by 16,3% in 2019 and by 15,7% in 2020. Looking at Chart 5 we notice that Cloud Advertising is the biggest slice of pie (increased by 67%), followed by Cloud

Application Services (increased by 107%), Cloud System Infrastructure Services (increased by 185%), Cloud Business Process Services (increased by 35%), Cloud Application Infrastructure Services (increased by 131%) ad Cloud Management and Security Services (increased by 96%).

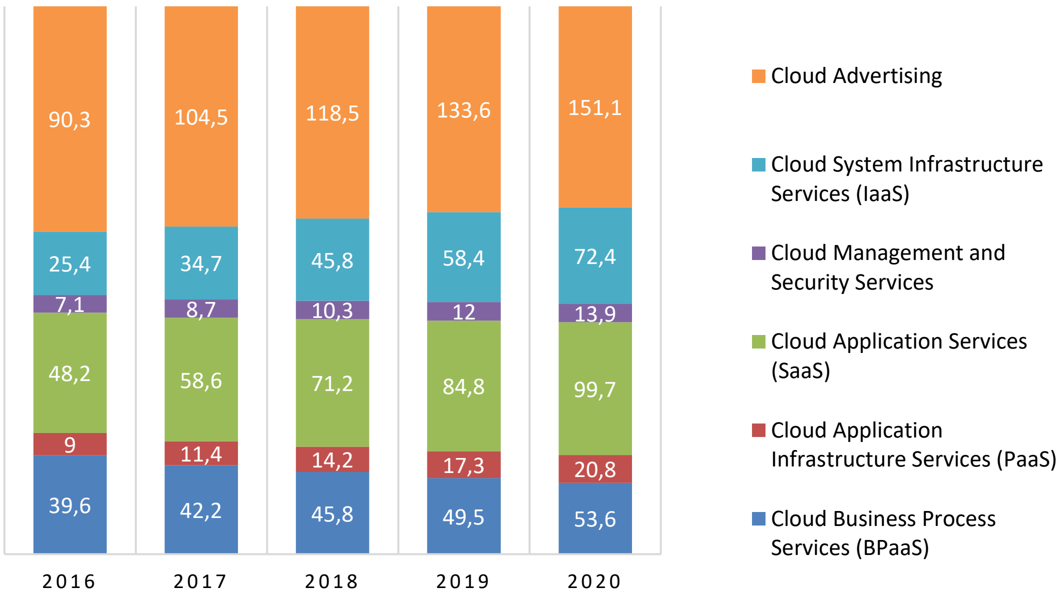


Chart 1.5: Worldwide Public Cloud Services Revenue Forecast, 2016-2020 ($US B) (Gartner, 2017)

1.5.7 3D Scanning

This technology captures the shape of every object using a 3D scanner in order to obtain a 3D file of the object scanned on a computer. The file can be edited and then 3D printed. There are different 3D scanning technologies (Aniwaa, 2018):

- laser triangulation: use either a laser line or a single laser point to scan across an object; the advantages of this technology are its resolution and accuracy, however very shiny or transparent surfaces are particularly problematic;
- structured light: use trigonometric triangulation based on projection of a series of linear patterns onto an object; the advantages are its speed, resolution and ability to 3D scan people, however it is sensible to lighting conditions;
- photogrammetry: it is the science of making measurements from photographs, based on a mix of computer vison and powerful computational geometry

algorithms. The main advantages are its precision and acquisition speed, but its sensibility to the resolution of the input photographs and the time it takes to run the algorithms is a downside;

- contact-based / Digitizing: there is a physical touch by a probe, while the object is firmly hold in place; the advantages are its precision and ability to scan transparent or reflective surfaces; a downside is its speed and inadequacy to work with organic freeform shapes;
- laser pulse-based: it measures how long a casted laser takes to hit an object and come back; the main advantage is its ability to 3D scan very big objects and environments, however it is quite slow.

Figure 1.22: 3D Scanner (3Dprint.com, 2015)

1.5.8 Augmented and Virtual Reality

First of all, we need to define these two technologies in order to understand the difference between them. Augmented Reality (AR) overlays virtual objects on the real-world environment, whereas Virtual Reality (VR) immerses users in a fully artificial digital environment. (Quora, 2018)

Hence there is a difference in the environment, real or digital, and then a difference in the experience of the users, in the AR there are virtual object in the real world in which the user is, in the VR the user is fully immerse in a virtual world. An example of Augmented Reality is Pokémon Go, the app that allows to the players to capture small virtual creatures in the real world they are living. An example of Virtual Reality in the game console world is given by PlayStation VR, a head set 3D viewer which allows players to fully immerge in a digital world and interact with it.

In the industrial field these technologies are used in several cases:

- prior to starting production, we can do simulation models of the entire production chain and make changes in order to optimize the process using VR;
- we can use AR in maintenance;
- we can do on-site assembly and safety for trainees using AR or VR;
- when we are testing or digital prototyping;
- in the operations sectors, logistic and service staff can work smoother if they have the data in front of their eyes;
- lastly, with a look to consumers, companies provide AR mobile app that enable their clients to see how a sofa could fit in their living room before purchasing it (see below Figure 23).

Figure 1.23: AR app of IKEA (techdigg.com, 2017)

1.5.9 Internet of Things

First of all, we focus our attention to the definition provided by the ISO/IEC JTC 1:

> *"IoT is an infrastructure of interconnected objects, people, systems and information resources together with artificial intelligent services to allow them to process information of the physical and the virtual world and react" (ISO, 2014)*

Concerning the IoT technology, we can consider other technologies as driver for the its growth: low-power devices (such as watches and microprocessors), connected devices, computing and distributed processing power, advanced (intelligent and predictive) sensors, and advanced actuators.

Now we highlight the classification of applications with the next figure:

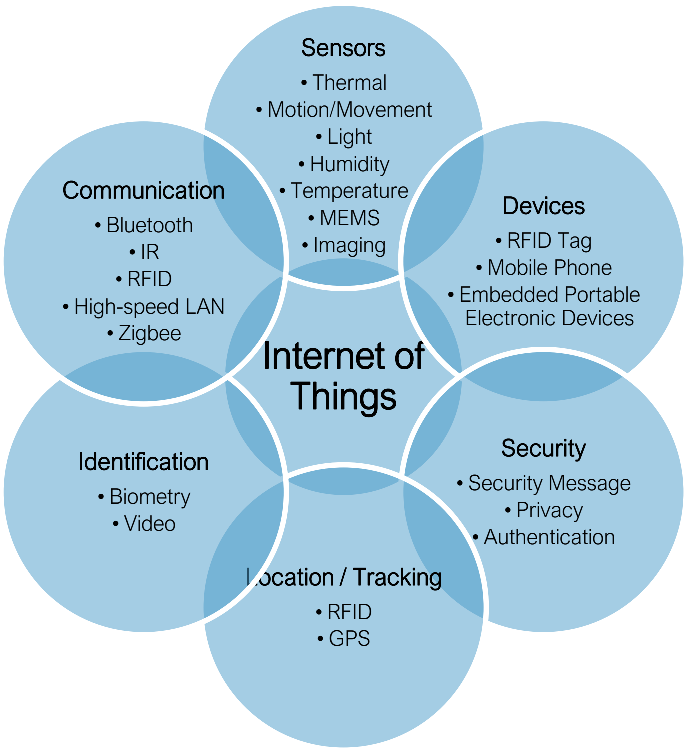


Figure 1.24: Classification of applications (n-tech research, 2014)

The development of the IoT has many consequences in the digital factory: high flexibility levels, one-product customization, real-time dialog among market, R&D,

suppliers and production, relevant implications on facilities, production volumes and product mix. (Zanardini, 2014)

IoT has a huge potential in terms of volume of products and objects, recognized as smart, because each of them may be equipped with a console able to transfer information and receive instruction, also remote. However, the realization of the IoT as a widespread system is not easy to implement. In fact, each product must have:

- an IP address (it is not possible with the actual protocol generation system);
- sensors that gather data on its utilization;
- new technologies for gathering, storage and interpretation (big data technology) (Magone, 2016).

Focusing on predictions about IoT we highlight the following considerations:

- the global Internet of Things (IoT) market is projected to grow from $2.99T in 2014 to $8.9T in 2020, attaining a 19.92% Compound Annual Growth Rate (CAGR) (Statista, Size of the IoT market worldwide in 2014 and 2020, by industry (in $US billion));
- industrial manufacturing is predicted to increase from $472B in 2014 to $890B in global IoT spending (Statista, Size of the IoT market worldwide in 2014 and 2020, by industry (in $US billion));
- the global IoT market share will be dominated by three sub-sectors; Smart Cities (26%), Industrial IoT (24%) and Connected Health (20%). Followed by Smart Homes (14%), Connected Cars (7%), Smart Utilities (4%) and Wearables (3%) (GrowthEnabler, 2017).

1.5.10 Social media and marketing

A relevant aspect of social media is the huge amount of data that people share in. Information is provided in several forms: photos, posts, likes, comments, shares, etc. Obviously, the type of data a company need differs one from each other. User profiling techniques of social media are more and more advanced and can be replicated by the industry in order to monitor customers practises and behaviour. Basically, if the producer sells smart products with sensors that send back information, the amount of data flowing back from customers can be gathered and analysed. The results from the data analysis may lead to a new set of meaningful information necessary for new business decisions.

Another relevant aspect of social media is the marketing function. Marketing is a process that needs to be monitored and managed. The difference is that the social media marketing process is iterative and can change and adapt more quickly than traditional marketing campaigns. Being this adaptive, it requires platforms that help marketing professionals properly design, initiate, and manage social media marketing campaigns, as well as perform the social media analytics that allow for deep customer understanding and monitoring for the effectiveness of these campaigns. (Wikipedia, 2018) As a matter of fact, the relationship between the firm and the customer becomes more intimate, almost individual. The interaction occurs in terms of customer care, for example answering to comments of customers that may have problems with company's products or services. Hence, company's social network page allows customers to make their voices heard. At the same time the company produces entertainment contents with the goal of create hype and spreading of them. This phenomenon is called "viral effect", due to the spontaneous word-of-mouth among users, which leads more and more people watching the content, allowing the company's content to reach as many people as possible. A vivid example of social media marketing is given by the viral marketing done in video sharing web site such as YouTube, Facebook, Instagram, Twitter and LinkedIn, where the users watch target advertising made ad hoc for them. Here below a numerical example in terms of revenues of one of the most famous company in the world, Facebook.

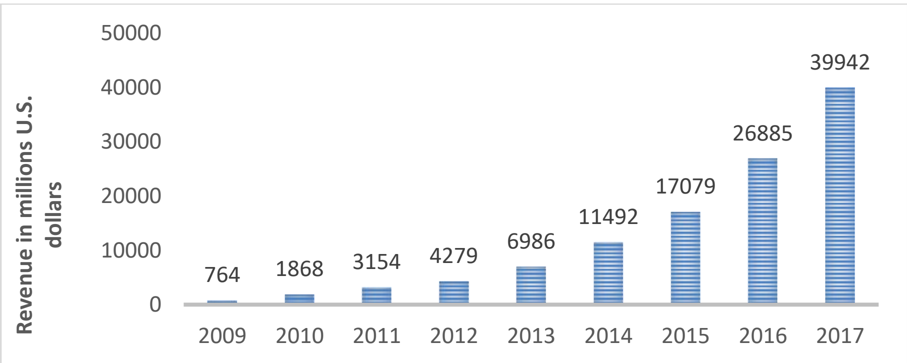


Chart 1.6: Facebook's annual revenue from 2009 to 2017, in million U.S. dollars (Statista, 2018)

CHAPTER TWO

2 INDUSTRY 4.0 IN THE WORLD

In this chapter we will discuss the main Industry 4.0 plans implemented by the most powerful countries in the world, namely Germany, Great Britain, France, USA, China and Italy. Doing this we will highlight the main differences among countries, starting from the year of implementation, indicator of how political and economic fabric are developed and do not want to fall behind, then we will emphasise the main guidelines of these plans, and lastly we will show the results, if already available. Prior to describe the current situation of the foreign countries, it is fair to start describing the Italian status concerning Industry 4.0.

2.1 Italy: "Piano Nazionale Impresa 4.0"

It was on 15th June 2016 when the Minister of Economic Development, Carlo Calenda, presented to the Chamber of Deputies the Industry 4.0 thematic for the first time. During his speech, he underlined the following key points:

- the digitalisation of the manufacturing processes it is not only an opportunity for the Italian industry, but especially a transition of historical significance;
- the Italian government has to consider a series of measures and policy lines regarding the promotion and support to undertakings that innovate, internationalise, with flexibility and reactivity;
- leaving aside the technology shift, the organisational change has allowed productivity gains in the past industrial revolution, hence, it is relevant to focus our attention to the organisational shifts needed;
- the fourth industrial revolution is made possible thanks to the increasing connection among computers, actuators and sensors available at low-cost and it is associated to a deployment more and more pervasive of data and information, of computational technologies, of new materials, components and

smart production systems fully digitalised and interconnected (IoT and machines).

Moreover, Minister Calenda synthetized the implication of the digitalisation of manufacturing in four main areas:

1. availability of digital data and analytics of Big Data: low-cost elaboration and analysis of huge amount of data allow better decisions and forecasts on production and consumptions and the development of on demand production systems with customised and real-time feedback capacity to consumer;
2. advanced robotics and automation: new interaction between humans and robots with artificial intelligence allows a zero defects production, a time and costs' reduction and a productivity and process security improvement;
3. boosted connectivity: the entire value chain is interconnected through mobile and fixed devices (Internet of Things) using ultra-wideband technology. This allows to reduce the time to market and to produce also very small batches (mass customisation);
4. digital contact with customers and sharing economy: Internet and the social media offer new interaction channels with customers and push the development of new services and business models (predictive maintenance, renting/lease-back, pay by use, e-commerce)

Another remarkable part of Minister Calenda's speech concerns the SME fabric: he underlined that Industry 4.0 will be firstly pushed by Italian skills and competences in the mechanic and mechatronic sectors, will promote Big Data as new competitive advantage, will foster a customer-based manufacturing, will exploit the already existing flexibility of Italian SME, and will strengthen the strategic positioning concept.

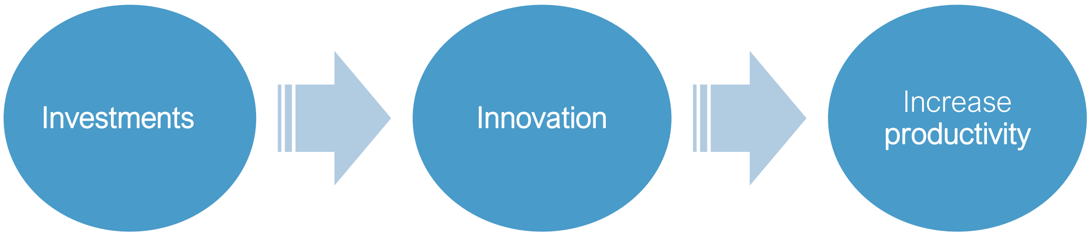
Then, he identified five areas on which government policy actions must focus:

1. investments on innovation and incentives: through a solution driven approach, government incentives and a new innovative entrepreneurship development;

2. enabling factors: such as ultra-wideband technology investments, digital innovation hubs, STEM (science, technology, engineering and mathematics) competences development, and educational model rethinking;
3. interoperability, security and IoT communication standards: definition at a national level, but mainly at international level;
4. job, salary and productivity relations: it means more flexible forms, that consider competences and skills;
5. corporate finance: it builds an alternative to the traditional credit sector, the banking system, trying to focus national saving to real economy engagements.

Lastly, Minister Calenda sustained that government has to remove obstacles to the incoming revolution, already begun in more advanced countries, in order to support the most innovative, brave and forward-looking undertakings. (MiSE, Audizione di Carlo Calenda - Industria 4.0, 2016)

Subsequently, the Italian government presented the official «Piano nazionale Industria 4.0» on the 21st September 2016. The plan focused on three key words: investments, productivity and innovation. We can find a rationale that links these words: public and private investments push innovation, this latter provides the outputs, which applied in the manufacturing process, increase productivity.



In the document presenting the Italian way to Industry 4.0, the government listed the following enabling technologies:

1. advanced manufacturing solutions, namely interconnected and quickly programmable collaborative robots;
2. Additive Manufacturing, i.e. 3D printers connected to digital development software;
3. Augmented Reality supporting production processes;

4. simulation among interconnected machines in order to optimise processes;
5. horizontal/vertical integration of information along the supply chain, from the supplier to the consumer;
6. Industrial Internet, namely multidirectional communication between production processes and products;
7. Cloud, useful to manage huge amount of data;
8. cyber-security, that is to say security during operations online or on open systems;
9. Big Data and Analytics useful to optimise products and production processes.

The resulting benefits from the adoption of these technologies 4.0 are:

- more flexibility through little batches production at large scale costs;
- more speed from prototype to series production through innovative technologies;
- increased productivity through less set-up time spending, less mistakes and grounding.
- better quality and less wastage through real-time production monitoring sensors;
- greater product competitiveness thanks to added functionalities resulting from the IoT.

The Italian industrial fabric is strongly SME-based, where prestigious university and research centres have key roles in R&D and with a strongly cultural connotation of finished products. Starting from these peculiar characteristics, the government proposed three key guidelines and two supporting ones for the 2017-2020 period. The first key guideline concerned innovative investments, in particular: to encourage private investments on Industry 4.0 technologies and assets, to boost private spending on R&D and innovation, to strengthen finance and support to Industry 4.0, Venture Capital and start-up. The second one regarded competences, specifically: to spread industry 4.0 culture through «Digital School» and «Study/work experience», to develop competences 4.0 through a specific second grade and university educational offer, to finance research 4.0 by reinforcing clusters and Ph.D., to create Competence Centres and Digital Innovation Hub. The third one concerned governance and awareness, namely to raise awareness on Industry 4.0 relevance and to create public and private governance. The first supporting guideline was about the enabling infrastructures, such us the Ultra-wide band and the collaboration to the Standards and IoT interoperability criteria definition. The second one related to public support instruments to ensure private investments, to support big innovative investments, to strengthen and innovate international markets presidium and to support the salary-productivity exchange through the business decentralised bargaining.

The government forecasted as objectives, for the 2017-2020 period, the following numbers concerning the guidelines synthetized below:

KEY GUIDELINES	
INNOVATIVE INVESTMENTS: **+ EUR 10 billion** private investments increase from 80 to EUR 90 billion in 2017 **+ EUR 11.3 billion** private spending in R&D and innovation in 2017-2020 period **+ EUR 2.6 billion** private early-stage investments mobilised for 2017-2020 period	**SKILLS:** **200˙000** university students and **3˙000** managers specialised in Industry 4.0 **+ 100%** students enrolled in technical high schools in Industry 4.0 topics ~ 1˙**400** Ph.D. focused on Industry 4.0 **National Competence Centres**
SUPPORTING GUIDELINES	
ENABLING INFRASTRUCTURES: **100 %** of Italian firms covered to 30Mbps within 2020 **50 %** of Italian firms covered to 100Mbps within 2020 **6 consortia** in IoT standards	**PUBLIC SUPPORT INSTRUMENTS:** **+ EUR 0.9 billion** SME Guarantee Fund reform and refinance in 2017 **+ EUR 1 billion** development contracts focused on Industry 4.0 investments **+ EUR 0.1 billion** investment on digital retail chains

Looking in detail into each guideline, we can highlight the most relevant initiatives by the government:

- hyper-depreciation: overvaluation of 250% of investments in new tangible assets, technologies and devices enabling transformation in key 4.0 acquired or in leasing;
- super-depreciation: overvaluation of 130% of investments in new capital equipment acquired or in leasing. For those benefiting of hyper-depreciation, there is the possibility of benefit from overvaluation of 140% for investments in intangible capital equipment (software and IT systems);
- Tax Credit to research: rate increase on internal research from 25% to 50% and maximum credit limit per taxpayer from € 5 million to €20 million;
- «Nuova Sabatini»: it is the facilitation made available to SME by the Ministry of Economic Development with a view to facilitate the credit access of firms and increase the competitiveness of Country's production system. The measure support investments to acquire or lease machineries, equipment, production and hardware capital equipment, software and digital technologies. The credit with a duration of less than 5 years, ranging between €20˙000 and €2 million, fully used to cover the eligible investments.
- Patent Box: it is a decree of the 28th November 2017 which provides for an optional special taxation applicable to income from the use of intangible assets: copyrighted software, industrial patent rights, industrial designs and models, processes, formulas and information related to acquired experience in the industrial, commercial or scientific field legally enforceable.
- innovative start-ups and SMEs: they benefit from a dedicated reference framework in subjects such as administrative simplification, labour market, tax benefits, insolvency law. Most of these measures are extended to innovative SMEs.

The Italian national plan changed the name from «Piano nazionale Industria 4.0» to «Piano nazionale Impresa 4.0» on 19th September 2017, when the government presented the result of the first semester of 2017 and planned the actions for 2018, considered as the second phase of the overall national plan.

Lastly, on the 8th February 2018 the Italian government presented the results from 2017 and the actions for 2018. First of all, the impact of the super-depreciation, hyper-depreciation and «Nuova Sabatini», given a gross fixed capital investment of €80 billion, is positive since that domestic orders in 2017 increased by 13% for machinery and other equipment, by 7% for electric and electronic equipment, and by 10% in other categories, in respect to 2016. Secondly, concerning firm expenditure in R&D and Innovation, 24˙000 out of 68˙000 firms of the sample, recorded R&D expenditures, in particular: 11˙300 invested more in respect with 2016 expense, 9˙700 invested the same, and 2˙800 invested less. Thirdly, early-stage investments are increasing in Italy but their level is too low comparing to the other main European economies, as we can see in the figure below.

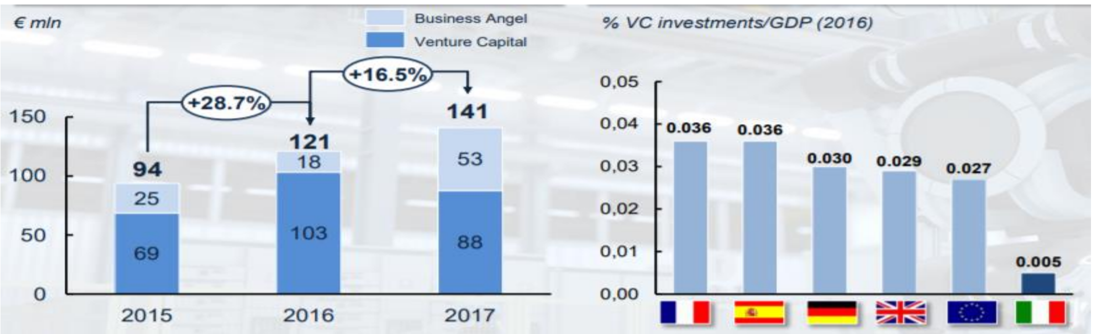


Figure 2.1: Early-stage investments results (MiSE, 2018)

Fourthly, from a labour market point of view, 58˙000 jobs have been created and safeguarded. Fifthly, more than €5 billion has been allocated for incentives and public intervention for new broadband infrastructure. Lastly, there is an ongoing tender referred to Competence Centres foundation.

Concerning the actions to be taken in 2018, primarily the government focused on investments in human capital, due to the challenges for employment posed by Industry 4.0:

- «The ten professions in highest demand on the market did not exist 10 years ago» → so we must innovate study curricula in order to train student on new digital skills and Industry 4.0;

- «Employment will increase in the very countries that have invested in digital skills, and will reduce in those where such skills were not adequately acquired by the labour force» → therefore it is relevant to manage the risk of technological unemployment and maximise new employment opportunities triggered by Industry 4.0, developing new digital skills and competences.

The government planned to invest €95 million between 2018 and 2020 to increase the number of students enrolled in Technical High Institutes, passing from current 9˙000 to about 20˙000. However, Italian current situation is really bad compared to German, French and Spanish ones, respectively they have 760˙000, 529˙000 and 400˙000 students enrolled in Technical High Institutes, namely 84, 58 and 44 times higher than Italian one. Hence, undoubtedly Italy has to invest in order to close the gap.

Another aspect to consider is training of existing labour force, in fact the government provide 40% tax credit on labour costs of personnel following training course in Industry 4.0 topics, with a maximum incentive per firm of €300˙000 per year.

Now, let's see how other world powers deal with the Fourth Industrial Revolution, in particular the cases of Germany, USA, and China.

2.2 Germany: "Industrie 4.0"

"We must (...) deal quickly with the fusion of the online world and the world of industrial production. In Germany, we call it «Industrie 4.0»."

With this statement the German Chancellor, Angela Merkel, talked about the fourth industrial revolution at the World Economic Forum in Davos (Switzerland) in January 2015. It is the national strategic action implemented by the German government through the Ministry of Education and Research (BMBF) and the Ministry for Economic Affairs and Energy (BMWI). The main objective was and is still to increase digitisation and the interconnection of products, value chains and business models, in order to drive digital manufacturing forward. Both Ministries allocated €200 million in funding. We can consider this initiative as a way to strengthen German technological leadership in the mechanical engineering sector, but also in a general view, a way for financing business projects, research centres and provide tax benefits for investments in technological start-ups. Germany considers «Industrie 4.0» vital in ensuring technological leadership. In the Government's Digital Agenda, Industry 4.0 and digitalisation through smart factories and IoTS are placed high, since digital economy and digital workplaces are among the agenda's focus areas. Below we list the main objectives of the action plan:

- ensure an industry fit for future manufacturing in Germany;
- support the integration of cyber physical systems (CPS) and Internet of Things and Service (IoTS) so that improve productivity, efficiency and flexibility of production processes, and ultimately economic growth;
- secure and develop Germany's leading position in industrial manufacturing;
- promote digital structural change and a framework to achieve it;
- develop a consistent overall understanding of Industry 4.0 through dialogue with stakeholders;
- demonstrate how industrial manufacturing can be digitised.

Germany's starting position was positive due to a stable manufacturing labour force and know-how simultaneously with upgraded-technology industry processes. An important role is played by labour unions which are highly integrated in the dialogue and are supportive of technical integration and reorganisations of workplaces. Moreover, companies have shown significant interest in addressing research, prototyping and collaboration in Industry 4.0 matters. (EU, 2017)

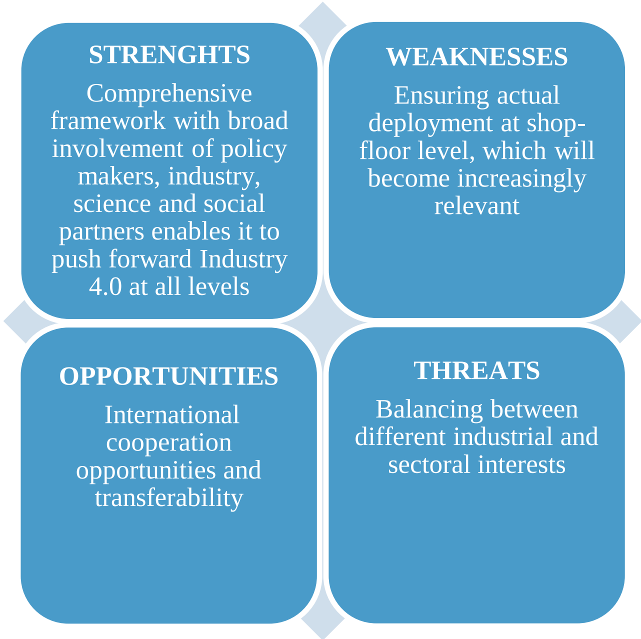


Chart 2.1: SWOT Matrix for Germany's Industry 4.0 (EU, 2017)

The results obtained are attributable to the fact that «Industrie 4.0» has become a dominant trend in terms of collaboration and deployment in a very short-time frame. This measure has been successful in moving from theory to practice, namely form research to testbeds and a reference framework, i.e. RAMI 4.0 (the Reference Architectural Model for Industrie 4.0). This latter has been developed by «Zentralverband Elektrotechnik- und Elektronikindustrie e.V.», an association that represents the economic and technological interests of the German electrical and electronics industry. The association provides consulting services in transport policy, research and technology policy, foreign trade promotion, and environmental policy. In this case ZVEI has developed and combined the idea and concepts of the Industry 4.0 through a three-dimensional map that ensures all participants involved in «Industrie 4.0» discussions understand each other. Below we can see the structure and the elements composing the map:

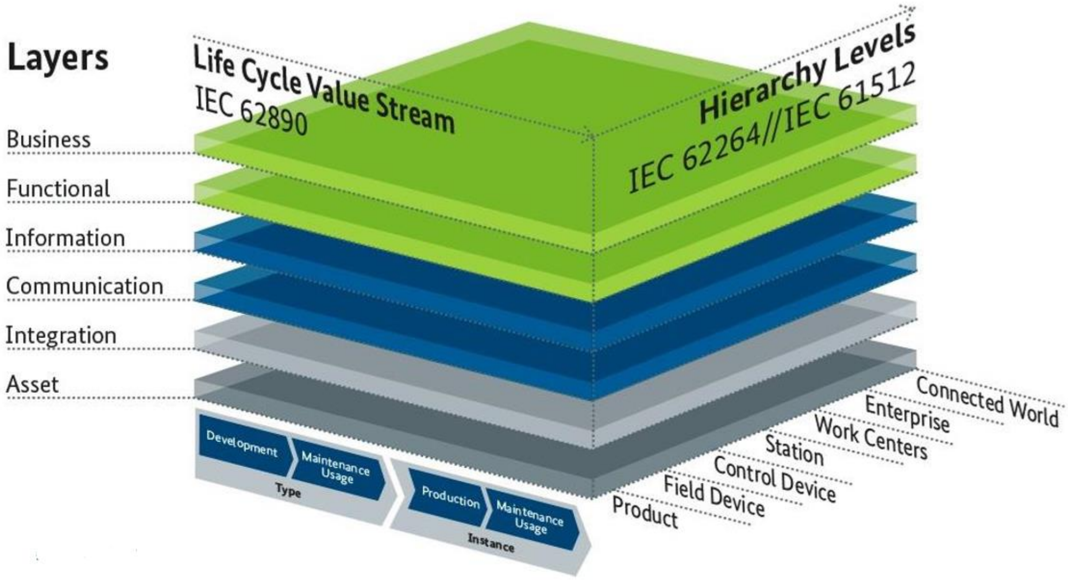


Figure 2.2: RAMI 4.0 3D Map (ZVEI, 2016)

The first axis of the 3D map is hierarchy of the factory 4.0. We can highlight the most relevant differences with the previous factory hierarchy:

Industry 3.0	Hardware-based structure
	Functions are bound to hardware
	Hierarchy-based communication
	Product is isolated
Industry 4.0	Flexible systems and machines
	Functions are distributed throughout the network
	Participants interact across hierarchy levels
	Communication among all participants
	Product is part of the network

Below, we can notice how graphically the differences are more impressive.

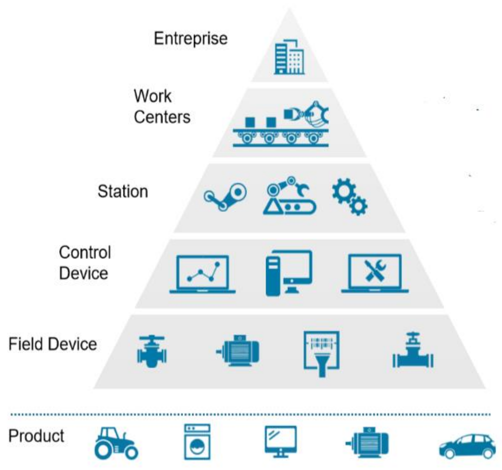


Figure 2.3: Hierarchy in Industry 3.0 **(ZVEI, 2016)**

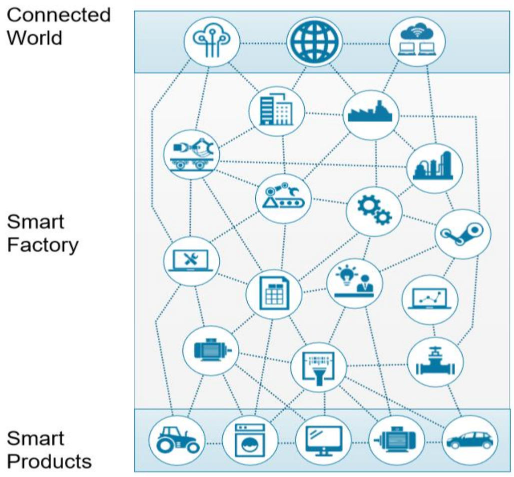
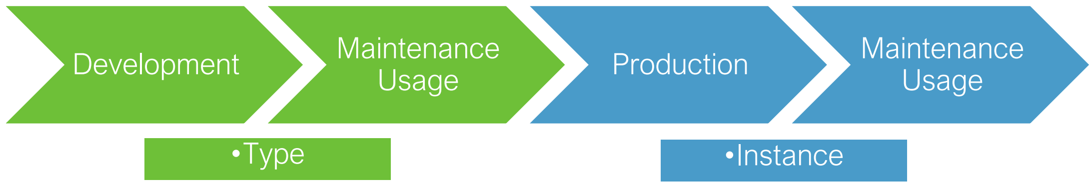
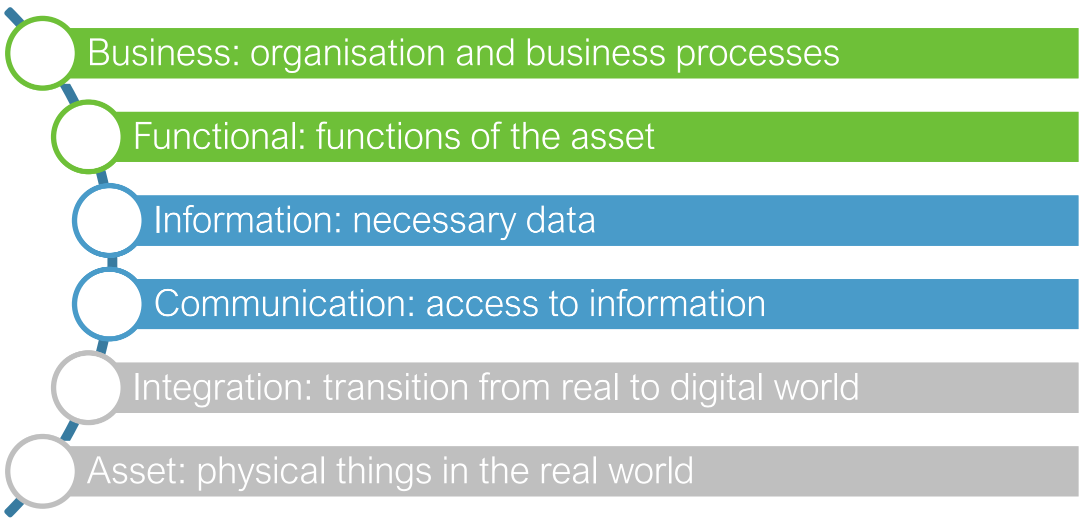


Figure 2.4: Hierarchy in Industry 4.0 **(ZVEI, 2016)**

The second axis of the 3D map is the Product Life Cycle and it is described as follow:



The third axis of the 3D map is the Architecture and we can specify its elements listed below:



After the description of the structural part, it is important to assign the task of connecting to the tangible assets and the IoT world; the RAMI 4.0 calls into question the Administration Shell, a tool which equips any industry component with capabilities to talk and to share information with the digital IoT world.

2.3 USA: "Manufacturing USA"

"Today, I'm calling for all of us to come together- private sector industry, universities, and the government- to spark a renaissance in American manufacturing and help our manufacturers develop the cutting-edge tools they need to compete with anyone in the world. With these key investments, we can ensure that the United States remains a nation that 'invents it here and manufactures it here' and creates high-quality, good paying jobs for American workers."

It was on 24th June 2011 when President Obama launched the Advanced Manufacturing Partnership (AMP), a national effort bringing together industry, universities, and the federal government to invest in the emerging technologies that will create high quality manufacturing jobs and enhance our global competitiveness. Investing in technologies, such as information technology, biotechnology, and nanotechnology, will support the creation of good jobs by helping U.S. manufacturers reduce costs, improve quality, and accelerate product development. (The White House, 2011)

Considering the fact that USA has been the leading economy for many years, and that only recently has been unseated by China, it is relevant for the government to support and collaborate with industry and the university, in order to rediscover again the ability to innovate that enabled it to be the leader of the manufacturing countries. Some of the most important initiatives supported by the US government are discussed at the government's Advanced Manufacturing Portal (http://manufacturing.gov/), and these initiatives shall focus on pushing forward the Industry 4.0, and leveraging on this latter, to allow manufacturing sector growth. The most important initiative concerns the establishment of the National Network for Manufacturing Innovation (NNMI), also known as "Manufacturing USA", which consists of research institutes focused on developing and also commercializing manufacturing technologies through public-private partnership among U.S. industry, universities, and federal government agencies. (Wikipedia, 2017)

There are currently fourteen institutes focused on different technological fields:

INSTITUTE	TECHNOLOGY
Advanced Functional Fabrics of America	Textiles
American Institute for Manufacturing Integrated Photonics	Photonic integrated circuits
America Makes	Additive manufacturing and 3D printing
Advanced Robotics Manufacturing	Robotics
BioFabUSA	Regenerative medicine / tissue engineering
Clean Energy Smart Manufacturing Innovation Institute	Smart sensors
The Digital Manufacturing and Design Innovation Institute	Digital manufacturing
The Institute for Advanced Composites Manufacturing Innovation	Lightweight materials
Lightweight Innovations For Tomorrow	Lightweight materials
NextFlex	Hybrid electronics
The National Institute for Innovation in Manufacturing Biopharmaceuticals	Biopharmaceutical
Power America	Semiconductor components
Rapid Advancement in Process Intensification Deployment Institute	Chemical processing
Reducing EMbodied-energy And Decreasing Emissions	Recycling

Table 2.1: Institutes part of "Manufacturing USA" (Manufaturing USA, 2018)

In order to launch the AMP, ex-President Obama announced several key steps undertaken by the federal government:

INITIATIVE	INVESTMENT
Building domestic manufacturing capabilities in critical national security industries	$ 300 million
Reducing the time to develop and deploy advanced materials	$ 100 million
Investing in next-generation robotics	$ 70 million
Developing innovative energy-efficient manufacturing processes	$ 120 million
New approaches that reduce the time required to design, build and test manufactured goods, so as to meet Defense Department needs	n.a.
Form a multi-university collaborative framework for sharing of educational materials and best practices relating to advanced manufacturing and its linkage to innovation	n.a.
Development of an advanced manufacturing technology consortium	$ 12 million
Proctor & Gamble announces that it will make available advanced software at no cost to American small and mid-sized manufacturers	n.a.
Department of Energy launch of an initiative with the Ford Motor Company and the National Association of Manufacturers to make use of the Department’s National Training & Education Resource to educate and train a new generation of manufacturers	n.a.
Defense Department invests in domestic manufacturing technology that address urgent operational needs including improvements for transparent armor, stealth technology, and targeting systems	$ 24 million

Table 2.2: Major commitments to Advanced Manufacturing (The White House, 2011)

There is a worth mentioning report presented by the AMP Steering Committee and by The President's Council of Advisors on Science and Technology (PCAST), that illustrates 16 recommendations aimed at reinventing manufacturing in a way that:

- it ensures U.S. competitiveness;
- it feeds into the Nation's innovation economy;
- it stimulates the domestic manufacturing base.

The goal is to place U.S. to lead the world in innovative disruptive advanced manufacturing technologies that are changing the aspect of manufacturing. Below se summarize the recommendations grouped around three pillars:

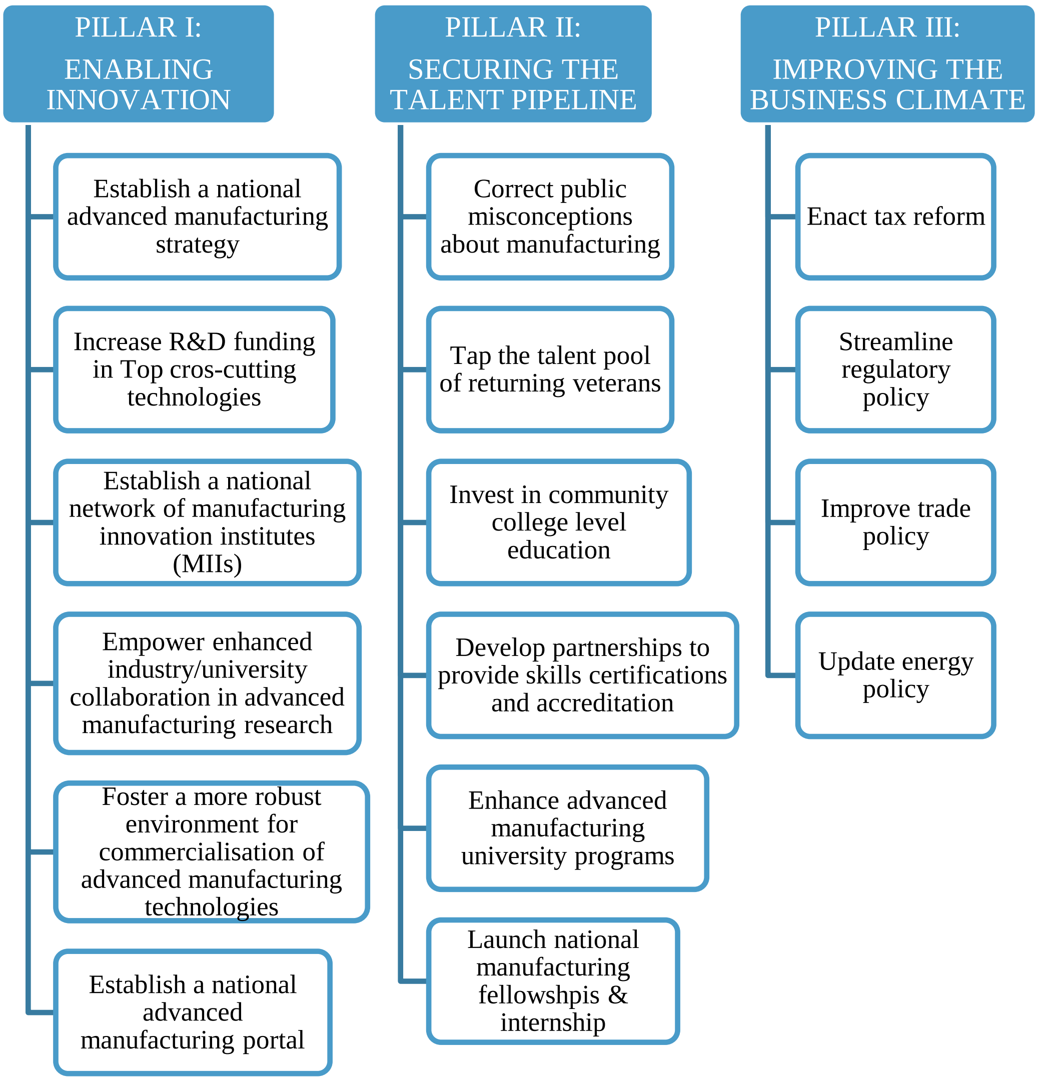


Figure 2.5: Recommendations for advanced manufacturing in the U.S. (PCAST, Report on capturing domestic competitive advantage in advanced manufacturing, 2012)

In October 2014 the Advanced Manufacturing Partnership (AMP 2.0) was re-chartered and it collaborated with the federal government to implement the highest priority recommendations from its original report.

	PILLAR I: ENABLING INNOVATION
Recommendation #1	Establish a national strategy for securing U.S. advantage in emerging manufacturing technologies
Recommendation #2	Create an Advanced Manufacturing Advisory Consortium
Recommendation #3	Establish a new public-private manufacturing research and development infrastructure to support the innovation pipeline
Recommendation #4	Develop processes and standards
Recommendation #5	Create a shared National Network for Manufacturing Innovation (NNMI) governance structure
	PILLAR II: SECURING THE TALENT PIPELINE
Recommendation #6	Launch a national campaign
Recommendation #7	Encourage private investment in the implementation of a system of nationally recognized, portable, and stackable skill certifications that employers utilize in hiring and promotion
Recommendation #8	Make the development of online training and accreditation programs eligible to receive federal support
Recommendation #9	Curate all documents created by AMP 2.0
	PILLAR III: IMPROVING THE BUSINESS CLIMATE
Recommendation #10	Leverage and coordinate existing federal, state, industry group and private intermediary organizations

Recommendation #11	Reduce the risk associated with scale-up of advanced manufacturing
	IMPLEMENTATION
Recommendation #12	The National Economic Council (NEC) and the Office of Science and technology Policy (OSTP), within 60 days, should submit to the President a set of recommendations

Table 2.3: Summary of the Advanced Manufacturing Partnership 2.0's Recommendations (PCAST, 2014)

The American way to Industry 4.0 has different shapes, but analog objectives in respect with the European way, in particular the German one, which has been the epicentre of the fourth industrial revolution. In fact, the U.S. commits to the smart product, Germany to the smart factory. In the former prevails the final customer relationship, in the latter the manufacture. The American version of Industry 4.0 has a direct connection with the "back to manufacturing" of the Obama's administration. Massimiliano Granieri, intellectual and industrial property professor at University of Brescia and at the Office Technology Transfer at the University of California, states:

> *"They are two convergent phenomena, that arise from the newfound awareness that the new industry gives identity to a complex society like the American one, giving a stronger job security compared with other sectors."* *(Bricco, 2016)*

2.4 China: "Made in China 2025"

As any other super-powerful country, China thought about an Industry 4.0 implementation plan in May 2015, obviously after Germany, source of inspiration since 2011, and presented to the world an ambitious industrial masterplan called "Made in China 2025". This strategic plan considers, as main objective, that China will maintain and strengthen its dominant position, among world's most advanced and competitive economies, through the adoption of the most innovative manufacturing technologies. The most high-tech industries that have a remarkable impact in an advance economy, such as China, are: automotive, aviation, robotics, high-tech maritime and railway equipment, energy-saving vehicles, medical devices and information technology. The Chinese government is conscious that most of industrial manufacturing process are outdated and so, it hopes that upgrading to a smart manufacturing will increase domestic and international competiveness of companies. Due to the fact that China is technologically a step backwards in respect to U.S. and the European advanced economies, it initially had a huge demand for smart manufacturing technologies, such as industrial robots, sensors and advanced chips. Those benefiting from Chinese technological upgrading where those supplier Countries with high-tech manufacturing companies able to provide high quality smart manufacturing “products”. However, this is a short-term solution because the forward-looking one, based on the “Made in China 2025”, wants to substitute foreign products with Chinese one, basically domestic produced. In fact, foreign competitors in China have a lot of barriers and difficulties, in particular:

- the closing of the market for information technology;
- the exclusion from local subsidy schemes;
- the low level of data security;
- the intensive collection of digital data by the Chinese state. (Wübbeke et al., 2016).

An important aspect that should not be neglected concerns the acquisitions of international high-tech company made by Chinese investors, done to speed up the technological upgrading, rather than develop it internally. Moreover, since the beginning, the Chinese government has decided to invest a large amount of money in the fourth industrial revolution. We are talking about €2.7 billion for the Advanced Manufacturing Fund and €19 billion for the National Integrated Circuit Fund, namely about hundred times more than German federal funding (€200 million).

Below we summarise the pros and cons of the “Made in China 2025” strategic plan:

+	−
great impact on China's domestic markets;	lack of bottom-up initiative and investment;
great impact on international markets;	China’s economy is currently experiencing downward pressure;
succeed in elevating a small avanguard of Chinese manufaturers;	upgrading the production processes might result in job losses among the less skilled workforce;
higher level of efficiency and productivity;	China’s education system is not prepared for training skilled personnel capable of operating sophisticated smart manufacturing tools;
frontrunners will dominate their sectors on the Chinese market;	ambitious timeframe set by the Chinese leadership;
frontrunners will become fierce fierce competitors on international markets;	
will rapidly increase the global competitiveness of key Chinese companies.	

Table 2.4: Pros and cons of "Made in China 2025" (Wübbeke et al., 2016)

The technological starting level of Chinese industrial fabric is very low and there is a lack of digitisation. Recalling the data included in Chart 4, where there is a list of the top worldwide robot adopter countries, we can notice that China is basically missing, because Chinese firms use 19 robots every 10.000 workers on average. This is the reason why China is currently undergoing a period of growing demand for high-tech automation systems and digitisation technologies. The Chinese government knows this situation and so it decided to implement “Made in China 2025”, a top-down strategy, that by the definition foresees that the government intervenes with policies, given less space to entrepreneurial initiatives, typical of the bottom-up strategy supported in Italy, U.S. and Germany.

Below we highlight the strengths and the weaknesses of the plan, and the result is a balanced situation:

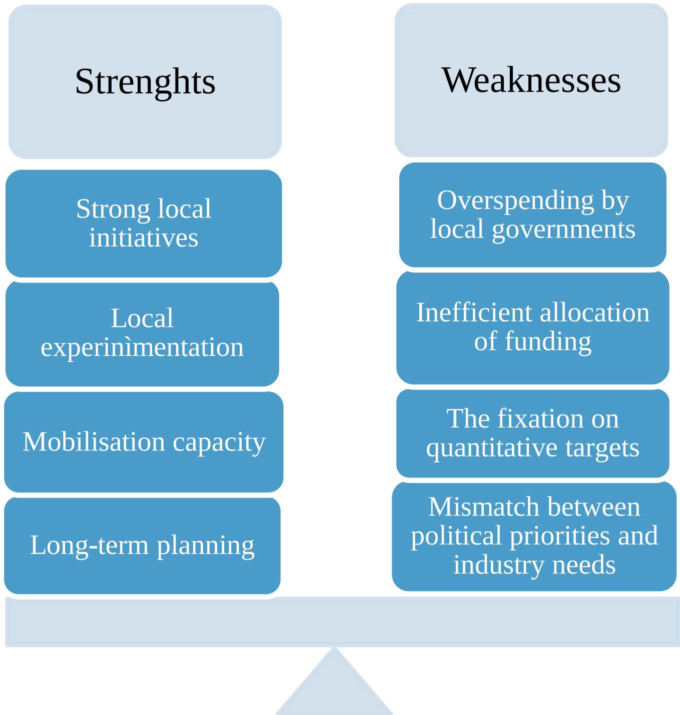


Figure 2.6: Strengths and Weaknesses of "Made in China 2025" (Wübbeke et al., 2016)

2.5 National plans summary

In the following table we summarise the main features of the plans concerning the countries just analysed:

COUNTRY	PLAN	FEATURES	INVESTMENT
ITALY	"Piano Nazionale Impresa 4.0"	Hyper-depreciation Super-depreciation Tax Credit to research «Nuova Sabatini» Patent Box Innovative start-ups and SMEs	€45 million: based on €34 million in public funding and €11 million in private funding (European Commission, Key lessons from national industry 4.0 policy initiatives in Europe , 2017)
GERMANY	"Industrie 4.0"	Increase digitisation Interconnection of products, value chains and business models	€200 million complemented by financial and in-kind contributions from industry

GERMANY	"Industrie 4.0"	Tax benefits for investments in technological start-ups Financing business project and research centres	(European Commission, Key lessons from national industry 4.0 policy initiatives in Europe , 2017)
U.S.A.	"Manufacturing USA"	Invest in the emerging technologies that will create high quality manufacturing jobs and enhance our global competitiveness establishment of the NNMI: research institutes focused on developing and commercializing manufacturing technologies	\$625 million invested by the government \$70-20 million federal investment per institute over 5/7 years \$481 million in private funding (National Institute of Standards and Technology, 2017)
CHINA	"Made in China 2025"	M&A of international high-tech company made by Chinese investors Government funds and subsidies	€2.7 billion for the Advanced Manufacturing Fund €19 billion for the National Integrated Circuit Fund (Wübbeke et al., 2016)

Table 2.5: National plans summary

CHAPTER THREE

3 EMPIRICAL ANAYSIS

“Manufacturing activities and value creation: redesigning firm's competitiveness through digital manufacturing in a circular economy framework”, this is the title of the Research Project conducted by a research group of the “Marco Fanno” Department of Economics and Business Science of the University of Padua (DSEA), coordinated by Prof. Eleonora Di Maria and Prof. Marco Bettiol. The research is founded on three main objectives, below listed:

1. to examine how Italian firms have adopted Industry 4.0 digital technologies;
2. to analyse how Italian firms cope with Industry 4.0 technologies, in particular concerning the difficulties and the benefits found in the implementation of them both at a production and competitive level;
3. to study how Industry 4.0 affects production and innovation business activities.

In this chapter we will explain how the research has been conducted, the type of sample in object and the results obtained by the survey.

3.1 Methodology and sampling

In order to conduct the research, students used a survey that could be completed directly online on the platform Surveymonkey, where the interviewer or the company interviewed basically filled in the answers to the questions. The answers were multiple choice, few words or a number. Obviously, the survey was structured in two different ways: the shortest one, for those companies that did not adopt Industry 4.0 technologies, and the longest one, for those that adopted at least one out of seven technologies. The geographical area subject to the research was the North Italy, in particular the following regions: Friuli-Venezia Giulia, Veneto, Trentino-Alto Adige, Lombardy, Emilia-Romagna and Piedmont.

Regarding the sectors subject to the analysis, the research team selected 10 sectors and below we can find a table listing them with the corresponding ATECO code, provided by the Italian national statistical institute, ISTAT, and the period in which the data have been collected.

ATECO CODE	SECTOR	PERIOD
13	Textile	17th July – 30th October 2017
14	Apparel	17th July – 30th October 2017
15	Leather goods and shoes	10th October – 20th December 2017
22 **22.1** **22.2**	Rubber and plastic goods	3rd May – 15th September 2017
27 **(no 27.9)**	Electric equipment	3rd May – 15th September 2017
29	Automotive	3rd May – 15th September 2017
31	Furniture	3rd May – 15th September 2017
32.12.1 **32.12.2** **32.13.0**	Jewellery	3rd May – 15th September 2017
32.3 **32.9**	Sport goods	3rd May – 15th September 2017
32.50.5	Glasses and Lens	3rd May – 15th September 2017

Table 3.1: Industry sector selected for the analysis

After that, the research team extracted the information concerning all the companies falling into the sectors subject to the analysis. In order to do that, we used AIDA, a database available to the Department, which contains all relevant information we needed, in particular: company name, telephone number, legal form, VAT registration number, year of establishment, ATECO code, fiscal code, address, turnover in €k, and number of employees. AIDA database contains financial, biographical and commercial data on over 200˙000 companies operating in Italy. The sample resulting from the AIDA database, containing all northern companies of the sectors we were interested in, has been further reduced because we excluded all companies that had a 2015 turnover less than €1 million, except for lighting equipment, jewellery, sport goods and glasses sectors. This fact was justified by necessity of including businesses of sectors that are characterized by districts containing a lot of small businesses. In the next table we listed all companies belonging to the sample, from a point of view as generic as possible, and then we divided those companies exceeding the €1 million 2015 turnover from those that did not exceed it.

ATECO CODE - SECTOR		Turnover > €1 M	Turnover ≤ €1 M	Total
13	Textile	1432	2417	3849
14	Apparel	1230	3931	5161
15.2	Leather goods and shoes	729	1130	1859
15.11	*Leather tanning and dyeing of fur*	308	/	
22.19.01	*Rubber soles and other rubber parts*	421	/	
22.29	*Plastic material goods*			
22	Rubber and plastic goods	2558	1274	3832
22.1	*Rubber goods*	413	184	
22.2	*Other plastic material goods*	2145	1090	
27	Electric equipment	2032	1609	3641
27.0-27.5	*Electric equipment*	1117	850	
27.4	*Lightning equipment*	230	253	
27.9	*Other electric equipment*	685	506	
29	Automotive	702	384	1086
31	Furniture	1627	1414	3041
32.1	Jewellery	306	377	683
32.3-32.9	Sport goods	109	98	207
32.50.5	Glasses and Lens	111	78	189
TOTAL		**16155**	**15595**	**23548**

Table 3.2: Sample composition

Focusing more in detail on Table 3.2, we highlighted in blue the numbers corresponding to the companies potentially included in the sample and we wrote in blue the sectors whose companies have a turnover lower than €1 million. Anyway, the total number of companies hypothetically included in the sample subject to the survey was composed by all the companies over the €1 million threshold (16˙155) and the companies below the threshold (806) part of the sectors mentioned above. Hence, we obtained a total of 16˙961 companies theoretically part of the sample. However, in practice, the number of companies assigned to the team is about half of it, as we can see below in the next table.

ATECO CODE - SECTOR		Population assigned to the team
13	Textile	1432
14	Apparel	1230
15.2	Leather goods and shoes	729
15.11	*Leather tanning and dyeing of fur*	*308*
22.19.01	*Rubber soles and other rubber parts*	*421*
22.29	*Plastic material goods*	
22.1	Rubber goods	413
27.0-27.5	Electric equipment	1117
27.4	Lightning equipment	483
29	Automotive	702
31	Furniture	1627
32.1	Jewellery	683
32.3-32.9	Sport goods	207
32.50.5	Glasses and Lens	189
TOTAL		**8812**

Table 3.3: Population composition

The population assigned to the team can be analysed from a dimensional point of view, in particular using the European Commission classification:

Company category	Staff headcount	Turnover	or Balance sheet total
Medium-sized	< 250	≤ € 50 m	≤ € 43 m
Small	< 50	≤ € 10 m	≤ € 10 m
Micro	< 10	≤ € 2 m	≤ € 2 m

Table 3.4: Size definition table (European Commission, 2003)

The result of the organisation of companies by size is summarised in the table and chart below:

Population assigned to the team	n°	%
≤ €1 M	806	9,1
Micro	2199	25,0
Small	3624	41,1
Medium	1270	14,4
Large	913	10,4
Total	**8812**	**100**

Table 3.5: Size division of the population

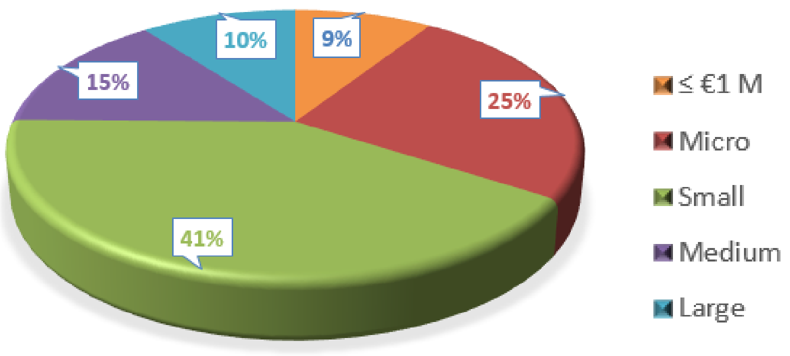


Chart 3.1: Size division of the population in %

We can notice that the major part of the population is given by small-sized companies (41%), followed in descending order by micro-sized companies (25%), medium-sized companies (15%), large-sized companies (10%) and last by companies with a turnover lower than €1 million (9%).

Moreover, we can analyse population composition by geographical area, dividing them by region, as we can see as follows in Table 3.6 and in Chart 3.2.

Region	**Population**	**%**
Emilia-Romagna	1129	12,8
Friuli-Venezia Giulia	384	4,4
Lombardy	3554	40,3
Piedmont	993	11,3
Trentino-Alto Adige	140	1,6
Veneto	2612	29,6
Total	**8812**	**100**

Table 3.6: Regional division of population

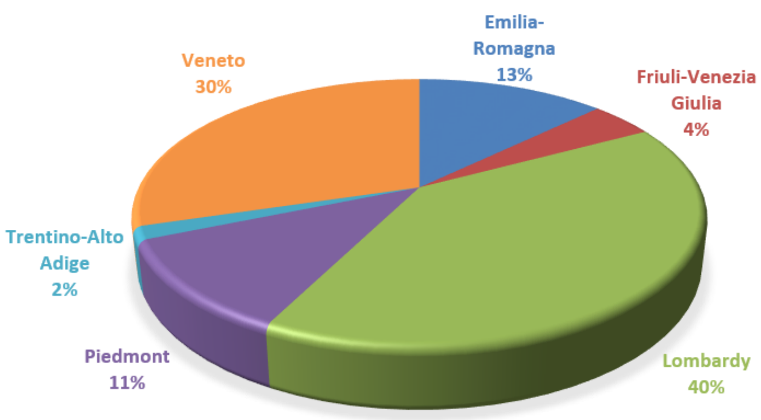


Chart 3.2: Regional division of population in %

The results of the geographical/regional division are quite impressive, because about 70% of the population is located in Lombardy and Veneto, respectively 40,3% and 29,6%. The remaining part is located in Emilia-Romagna (12.,8%), Piedmont (11,3%), Friuli-Venezia Giulia (4,4%) and Trentino-Alto Adige (1,6%).

In the following Table 3.7, we presented the number of respondents to the survey on the online platform divided by sector. The resulting total number of respondents to the Surveymonkey's questionnaire is 1˙129. In the fourth column we have calculated the percentage of respondents by sectors given the total of respondents. The sectors which has obtained the highest percentages are: electric equipment (23,5%), shoes manufacturing (18,6%), leather goods (15,1%), and Jewellery (12,7%). In the last column we showed the response rate within each sector. The highest percentages have been reached in the following sectors: leather goods (55,5%), shoes manufacturing (49,9%), electric equipment (23,7%), and jewellery (20,9%). The lowest response rates have been obtained in the sectors of textile (1,5%), rubber goods (2,7%), furniture (3,9%), and apparel (5%).

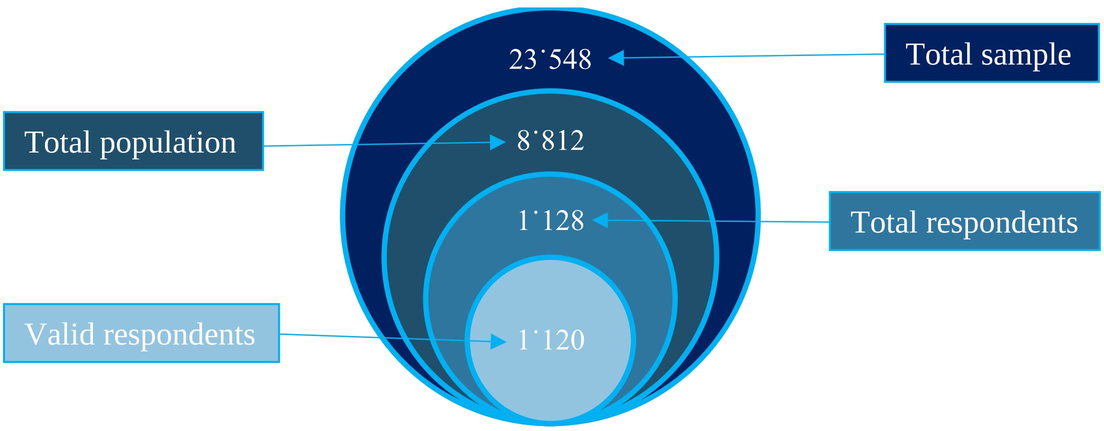
In the following empirical analysis we will not consider the textile sector because the results coming from it have been erroneously submitted by companies that fall into other ATECO code. Hence, in order to maintain the analysis as objective as possible, the textile sector will not be taken into consideration for future reference.

Finally, we want to underline the fact that eight companies had to be removed from the dataset mainly due to tax numbers or business names not found or non-existent. In the case of a double entry for the same company, the most complete response was kept as valid while the other was deleted from the database. (Bragagnolo, 2017)

Hence, the final sample comprises 1˙120 companies in total, after having cleaned up the final value from duplicates and discrepancies.

ATECO CODE	SECTOR	n° of respondents	% in respect to the tot respondents	% in respect to the sector
13	Textile	21	1.9	1.5
14	Apparel	61	5.4	5
15.2	Leather goods and shoes			
15.11	*Leather tanning and dyeing of fur*	*171*	*15.2*	*55.5*
22.19.01	*Rubber soles and other rubber parts*	*209*	*18.5*	*49.9*
22.29	*Plastic material goods*			
22.1	Rubber goods	11	1.0	2.7
27.0-27.5	Electric equipment	265	23.5	23.7
27.4	Lightning equipment	72	6.4	14.9
29	Automotive	56	5.0	8
31	Furniture	64	5.7	3.9
32.1	Jewellery	143	12.7	20.9
32.3-32.9	Sport goods	17	1.5	8.2
32.50.5	Glasses and Lens	38	3.4	20.1
TOTAL		**1128**	**100**	**17.9**

Table 3.7: Respondents, numbers and percentages



In the next paragraph we will deeply analyse the final sample considering the number of employees, the turnover and the regional distribution of the respondents.

3.2 Aggregate sample description

As already anticipated, we decided to analyse the final sample obtained in respect with the size of the companies using two measures: the number of employees and the turnover; and in respect with the geographical distribution. Before starting the analysis based on the number of employees belonging to the 1˙120 respondents, we considered as yardstick the classification of the European Commission already seen before in Table 3.4. Here below a recall concerning the part we are interested into:

Company category	Staff headcount
Medium-sized	< 250
Small	< 50
Micro	< 10

Table 3.8: Classification of the European Commission (European Commission, 2003)

Now we can underline, through the next table, the dimension of the respondents based on the number of their employees.

Size	n° of companies	%
MICRO	317	28,5
SMALL	669	60,1
MEDIUM	118	10,6
LARGE	10	0,9
TOTAL	1114	100

Table 3.9: Respondents divided by dimension based on n° of employees

First of all, we point out that the total number of respondents is lower than the final sample (1˙120) due to the fact that not all companies provided the number of employees of the year 2015. However, the total resulting from the analysis maintains its reliability and completeness. As we can imagine, the major part (60%) of the respondents is represented by small companies, due to the typically small-oriented Italian fabric. In support of this, we added the 28,5% of micro companies belonging to the overall respondents. With a simple calculation we obtain that the 88,6% of the respondents has less than 50 employees, demonstrating again that the potential of the Italian manufacturing fabric is composed by small realities; and another proof is given by the small number of large companies belonging to the respondents, only 0,9%. Last, we underlined the presence of medium-sized companies, the 10,6% of the sample, evidence of the fact that a little slice of the pie has a remarkable size in terms of employees.

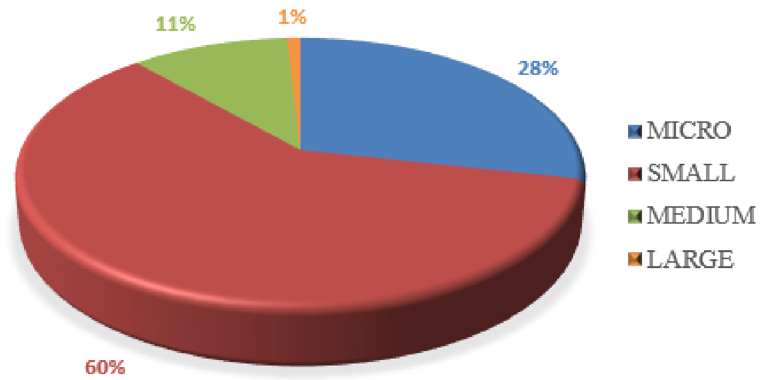


Chart 3.3: Pie divided by the % for each size, compared to the n° of employees

In the next rows we will analyse the dimension of the companies by dividing them in terms of turnover. In particular, we used the data of 2015 – as for the employees – for sake of completeness because those of 2016 were often not available, so we preferred a less recent data analysis, in respect to an analysis with a lot of shortcomings. In the following table (Table 3.10) we summarised the number of companies that answered to the survey, dividing them by size, using as yardstick their 2015 turnover, basing the division by size on the standard of the European Commission (European Commission, 2003). Basically, we followed these classification:

- Micro ≤ €2 M
- €2 M < Small ≤ €10 M
- €10 M < Medium ≤ €50 M
- Large > €50M

Looking at the numbers we have obtained from this division, first of all, we underline the fact that we take into account also companies with less than €1 million turnover, because the data from AIDA was complete. We can notice than the major part of the companies belongs to the small-sized category (43,9%), followed by micro-sized

(28,6%), medium-sized companies and those with less than €1 M turnover, respectively 12,8% and 12,7%, and last the large companies (2%).

Size	n° of companies	%
<1M	142	12,7
MICRO	319	28,6
SMALL	490	43,9
MEDIUM	143	12,8
LARGE	23	2,1
TOTAL	1117	100

Table 3.10: Respondents divided by dimension based on turnover

In Chart 3.4 we can better see the division by size, in fact about half of the pie belongs to small-sized companies, about one-third to micro-sized and the remaining one-third to large, medium and less than €1 M turnover companies.

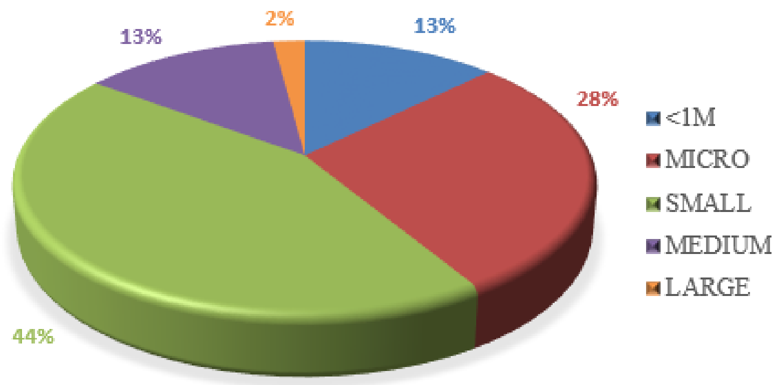


Chart 3.4: Pie divided by the % for each size, compared to the turnover

We did a comparison between percentages obtained with division based on employees and division based on turnover of the companies. The results obtained are shown in the following table (Table 3.11).

Size	%, employee	%, turnover	|Δ%|
MICRO	29	29	**0**
SMALL	60	44	**16**
MEDIUM	11	13	**2**
LARGE	1	2	**1**

Table 3.11: Gap between turnover and employees' analyses

We pointed out the fact that the gap is inconsistent looking at micro, medium and large categories, respectively no difference, 2% and 1% gap; whereas the 'small' category has shown a remarkable gap (16%). We supposed that using the classification of European Commission - which considers 'small' a company with more than 10 and less than 50 employees, or more than €2 million and less than €10 million - can create discrepancies due to the fact that, basically, there is not a rule linking the number of employees and the turnover of company. There will be more efficient and productive companies that with less employees, get a turnover similar to companies with more employees. Obviously, this type of analysis may be extremely articulated.

Lastly, from a geographical point of view, we analysed how companies, that answered to the survey, are distributed at regional level in the North of Italy. We started from Table 3.12, where we can see how, numerically speaking, companies are located.

Region	n° of companies	%
Emilia-Romagna	123	11,0
Friuli-Venezia Giulia	35	3,1
Lombardy	315	28,1
Piedmont	117	10,5
Trentino-Alto Adige	17	1,5
Veneto	512	45,6
Other	2	0,2
TOTAL	1121	100

Table 3.12: Regional distribution of companies

In Figure 3.1 we represented a map of the North of Italy characterized by regions coloured with more intense colour if the number of companies located in is higher.

The region with the most remarkable number of companies is Veneto, with 512 companies corresponding to the 45,6% of the respondents. Then we found Lombardy, with about 200 companies less (315), corresponding to the 28,1%. The other two noteworthy regions are Emilia-Romagna, that has 123 companies (11,0%), and Piedmont, with 117 companies (10,5%). Friuli-Venezia Giulia and Trentino-Alto Adige close the loop, respectively with 35 (3,1%) and 17 (1,5%).

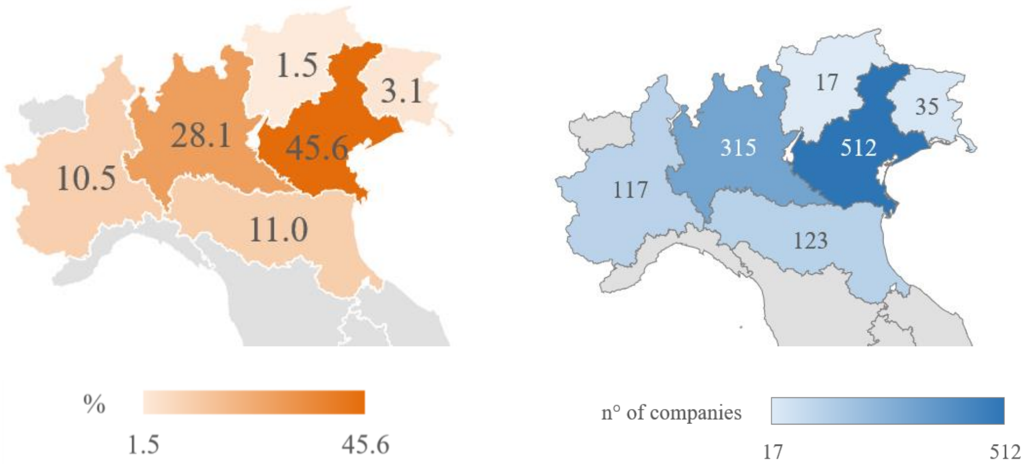


Figure 3.1: Northern Italy map, %

In the following paragraphs we will analysed the specific results obtained by the survey.

3.3 Footwear and tanning sample description

Before describing the type of survey conducted, we have to specify that the sectors under investigation were two: the footwear sector and the tanning sector. Concerning the former, Italy is the first producer of shoes in EU, and the eleventh producer, in terms of number of pair, in the world. It is the leader among producers of high-end and luxury goods. There are about 5˙000 companies and 80˙000 employees in this specific sector, with a total annual turnover of €14,2 billion. The sector is characterised by a vivid entrepreneurial capacity and by a particular value chain which includes a system of subcontracting that range from raw material, manufacturers of machineries, tanneries and components to accessorises, pattern makers and stylists. (Assocalzaturifici, 2016)

The result is a concentration in specific areas, called districts, such as: Riviera del Brenta's district, Montebelluna's district, San Mauro Pascoli's district, Vigevano's district and Verona's district. In Table 3.13 we summarised the numbers relative to the main important districts of the footwear sector in the Northern Italy. The five biggest districts constitute the 65% of the companies belonging to the sample (421). One fourth of the companies are part of the Riviera del Brenta's district, whereas the 17%

are located in the Treviso area, 25 out 72 specifically in Montebelluna. About the ten percent of the companies are established in San Mauro Pascoli (20) and in Vigevano (19).

Province *(District)*	**n° of companies**	**%**
Padova/Venezia *(Riviera del Brenta)*	105	25
Treviso *(Montebelluna)*	72 *(25)*	17 *(6)*
Forlì-Cesena *(San Mauro Pascoli)*	37 (20)	9 *(5)*
Verona	35	8
Pavia *(Vigevano)*	25 *(19)*	6 *(5)*
TOTAL	274	65

Table 3.13: Numerical analysis of the main districts of the Northern Italy

We can undoubtedly state that the footwear sector is one of the pillars of the Fashion Industry.

Regarding the tanning sector, in 2016, it has realised the 65% of the total annual turnover in EU and the 19% at a global level. Italian players imported 800 thousand tons of raw materials and semi-finished products, for an economic value of €2,3 billion, whereas they exported tanned leather goods for an economic value of €3,8 billion. There are about 1˙200 companies and 17˙600 employees in this specific sector, with a total annual turnover of €5 billion. The most important region in the tanning sector is Veneto (in particular the area of Arzignano, province of Vicenza) with the 55% of the national market, followed by Tuscany (in particular the area of Santa Croce sull’Arno, province of Pisa) with the 28,5%. The destination sectors of the tanned leather are: footwear (41,8%), leather goods (24%), furniture (15,8%), bodywork (11,2%), and clothing and gloves (5,1%) (Unione Nazionale Industria Conciaria, 2016).

Furthermore, even the tanning sector is characterised by concentration in districts, in particular, the most important is the Vicenza’s district (specifically the “triangle” Arzignano – Montebello Vicentino– Valle del Chiampo) with about 450 companies and 8˙300 employees. Another remarkable district is the Santa Croce sull’Arno’s one, with 520 companies and 5˙800 employees. (Ulivieri, 2017)

In our sample, the tanneries located in the district of Vicenza are 238 out of 308, in particular, 91 are established in Arzignano (30%), 49 in Chiampo (16%) and 22 in

Montebello Vicentino (7%). Hence, the 53% of our sample is located in this “triangle” in Figure 3.2.

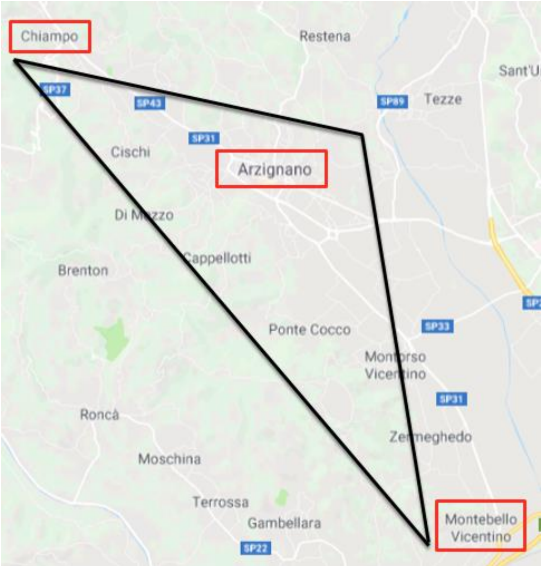


Figure 3.2: The "triangle" of Chiampo-Arzignano-Montebello Vicentino (Google Maps, s.d.)

3.4 Contents of the survey

The survey contains 38 questions, articulated as follows:

- The first three questions concern the name and the sector of the company, and the technologies relating to Industry 4.0 that it adopts. If the company does not adopt any of the listed technologies, the survey will finish with question n°4, related to the reasons behind the non-adoption of 4.0 technologies; then, the company can decide if it wants to be informed on the results of the research (question n°37) and, despite the decision, the interviewer enters the fiscal code of the company (question n°38).
- Questions n°5, 6 and 7 ask to the company the sector and the production specialisation, the n° of employees (total, in the production line, in the R&D or innovation function and in the marketing function) and the 2016 turnover.
- Question n°8 focuses the attention to the first factor of competitive advantage of the company (quality, innovation, design, etc.)
- Question n°9 is related to the export information.

- Questions n°10 and 11 concern R&D spending.
- From question n°12 to question n°19 we gather information about: the year of adoption, the processes updated to Industry 4.0 standards and the types of technologies adopted in each process, the customised integration of the technologies and the reasons behind the investment.
- From question n°20 to question n°29 we try to understand the impacts, the results obtained, the main difficulties, the changes in the working environment, in the products peculiarities and in the environmental impacts.
- From question n°30 to question n°36 we conclude the survey gathering information about products and production.

3.5 The results

In this paragraph we analyse the results obtained through the surveys compiled by the companies, or by the interviewers, in the online platform Surveymonkey. The analysis will be done question by question, looking at the answers given by the companies.

3.5.1 Adopters vs. Non-Adopters

First of all, thanks to questions n°3 and n°4, we made the first significant distinction:

- we considered as "adopters", those who in question n°3 claimed to own at least one the listed technologies (in the next rows), obviously belonging to the Industry 4.0 world;
- whereas, we treated as "non-adopters", those who in question n°3 said they do not own technologies 4.0.

We considered question n°3 as the crossroad between adopters and non-adopters, because the survey has basically taken two different directions. This question specifically asked companies if they own at least one or more of the following technologies:

- Robot
- Additive Manufacturing (hereafter referred to as AM)

- Laser Cutter
- Big Data & Cloud
- 3D Scanner
- Augmented Reality (hereafter referred to as AR)
- Internet of Things (hereafter referred to as IoT)

If the companies do not own any of the listed technologies, they become a “non-adopters” and they complete the survey with question n°4, in which they were asked to select the reasons behind the choice to not adopt technologies 4.0, by choosing among:

- Lack of economic resources
- Lack/limited internal competences
- Lack of an adequate internal technological infrastructure
- Scarce topic knowledge
- Uncertain ROI
- Not of interest to our business
- Under evaluation

Now, we focus our attention on the data obtained by the answers to these first questions, starting from the non-adopters’ category. The first quantitative aspect to consider is the number of companies that have displayed a positive approach to the interview request made by the interviewer. Specifically, in the footwear and tanning sectors, the results are summarised below, in Table 3.14.

		FOOTWEAR SECTOR	TANNING SECTOR
Sample to interview		421	308
Interview denied		44	41
Unreachable		50	78
Mail contact, but no answer		102	8
Do not produce		15	10
Interviewed		**210**	**171**
Of which:	**Non-Adopters**	**195**	**170**
	Adopters	**15**	**1**

Table 3.14: Types of feedback obtained from the survey and relative quantities (n° of companies)

As we can see, there are 729 companies belonging to the Fashion category of the research, respectively 421 for the footwear sector and 308 for the tanning sector. The interviewer, after contacting each company by telephone, has obtained different feedback, organised in the following categories:

- Interview denied: if the company, since the beginning, has shown a negative feedback to a possible interview concerning the adoption of technologies 4.0;
- Unreachable: if the interviewer has not obtained an answer after calling the company at least twice, or if the company does not exist anymore (bankruptcy or closed);
- Mail contact, but no answer: if the interviewer, after the first call, has obtained the email address of the company in order to forward a presentation letter so as to provide information to the company regarding the survey, but, despite a second email asking for the company's availability, or not, to participate to the survey, did not receive an answer by the company;
- Do not produce: if the company, during the call, stated it did not produce goods. Hence, it did not have production lines or similar. Typically, in these categories we find the so called "trading/commercial companies";
- Interviewed: if the company, during the first call, has displayed a positive approach to the survey. In particular, the interviewer has been able to conclude immediately the survey, when the company declare to not adopt technologies 4.0 (hence, asking questions n°3 and n°4); otherwise, if the company adopted

at least one of the technologies, the interviewer asked to company to participate to the research, and then, both agree upon the way to compile the survey (via a telephone call, or the company itself compile the survey directly online, at the link provided via mail).

Hence, the adopters and non-adopters' categories are the result of the interviews completed by the interviewer. Below, we show the percentage relative to the data included in Table 3.14, so as to analyse the feedback in the different sub-categories.

<table>
<tr><th colspan="2"></th><th>FOOTWEAR SECTOR</th><th>TANNING SECTOR</th></tr>
<tr><td colspan="2">Sample to interview</td><td>421</td><td>308</td></tr>
<tr><td colspan="2">Interview denied</td><td>10,5%</td><td>13,3%</td></tr>
<tr><td colspan="2">Unreachable</td><td>11,9%</td><td>25,3%</td></tr>
<tr><td colspan="2">Mail contact, but no answer*</td><td>24,2%</td><td>2,6%</td></tr>
<tr><td colspan="2">Do not produce</td><td>3,6%</td><td>3,2%</td></tr>
<tr><td colspan="2">Interviewed</td><td>49,9%</td><td>55,5%</td></tr>
<tr><td rowspan="2">Of which:</td><td>Non-Adopters</td><td>92,9%</td><td>99,4%</td></tr>
<tr><td>Adopters</td><td>7,1%</td><td>0,6%</td></tr>
</table>

Table 3.15: Types of feedback obtained from the survey and relative quantities (%)

As we can notice, there are not remarkable differences between the two sectors in the categories "Interview denied" and "Do not produce". Instead, the category "Unreachable" in the tanning sector, almost double the percentage of the footwear sector, due to the fact that, in many cases, contact information was unreachable, both in the excel file from AIDA and from online research, and also because some companies were failed. The low percentage (2,6%) of the tanning sector related to the category "Mail contact, but no answer" is quite interesting because the interviewer has noted that the respondents were more informed about the technologies adopted by the company, and so were able to respond immediately, justifying the reasons behind the non-adoption, in respect to the colleagues of the footwear sector. Probably, the small dimension of the company allows employees to be aware of the technologies and the decisional dynamics adopted by the company. The most important percentages are those related to interviewed companies, about 50% for the footwear sector, and about 56% for the tanning sector; in particular, we notice that only one company out of 171 interviewed adopts technologies 4.0 in the tanning sector (0,6%), whereas, in the footwear one, 15 companies out of 210 interviewed (7,1%), adopt technologies 4.0. We have to remind that, almost certainly, among the companies belonging to the categories "Interview denied", "Unreachable" and "Mail contact, but no answer", there are companies adopting technologies 4.0, but, unfortunately, we cannot investigate more than we have already done.

The next step of the analysis concerns the size of the companies interviewed, and we start from the turnover classification, using the same parameters shown in Table 3.4, namely:

- Micro ≤ €2 M
- €2 M < Small ≤ €10 M
- €10 M < Medium ≤ €50 M
- Large > €50M

Instead, the employees' classification presents the following classes:

- Micro < 10
- 10 ≤ Small < 50
- 50 ≤ Medium < 250
- Large ≥ 250

After recalling the standards of the European Commission, we can present the analysis of the size of the interviewed companies, starting from the non-adopters' companies of the footwear sector.

TURNOVER DIMENSION		
Size	**n° of companies**	**%**
MICRO	56	29%
SMALL	107	55%
MEDIUM	30	15%
LARGE	2	1%
TOTAL	195	100%

Table 3.16: Size of non-adopters' companies of the footwear sector, in turnover terms

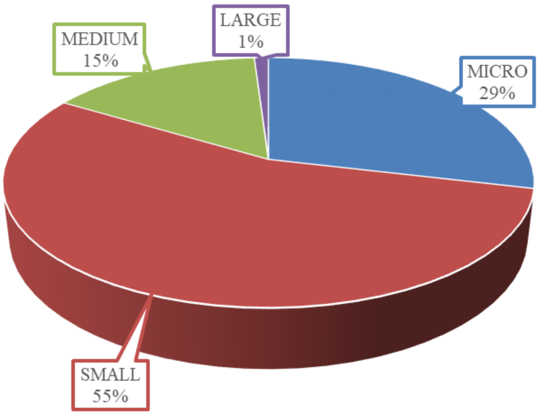


Chart 3.5: Pie divided by the % for each size, compared to the turnover, of non-adopters' companies of the footwear sector

Regarding the classification in respect to the turnover, we can see how relevant are the numbers of the micro and small categories; in fact, about 85% out of 195 respondents has less than €10 million turnover, and this small dimension can justify the limited investments that these types of companies can afford, even if, not necessarily, the integration of technologies 4.0 is an expensive investment.

EMPLOYEES DIMENSION		
Size	**n° of companies**	**%**
MICRO	20	10%
SMALL	150	77%
MEDIUM	24	12%
LARGE	1	0,5%
TOTAL	195	100%

Table 3.17: Size of non-adopters' companies of the footwear sector, in employees' terms

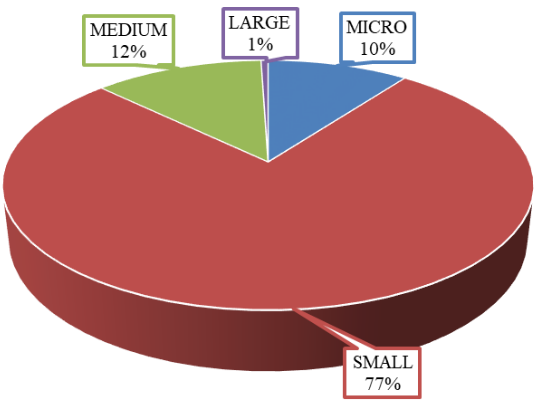


Chart 3.6: Pie divided by the % for each size, compared to employees' number, of non-adopters' companies of the footwear sector

Concerning the classification according to the number of employees, we can notice that the percentage underlined before, 85% given by the sum of micro and small classes, now is increased to 87%, but the composition is different: only the 10% is composed by micro companies (one-third in respect to the turnover classification), and the other 77% are small companies (22% more in respect to the turnover classification). Lastly, we have a small inflection for the medium class, from 15% to 12%.

In the next rows, we show the numbers relative to the non-adopters' companies of the tanning sector. We start from the classification in terms of turnover, and then we see the results in terms of number of employees.

TURNOVER DIMENSION		
Size	**n° of companies**	**%**
MICRO	37	22%
SMALL	93	55%
MEDIUM	34	20%
LARGE	6	4%
TOTAL	170	100%

Table 3.18: Size of non-adopters' companies of the tanning sector, in turnover terms

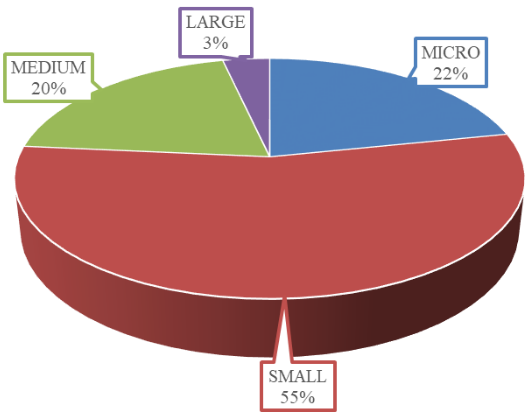


Chart 3.7: Pie divided by the % for each size, compared to the turnover, of non-adopters' companies of the tanning sector

Regarding the classification in respect to the turnover, in the tanning sector, we can underline a difference in respect to the footwear sector, namely, the quite similar percentages of the micro and medium classes, respectively 22% with 37 companies and 20% with 64 companies, whereas they are one the half of the other (29% micro and 15% medium) in the footwear sector. The percentage of small companies is the same as in the footwear sector (55%), whereas the large class is three times more (3%).

EMPLOYEES DIMENSION		
Size	**n° of companies**	**%**
MICRO	39	23%
SMALL	108	64%
MEDIUM	20	12%
LARGE	2	1%
TOTAL	169	100%

Table 3.19: Size of non-adopters' companies of the tanning sector, in employees' terms

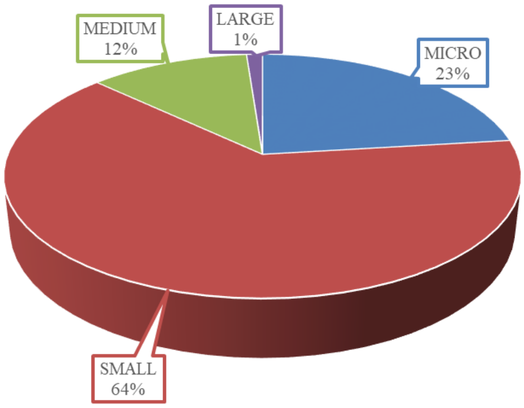


Chart 3.8: Pie divided by the % for each size, compared to employees' number, of non-adopters' companies of the tanning sector

Concerning the classification in respect to the number of employees, we can evidence an increase in the percentage of the small class, in this classification (from 55% to 64%), such as the increase shown in the footwear sector. The micro class remains basically unchanged (23%), whereas in the footwear sector there is a huge reduction (from 29% to 10%). A significant reduction occurs in the medium class (from 34 to 20 companies, equal to -8%) and also the large class suffers a reduction of two third (from 3% to 1%). These last two classes have the same percentage dimension as in the footwear sector.

Geographically, the distribution of the non-adopters' companies is represented in the next tables, both footwear sector (Table 3.20) and tanning sector (Table 3.21).

Regions	n° companies	%
Trentino-Alto Adige	1	0,5%
Friuli-Venezia Giulia	2	1%
Piedmont	6	3%
Emilia-Romagna	27	14%
Lombardy	44	23%
Veneto	115	59%
TOTAL	195	100%

Table 3.20: Regional distribution of the non-adopters' companies in the footwear sector

Regions	n° companies	%
Emilia-Romagna	0	0%
Friuli-Venezia Giulia	1	0,6%
Trentino-Alto Adige	2	1%
Piedmont	6	3,5%
Lombardy	21	12%
Veneto	140	82%
TOTAL	170	100%

Table 3.21: Regional distribution of the non-adopters' companies in the tanning sector

Looking at the numbers, we can underline the fact that Veneto is the region with the highest number of companies that do not adopt technologies 4.0, namely, 255 companies out of 365 (about 70% of the non-adopters' population). The second region, in terms of quantity of companies located in there, is Lombardy: it counts 44 footwear companies and 21 tanneries, namely about 18% of the non-adopters' population. Emilia-Romagna and Piedmont are the third regions, respectively in the footwear sector and the tanning one, with 27 companies (14% of the footwear sector, 7% of the total population) and 6 companies (3,5% of the tanning sector, 1,5% of the total population). The other regions, Friuli-Venezia Giulia and Trentino Alto-Adige, have very low percentages, respectively 1% and 0,5% in the footwear sector and 0,6% and 1% in the tanning sector. Another thing to notice is the absence of tanneries in Emilia-Romagna. Below, we summarise graphically the numbers of companies by region.

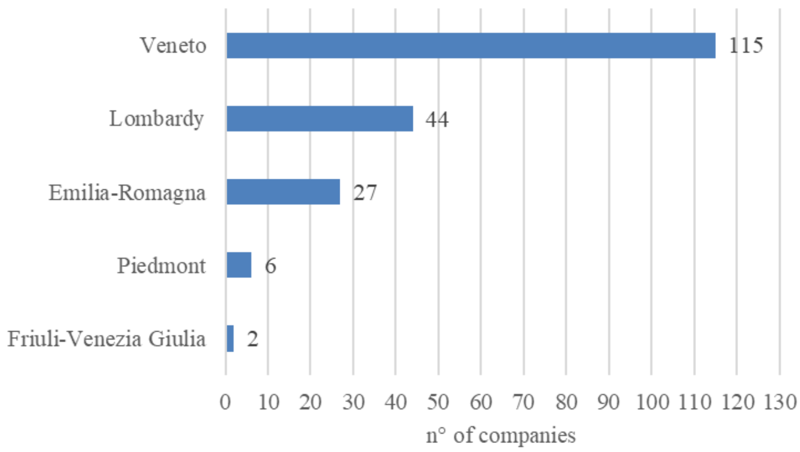


Chart 3.9: Regional distribution of the non-adopters' companies in the footwear sector

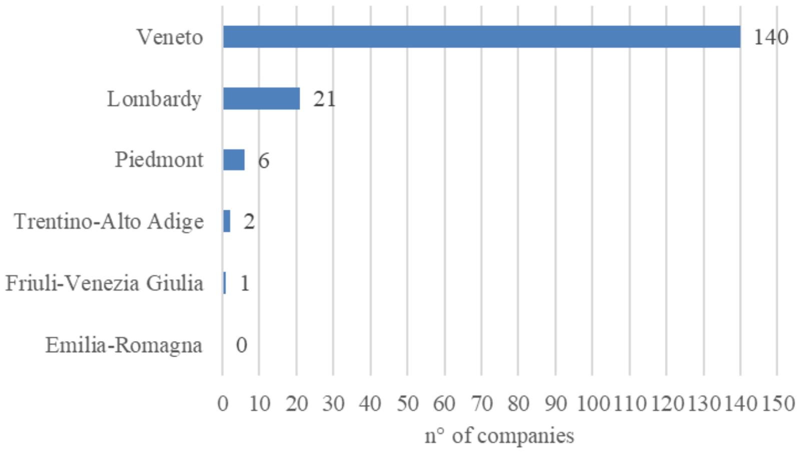


Chart 3.10: Regional distribution of the non-adopters' companies in the tanning sector

In Chart 3.9 and Chart 3.10 we graphically see the remarkable number of companies in Veneto and the distribution of the remaining companies in the other regions.

After analysing the size of the companies that do not adopt technologies 4.0 and their regional distribution, we focus our attention to the answers given to question n°4, namely, the reasons why the company do not adopt technologies 4.0 listed in question n°3. Below, we have summarised the results, both for the footwear sector (Table 3.22) and the tanning sector (Table 3.23).

Reasons behind the non-adoption:	**n° of companies**	**%, in respect to the total (195)**
Lack of economic resources	5	3%
Lack/limited internal competences	1	0,5%
Lack of an adequate internal technological infrastructure	4	2%
Scarce topic knowledge	10	5%
Uncertain ROI	1	0,5%
Not of interest to our business	171	88%
Under evaluation	8	4%
Other	34	17%
of which:		
Exclusively artisanal production	7	4%
Very small business	8	4%

Table 3.22: Reasons behind the non-adoption for the footwear sector

Reasons behind the non-adoption:		n° of companies	%, in respect to the total (170)
Lack of economic resources		0	0%
Lack/limited internal competences		0	0%
Lack of an adequate internal technological infrastructure		5	3%
Scarce topic knowledge		11	6%
Uncertain ROI		0	0%
Not of interest to our business		157	92%
Under evaluation		6	4%
Other		19	11%
	of which:		
	Exclusively artisanal production	9	5%
	Very small business	3	2%

Table 3.23: Reasons behind the non-adoption for the tanning sector

The most common answer given by both sectors was "Not of interest to our business", in the 88% of cases in the footwear sector and in the 92% of cases in the tanning sector. We think that this kind of answer has different facets:

- first, we can assume that many companies chose this answer due to the fact that it is quite general answer, giving us the sense that they probably do not take into consideration the adoption of these technologies, basically, because they think that they are not useful for their business, maybe without gathering any information about a tangible upgrade of the manufacturing process;
- second, we can suppose that owners and managers of SMEs are quite busy by the daily activities that they leave aside the planning of a technological swift of their manufacturing facilities. Probably, they tend to focus more on the short-term period rather than be forward-looking and try to gain a competitive advantage though a technological upgrade to Industry 4.0;
- third, the answer given by the companies corresponds to the real reason for the non-adoption. Basically, we hope that they take into consideration these technologies, but after all, they really do not find an interest, economically viable and cost-effective, for the company.

The second most common answer belongs to the category "Other", in which the interviewer writes down the reason expressly given by the company. We obtained 53 answers belonging to this category, and, analysing them, we found out two answers given very often, and these are: "exclusively artisanal production" and "very small business", respectively given by 16 and 11 companies. Effectively, checking the number of employees of the company that claims to be a "very small business", we found out that they have from 6 to maximum 26 employees; hence, in some cases, they consider themselves as a very small business (namely a micro company) even if they belong to the "small" class (10 ≤ n° of employees < 50) of the European Commission classification.

The third most common answer was "Scarce topic knowledge", respectively, 5% in the footwear sector and 6% in the tanning one. These percentages are very low in respect to the preceding two, however they have a relevance in the analysis of the reasons behind the non-adoption. As a matter of fact, companies that stated this particular reason are aware of their lack of knowledge regarding Industry 4.0, highlighting a backwardness that may derive from many peculiarities of our industrial fabric.

After showing the outputs of question n°4 for the Fashion category of the sample, we display, through Table 3.24 and Table 3.25, the aggregate results for all sectors of the research.

Reasons behind the non-adoption:	**n° of companies**	**%, in respect to the total**
Lack of economic resources	51	5%
Lack/limited internal competences	32	3%
Lack of an adequate internal technological infrastructure	68	6%
Scarce topic knowledge	124	11%
Uncertain ROI	36	3%
Not of interest to our business	702	65%
Under evaluation	73	7%
TOTAL	1086	100%

Table 3.24: Aggregate results considering all sectors of the research

The aggregate results show that for the 65% of the non-adopters' companies the reason why they do not adopt technologies 4.0 was because they are "Not of interest to our business", hence, 702 companies out of 1˙086 consider the technologies of the Fourth Industrial Revolution as not of interest to their business. Immediately, such a high value, suggests that more than one company out of two claims that it does not need an improvement in its manufacturing facility, in its R&D department, or in its prototyping tools. The 11% admits that it does not know the topic, whereas the 7% is considering a potential adoption of such technologies. Lastly, we have 68 companies that do not adopt because they "Lack of an adequate internal technological infrastructure" (6%) and 51 companies that "Lack of economic resources" (5%).

SECTOR	**Lack of economic resources**	**Lack/limited internal competences**	**Lack of an adequate internal technological infrastructure**	**Scarce topic knowledge**
Apparel	12%	15%	27%	9%
Automotive	11%	3%	22%	14%
Electric equipment	4%	0%	2%	30%
Electric lighting equipment	20%	4%	4%	16%
Furniture	29%	42%	6%	0%
Glasses and Lens	9%	5%	9%	27%
Jewellery	2%	10%	21%	3%
Leather goods and shoes	**1,3%**	**0,3%**	**2,5%**	**5,6%**
Footwear sector	*2,6%*	*0,5%*	*2%*	*5%*
Tanning sector	*0%*	*0%*	*3%*	*6%*
Rubber and plastic goods	0%	0%	0%	0%
Sport goods	15%	15%	0%	0%
Others	9%	4%	4%	17%

SECTOR	Uncertain ROI	Not of interest to our business	Under evaluation	n° of respondents by sector
Apparel	15%	58%	12%	33
Automotive	30%	51%	22%	37
Electric equipment	3%	68%	11%	224
Electric lighting equipment	11%	47%	16%	55
Furniture	0%	0%	13%	31
Glasses and Lens	5%	64%	9%	22
Jewellery	0%	78%	2%	131
Leather goods and shoes	**0,3%**	**90%**	**4%**	**366**
Footwear sector	*0,5%*	*88%*	*4%*	*195*
Tanning sector	*0%*	*92%*	*4%*	*171*
Rubber and plastic goods	0%	100%	0%	2
Sport goods	15%	46%	15%	13
Others	0%	78%	9%	23

Table 3.25: Reasons behind the non-adoption by sectors

Analysing the aggregate results by sector (Table 3.25), we noticed how in all the sectors, except for the furniture one, the most used reason (in red) behind the non-adoption choice was “Not of interest to our business”, ranging from 46% in Sport good sector to 100% in Rubber and plastic goods sector. Other high values were found in Leather goods and shoes sector (90%), Jewellery sector (78%) and Electric equipment sector (68%). In the Furniture sector the first choice was “Lack/limited internal competences” with the 42%, whereas the second choice (in blue) fell on “Lack of economic resources” with the 29%, such as for Electric lighting equipment with the 20%. “Uncertain return on investments (ROI)” was the second choice in the Automotive sector (30%), whereas “Lack of an adequate internal technological infrastructure” was the second choice in Apparel sector (27%) and Jewellery sector (21%). The most common second choice was “Scarce topic knowledge”, which obtained 30% in Electric equipment sector, 27% in Glasses and lens sector, and 5,6% in Leather goods and shoes sector. We noticed that, if the first choice was basically equal in all sectors, this was not true for the second choice, which has shown a high variability among sectors.

After having deeply analysed the non-adopters' companies, both focusing on the Fashion sectors (footwear and tanning) and showing the aggregate numbers considering all sectors subject to survey, we concentrated on the analysis of the adopters' companies, which have provided many information by answering to the survey. First of all, we want to summarise some aggregate data:

- we got **1˙117 respondents** to the survey;
- of which, **380** of the Fashion sectors (**footwear and tanning**),
- and **737** of the **other sectors**;
- **15** out of 380 are **adopters** of the **Fashion sectors**
- and **148** out of 737 are **adopters** of the **other sectors**;
- hence, we got **163 adopters** out of 1˙117 respondents,
- the **14,6%** of the total.

Starting from these numbers, we analysed the results of question n°3, related to the technologies 4.0 owned by the adopters' companies. The companies that adopt only one technology amount to 68 out of 163 (42%), those adopting two technologies amount to 45 (28%), and the ones adopting at least three technologies amount to 49 (30%). In the Fashion sectors, since we got 15 adopters, the 40% owns one technology 4.0 (6 companies), then the 27% (4 companies) has two technologies, another 27% has three technologies, and the 7%, only one company, has four technologies. In the next tables (Table 3.26 and Table 3.27) we have analysed the number of companies and their percentages dividing them by their size, using the classification of the European Commission, based on the 2015 turnover.

Size	**Robot**	**AM**	**Laser Cutter**	**Big Data – Cloud**	**3D Scanner**	**AR**	**IoT**	**n° of companies**	**%**
<1M	2	7	6	3	3	2	4	**12**	**7%**
MICRO	16	10	24	14	5	7	5	**42**	**26%**
SMALL	28	16	9	1	12	0	1	**70**	**43%**
MEDIUM	16	13	13	17	7	3	8	**31**	**19%**
LARGE	5	4	3	4	0	1	2	**8**	**5%**
TOTAL	**67**	**50**	**55**	**39**	**27**	**13**	**20**	**163**	100%

Table 3.26: Number of adopters' companies by dimension

In Table 3.26 we can see that the most owned technologies 4.0 are Robot (67), Laser Cutter (55), Additive Manufacturing (50) and Big Data – Cloud (39). Looking at the technology most used by each size class we got:

- Additive Manufacturing for companies with turnover < €1M;
- Laser Cutter for micro-sized companies;
- Robot for small-sized companies;
- Big Data – Cloud for medium-sized companies;
- and Robot for large-sized companies.

Instead, looking at the technology and the specific size class that uses it most, we got:

- small-sized company for Robot technology;
- small-sized company for Additive Manufacturing;
- micro-sized company for Laser Cutter;
- medium-sized company for Big Data – Cloud;
- small-sized company for 3D Scanner;
- micro-sized company for Augmented Reality technology;
- medium-sized technology for Internet of Things.

In the last two columns of Table 3.26 we have the number of adopters' companies belonging to each class and the relative percentages. Below, in

Chart 3.11, we represented the second-to-last column, and we noticed that the trend is quite similar to the bell-shaped Gauss Curve, with a pike in the middle and the lowest values in the extremities.

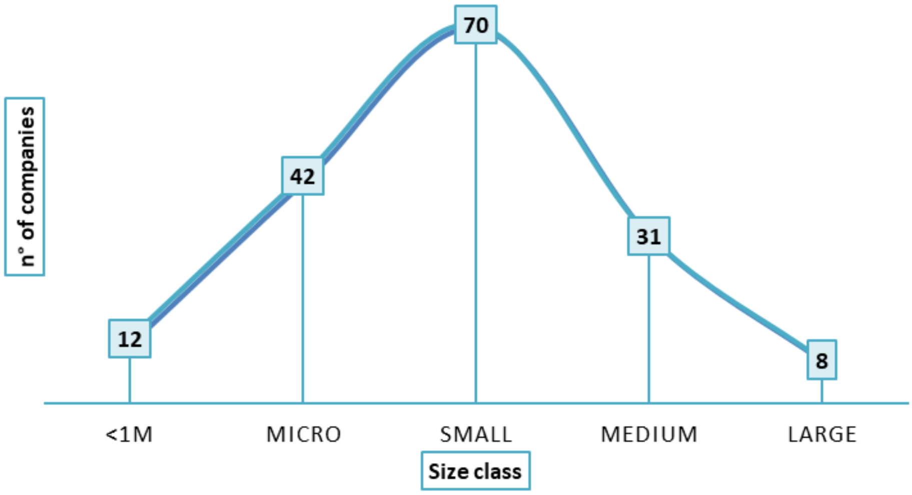


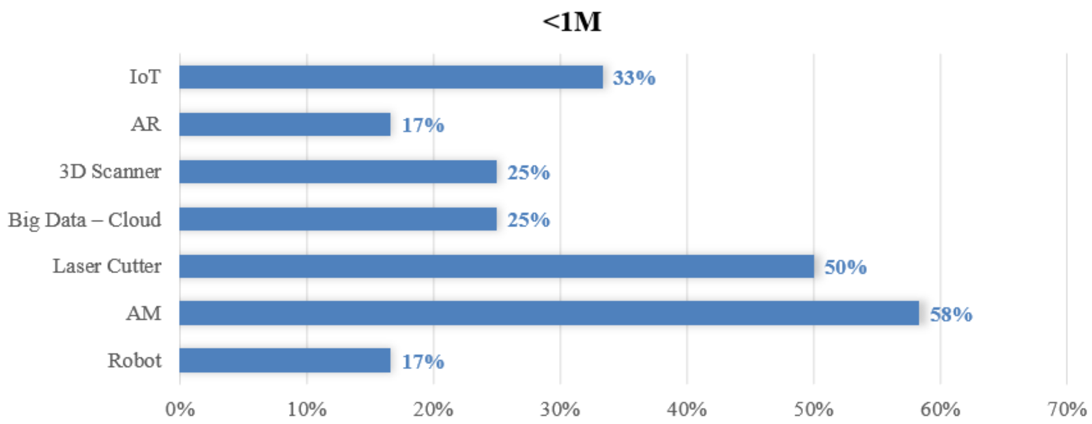
Chart 3.11: Number of companies belonging to each class

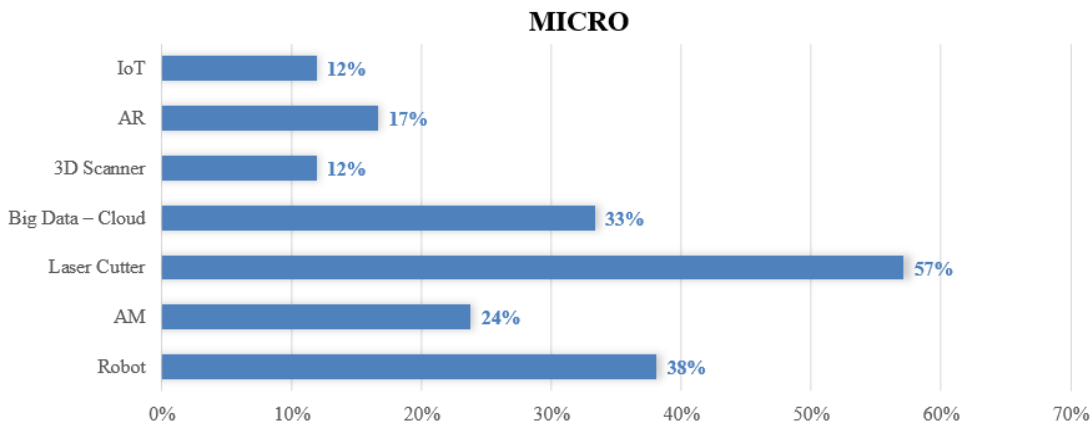
Size	**Robot**	**AM**	**Laser Cutter**	**Big Data – Cloud**	**3D Scanner**	**AR**	**IoT**
<1M	17%	58%	50%	25%	25%	17%	33%
MICRO	38%	24%	57%	33%	12%	17%	12%
SMALL	40%	23%	13%	1%	17%	0%	1%
MEDIUM	52%	42%	42%	55%	23%	10%	26%
LARGE	63%	50%	38%	50%	0%	13%	25%

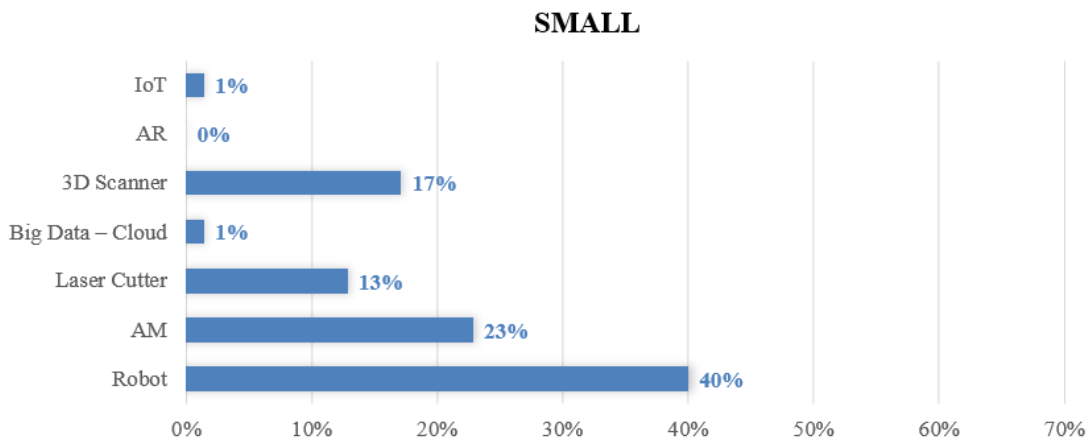
Table 3.27: Percentage of adopters' companies by dimension

Looking at Table 3.27, we can easily notice the lowest percentages of some technologies and the relative size class. We highlight the lack of 3D scanning technologies in large-sized class and of Augmented Reality in small-sized class. We notice also a very low presence of IoT and Big Data – Cloud technologies in small-sized class (only 1%).

Below we represented different charts in order to graphically show the differences across size classes.







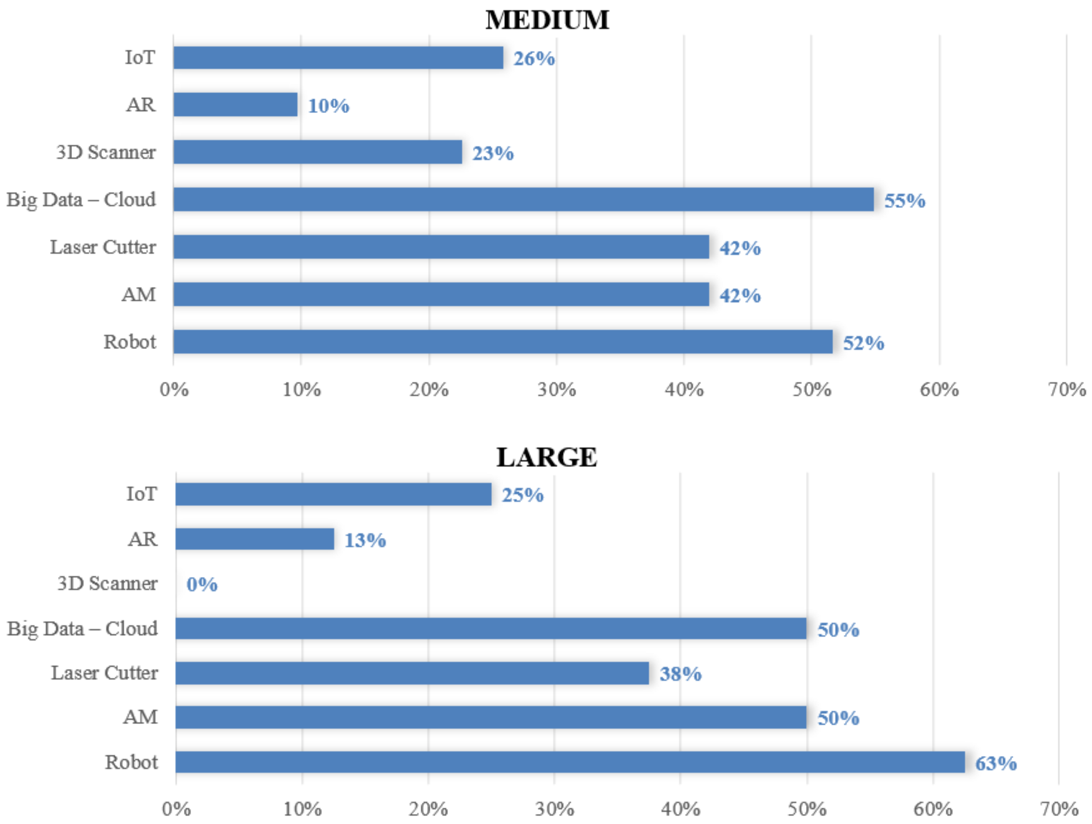


Chart 3.12: Percentages of adoption of I4.0 technologies for each size class

At first glance, we noticed the variety among the different size classes. In fact, the distribution of Industry 4.0 technologies differs a lot; for instance, Robot range from 17% to 63%, IoT range from 1% to 33 %, Big Data – Cloud range from 1% to 55%, Augmented Reality range from 0% to 17%, and so on.

Another interesting number that we calculated from Table 3.26 is the average of technologies adopted by each size class, and it is given by the sum of each technology in the specific class divided by the number of companies belonging to this specific class. Doing so, we obtained the following results:

Size	Average n° of technologies per size class
<1M	2,25
MICRO	1,93
SMALL	0,96
MEDIUM	2,48
LARGE	2,38

Table 3.28: Average n° of technologies per size class

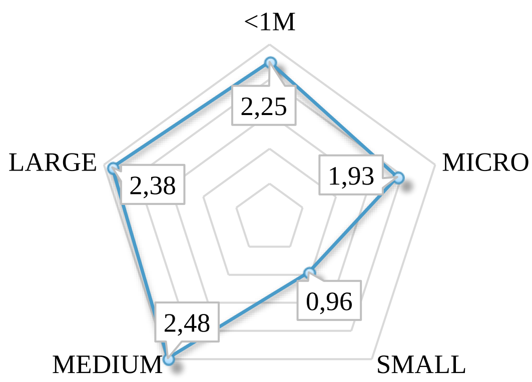


Chart 3.13: Radar of the average n° of technologies per size class

We noticed that less than €1 million, medium and large size classes obtained quite the same results, respectively 2,25, 2,48 and 2,38. Just behind them we found micro size class with 1,93 and with the lowest value (0,96) we had small size class. The radar chart helps us into the understanding of these numbers: in fact, if the number are quite similar, it means that the size of companies is quite irrelevant, when we have to consider how many Industry 4.0 technologies companies adopt in theirs manufacturing process.

In the Table 3.29 we represented the number of companies that adopt technologies 4.0 divided by sector. We noticed how different sectors have different needs in technological terms. In fact, we have sectors where Robots are essential, such as in the Automotive and Furniture sectors, the IoT technologies in the Electric lighting equipment, or Laser Cutter technologies adopted by Jewellery, Furniture and Glasses and Lens sectors; in the Fashion sector (Leather goods and shoes) the laser Cutter and 3D Scanner technologies are the most adopted. The lack of specific technologies in some sectors is also relevant. For instance, in the Electric equipment and Fashion sectors, no one has adopted Augmented Reality technologies, whereas in the Furniture sector, no one has adopted Big Data – Cloud, 3D scanner and Augmented Reality technologies.

SECTOR	Robot	A M	Laser Cutter	Big Data – Cloud	3D Scanner	AR	IoT	Total adopters
Apparel	4	3	9	13	2	3	6	26
Automotive	13	8	8	7	5	1	4	20
Electric equipment	6	5	3	10	1	0	6	17
Electric lighting equipment	4	9	7	6	2	6	10	19
Furniture	22	9	10	0	0	0	4	30
Glasses and Lens	8	9	10	8	4	3	4	13
Jewellery	2	9	11	2	4	3	1	13
Leather goods and shoes	**3**	**5**	**9**	**3**	**9**	**0**	**1**	**15**
Rubber and plastic goods	3	0	2	3	0	0	0	6
Sport goods	0	2	0	0	0	0	0	2
Others	3	3	3	5	0	0	1	6
								167

Table 3.29: Number of adopters' companies divided by sectors and type of technologies

Using the data of the table above, we calculated the average number of technologies per sector and we represented it in a radar chart, as we did before for the size class of adopters' companies.

SECTOR	Average n° of technologies per sector
Apparel	1,54
Automotive	2,30
Electric equipment	1,82
Electric lighting equipment	2,32
Furniture	1,50
Glasses and Lens	3,54
Jewellery	2,46
Leather goods and shoes	2,00
Rubber and plastic goods	1,33
Sport goods	1,00
Others	2,50

Table 3.30: Average n° of technologies per sector

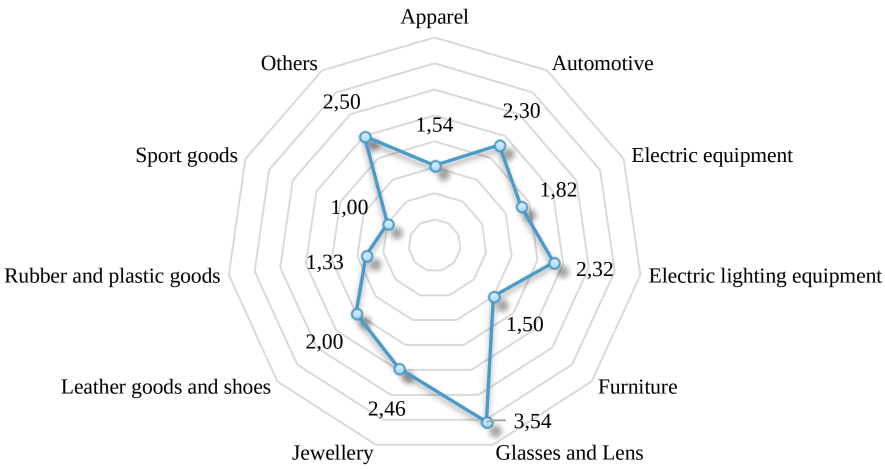


Chart 3.14: Radar of the average n° of technologies per sector

As we can see, there is a lot of variability among different sectors. The most higher values are those of Glasses and Lens (3.54), Jewellery (2.46), Electric lighting equipment (2.32) and Automotive (2.30) sectors. The lowest values are those of Furniture (1.50), Rubber and plastic goods (1.33) and Sport goods (1.00). These significant differences are justified by the different technological needs of each sector: in the sectors with the highest values, high-tech and precision machineries are typically used (Glasses and Lens and Jewellery), whereas other sectors do not include technology intensive businesses (Sport goods).

3.5.2 Number of employees and its distribution among functions

In question n°6, the survey required to adopters' companies to specify the number of employees in 2016, and then to split among those in the production, R&D and marketing functions (these last two only if existing). The results are summarised in Table 3.31, and, as we can see, there are discrepancies among sectors. For instance, the marketing function is more relevant in the Jewellery sector (10%) compared to the Automotive one (2%); on the contrary, the R&D function is more relevant in the Automotive sector (20%) rather than in the Furniture one (7%); at last, the production function, which includes most of the personnel, has a greater role in sectors as Sport goods (81%), Leather goods and shoes (74%), and Automotive (73%), rather than in sectors like Electric lighting equipment (53%), Apparel (50%) and Electric equipment (38%).

SECTOR	Production	R&D	Marketing	Total adopters
Apparel	50%	10%	4%	21
Automotive	73%	20%	2%	16
Electric equipment	38%	12%	7%	15
Electric lighting equipment	53%	10%	4%	19
Furniture	65%	7%	4%	30
Glasses and Lens	73%	8%	4%	12
Jewellery	71%	9%	10%	13
Leather goods and shoes	74%	10%	6%	13
Rubber and plastic goods	56%	11%	8%	5
Sport goods	81%	12%	0%	2
Others	48%	12%	11%	5
				151

Table 3.31: Distribution of employees across functions by sector

Doing the average of the values obtained for each sector, in every one of the three functions, we got the following average percentages:

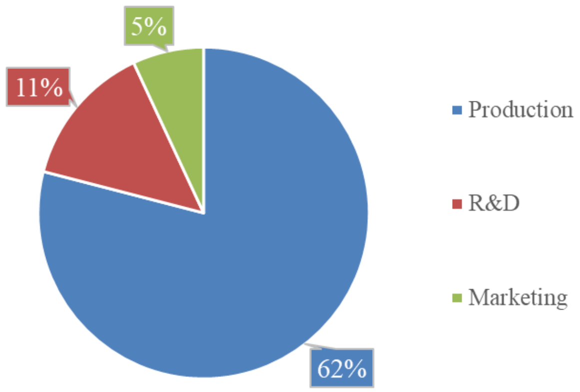


Chart 3.15: Average employment distribution among functions

The average values highlighted that the personnel of the R&D function doubles the marketing function staff, whereas, as one might imagine, the employees of the production function are the majority in respect to the other ones. The Fashion sector (leather goods and shoes) is above the average in the marketing function (+1%) and in the production function (+12%), whereas the R&D one is just below (-1%).

3.5.3 The first factor of competitive advantage

In question n°8 companies specified which is their first factor of competitive advantage. They have chosen among the list presented in the table below (Table 3.32), in which we summarised the frequency of each factor and its percentage given the total answers.

Factor of competitive advantage	Frequency	%
Production cost reduction	8	5%
Design	10	7%
Product innovation	19	13%
Customer service	24	16%
Production flexibility	32	21%
Product quality	58	38%
Total	151	

Table 3.32: Factors of competitive advantage

The most frequent factor is the product quality (38%), which underlined the relevance of excellence, in qualitative terms, in order to success over competitors; the second most chosen factor is production flexibility (21%), that highlighted the need of flexibility in the manufacturing process, both in quantitative and customisation terms. Linked to this last aspect, customisation, is the customer service, in third place with a percentage of 16%, which refers to both pre-sale and post-sale service to customer. The last three factors are product innovation (13%), design (7%) and production cost reduction (5%).

Size	Product quality	Production flexibility	Customer service	Product innovation	Design	Production cost reduction	Total Resp.
<1M	17%	33%	17%	17%	8%	8%	12
MICRO	40%	23%	19%	8%	11%	0%	38
SMALL	33%	20%	18%	18%	7%	5%	61
MEDIUM	55%	17%	4%	11%	4%	11%	29
LARGE	57%	14%	29%	0%	0%	0%	7
							147

Table 3.33: Factors of competitive advantage divided by size class

In the table above we computed the percentages of each factor for every size class. The first aspect we noticed is the first place (in red) occupied by product quality in all size classes, except for less than €1 million size class (only 17%). This latter seems to be more interested in having a production flexibility (33%), as first factor of competitive advantage; and the more the company size increases, the more the percentage of production flexibility decreases. Despite this downward trend, production flexibility is the second most important factor of competitive advantage for most of categories, except for large size class which favours the customer service (29%).

3.5.4 Export

In question n° 9 the survey asked companies the percentage of export compared to the revenues and the first country of export. The results are the following:

- 122 respondents;
- an average of 46% of revenues from export;
- for the Fashion sector (only footwear and tanning sectors), an average of 37% of revenues from export, with a range from 2% to 90%.

The first country of export is typically an European Country, such as France, Germany, Spain, UK, Portugal, Ireland and Switzerland among others. But there are also non-European Countries, namely U.S., Middle East Countries, Australia and Asia (only a small percentage cited South-American Countries). On average 27% of total exports is directed to these first export countries. (Bragagnolo, 2017)

3.5.5 R&D expenditures and their changes in the last 5 years

Sector	Average R&D expenditures (%)
Apparel	7,44
Automotive	4,92
Electric equipment	8,70
Electric lighting equipment	6,57
Furniture	5,50
Glasses and Lens	5,07
Jewellery	10,38
Leather goods and shoes	1,76
Rubber and plastic goods	5,88
Sport goods	3,00
Others	5,38

Table 3.34: Average R&D expenditures by sector

In the question n°10 the companies provided the percentage of R&D expenditures compared to the 2016 revenues. In question n°11 the survey asked if the R&D expenditure has increased, decreased or remained stable in the last 5 years.

In the previous table we computed the average, R&D expenditures, in percentage terms, for each sector. The most interesting values are those of Jewellery (10,38), Electric equipment (8,70), Apparel (7,44), Sport goods (3,00) and Leather goods and shoes (1,76%). The first three represent the sectors in which on average companies invest more in R&D, whereas the last two those sectors where on average companies invest less. The other sectors have values that range from 4,92 to 6,57. Hence, we noticed that about half of sectors invest an amount of 5%, more or less, whereas one fourth are above and one fifth are below the average; this fact highlighted the several discrepancies among the sectors subject to the survey.

Size	Average R&D expenditures (%)
<1M	3,97
MICRO	7,68
SMALL	5,45
MEDIUM	6,68
LARGE	3,25

Table 3.35: Average R&D expenditures by size class

Considering the size class and computing the average R&D percentage for each class, we noticed again a significant variability. In particular, micro-sized, small-sized and medium-sized companies invest on average almost twice the value of large-sized companies. In fact, micro-sized companies invest on average 7,68% of their revenues, whereas less than €1 million companies only 3,97%.

R&D expenditure is:	n° of respondents	%
Decreased in the last 5 years	15	11%
Remained stable	53	39%
Increased in the last 5 years	67	50%
Total	135	

Table 3.36: Variation of R&D expenditures on the last 5 years

In this table, the most interesting number is related to the percentage of companies that increased their R&D expenditure in the last 5 years: exactly the 50% out of 135 respondents stated this. Moreover, about 40% of respondents do not decrease their expenditures, but they maintain them stable; finally, only the 11% decreases the R&D expenditures in the reference period.

Size	Increased in the last 5 years	Remained stable	Decreased in the last 5 years	Total resp.
<1M	36%	45%	18%	11
MICRO	48%	42%	9%	33
SMALL	46%	43%	13%	56
MEDIUM	58%	33%	8%	24
LARGE	71%	14%	14%	7
				131

Table 3.37: Variation of R&D expenditures by size class

We noticed that the number of companies that have increased their R&D investments rises with the size class (except for small-sized class); whereas the percentage of company that maintain stable R&D expenditures decreases with the size class. More variability is found for the companies that decreased their R&D expenses.

Sector	Increased in the last 5 years	Remained stable	Decreased in the last 5 years	Total respondents
Apparel	47%	32%	21%	19
Automotive	53%	41%	6%	17
Electric equipment	62%	38%	0%	13
Electric lighting equipment	47%	41%	12%	17
Furniture	48%	33%	19%	27
Glasses and Lens	50%	50%	0%	8
Jewellery	50%	50%	0%	12
Leather goods and shoes	60%	40%	0%	10
Rubber and plastic goods	50%	25%	25%	4
Sport goods	0%	50%	50%	2
Others	20%	60%	20%	5
				134

Table 3.38: Variation of R&D expenditures by sector.

As we can see in the table above, in most of sectors (7 out of 11) the companies decided to increase their R&D expenditures in the last 5 years. In Jewellery and Glasses and Lens sectors, respondents split equally between those who increase and those who maintain stable the R&D expenditures. Instead, in Sport goods sector respondents split equally between those who decrease and those who maintain stable the R&D expenditures. Finally, we observed that there is not so much variability across different sectors.

3.5.6 Year of adoption of the Industry 4.0 technologies

In question n°12 the companies were requested to provide the year of adoption of the technologies they stated to own in question n°3. The results have been represented in a timeline, in which we can see the average year of adoption of each technology by the companies that adopt Industry 4.0 technologies and, at the same time, provide the information of the year of adoption of the specific technologies.

The result is the following:

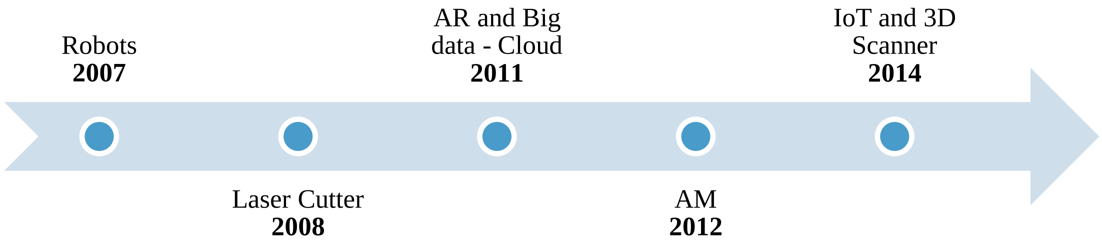


Figure 3.3: Timeline of the average year of adoption of technologies 4.0, for the aggregate data

In the Fashion sector (only footwear and tanning sectors), the average years of adoption are quite different, as we can see in the following figure:

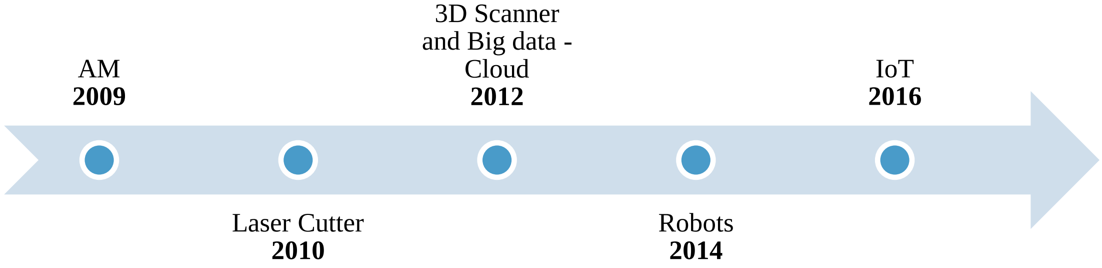


Figure 3.4: Timeline of the average year of adoption of technologies 4.0, for the Fashion sector (only footwear and tanning sectors)

First of all, we specify that where the frequency of adoption is very low, such as for AM, Big Data – Cloud and IoT, the comparison with the aggregate data (composed by more than 160 companies) is irrelevant. Whereas, in the cases of Robot, Laser cutter and 3D Scanner, the frequency is remarkable, and so, comparing the aggregate average years of the respective technology to the ones of the Fashion sector, we noticed some differences: on average, in the first case Robots are 7 years younger, Laser cutters are 2 years younger and 3D Scanners are 2 years older.

3.5.7 Adoption of other Industry 4.0-related technologies

In question n°13 the companies checked off the technologies that they own and use, from the following list:

- Website
- Social media (f.i. Facebook, Twitter, LinkedIn, etc.)
- E-commerce
- CRM Customer Relationship Management
- SCM Supply Chain Management
- ERP Enterprise Resource Planning
- MRP Material Requirement Planning
- CAD/CAM
- CNC
- Other

The outputs of this question are summarised in the next table.

Other technologies	Frequency	%
Other	10	6%
SCM	15	10%
MRP	29	19%
E-commerce	32	21%
CRM	33	21%
ERP	36	23%
CNC	63	40%
Social media	64	41%
CAD/CAM	90	58%
Website	148	95%
Total respondents	156	

Table 3.39: Frequency and percentage of adoption of other technologies

The numbers included in Table 3.39 are based on the answers of 156 companies. They display that almost everyone has a website (95%), six companies out of ten have CAD/CAM software for the design process, a percentage of 41% has a social media useful for gaining more visibility, in addition to the classic website and the 40% adopts computer numerical control machines (CNC); ERP, CRM, e-commerce and MRP are near to the 20%, whereas SCM only 10%.

Other technologies mentioned by responders include alternative management software applications, 3D drawing software not included among the provided options, monitoring systems for energy-savings, remote control and maintenance systems, products with remote assistance, other tools for measuring performance of prototypes, other systems integrating orders registered on iPads with production and accounting (Bragagnolo, 2017), and statistical queries from smartphone and tablet for salesmen.

Sector	Website	Social media	E-commerce	CRM	SCM	ERP	MRP	CAD/CAM	CNC	Other	Total resp. By sector
Apparel	78%	61%	50%	22%	22%	28%	11%	61%	6%	6%	18
Automotive	100%	15%	10%	20%	5%	15%	20%	45%	35%	5%	20
Electric equipment	100%	29%	18%	12%	0%	18%	18%	47%	41%	6%	17
Electric lighting equipment	100%	47%	11%	32%	16%	47%	37%	53%	26%	5%	19
Furniture	100%	60%	37%	27%	13%	17%	20%	67%	57%	7%	30
Glasses and Lens	100%	54%	0%	23%	8%	31%	15%	69%	77%	0%	13
Jewellery	100%	38%	31%	15%	0%	0%	8%	46%	23%	15%	13
Leather goods and shoes	67%	42%	8%	17%	8%	25%	8%	83%	58%	8%	12
Rubber and plastic goods	100%	0%	0%	0%	0%	0%	0%	40%	20%	20%	5
Sport goods	100%	0%	0%	0%	0%	0%	0%	50%	50%	0%	2
Others	100%	17%	0%	33%	17%	67%	33%	67%	67%	0%	6
											155

Table 3.40: Percentages of adoption of other technologies by sector

We noticed that the most adopted technology is the web site (100% in all sectors and 78% in Apparel sector), except for the leather goods and shoes sector, where the CAD/CAM software is dominant (83%). The second most adopted technology is CAD/CAM software, except for Glasses and Lens sector, where CNC machines are more relevant (77%). In the Apparel sector also the social media are the second most adopted technology (61%).

3.5.8 Processes towards which investments are most addressed to

The investments done by the owners, entrepreneurs and managers of the companies that answered to the survey, have necessarily specific activities and/or processes as destinations. In question n°14 each company checked off the activities, or processes, towards which investments are directed to and we highlighted the results in Table 3.41.

Activities / Processes	**Frequency**	**%**
Spare parts production & after-sale service	8	6%
Logistic & supply chain management	15	11%
Sale & Marketing activities	37	28%
Production planning	54	41%
R&D	65	49%
Prototyping	75	57%
Production activities	77	58%
Total respondents	132	

Table 3.41: Activities and processes where investments are addressed to

The most frequent destination activities are “production activities” (58%) and “prototyping” (57%); then, half of the respondents addressed investments to the “R&D”. Also “production planning” and “sale & marketing activities” are relevant destination for investments 4.0, respectively with the 41% and the 28%.

Sector	**R&D**	**Prototyping**	**Production activities**	**Production planning**	**Logistic & supply chain management**	**Sale & Marketing activities**	**Spare parts production & after-**	**Total resp. by sector**
Apparel	44%	50%	39%	50%	11%	28%	0%	18
Automotive	58%	75%	58%	33%	17%	0%	0%	12
Electric equipment	23%	38%	46%	46%	8%	38%	8%	13
Electric lighting equipment	53%	53%	71%	41%	24%	35%	6%	17
Furniture	56%	56%	59%	41%	15%	44%	19%	27
Glasses and Lens	55%	82%	82%	36%	9%	18%	9%	11
Jewellery	50%	67%	50%	33%	0%	33%	0%	12
Leather goods and shoes	46%	54%	62%	38%	8%	15%	0%	13
Rubber and plastic goods	50%	0%	50%	50%	0%	0%	0%	4
Sport goods	0%	100%	0%	100%	0%	0%	0%	1
Others	67%	100%	100%	0%	0%	33%	0%	3
								131

Table 3.42: Activities and processes towards which investments are addressed to by sector

As we could easily notice, the main part of the investments is focused on three activities, or processes, namely, prototyping, production activities and production planning, with a range from 46% to 100%. Also the R&D function is considered as an important destination of investments (excluding Electric equipment and Sport good sectors), as we can see from the percentages, which range from 46% to 58%.

3.5.9 Technologies adopted in the business activities

In question n°15 the respondents have checked off which activities, or processes, the technologies adopted are used in the company. In order to better understand where each technology is employed the most, we represented the percentages of employment in each activity (from question n°14) for every technology (from question n°3) in the following table.

Activity	Robots	AM	Big data - Cloud	3D Scanner	AR	IoT
R&D	35%	56%	32%	47%	63%	20%
Prototyping	24%	80%	30%	87%	25%	20%
Production activities	84%	41%	34%	33%	31%	48%
Production planning	29%	15%	70%	7%	13%	28%
Logistic & supply chain management	0%	5%	28%	0%	0%	16%
Sale & Marketing activities	4%	10%	47%	13%	38%	12%
Spare parts production & after-sale service	14%	5%	15%	0%	0%	12%
Other	0%	7%	4%	0%	0%	0%

Table 3.43: Technology adoption in each activity, in percentage

In Table 3.43 we highlighted (in red) the highest percentage for each technology, so as to display in which activity it is most employed. We immediately observed that the highest percentages fell into 4 categories: R&D, prototyping, production activities and production planning. In particular, the following technologies are most employed in:

- robots → production activities (84%);
- AM → prototyping (80%);
- Big data – Cloud → production planning activities (70%);
- 3D Scanner → prototyping (87%);
- AR → R&D (63%);
- IoT → production activities (48%).

Also the presence of robots (35%), AM (56%) and 3D scanner (47%) technologies is remarkable in the prototyping activity.

Below we summarised only the data of the Fashion sector (only footwear and tanning sectors), using the same table as above.

Activity	Robots	AM	Laser cutting	Big data - Cloud	3D Scanner
R&D	0%	8%	46%	0%	54%
Prototyping	15%	8%	46%	0%	54%
Production activities	23%	8%	46%	15%	23%
Production planning	0%	0%	8%	15%	0%
Logistic & supply chain management	0%	8%	0%	8%	0%
Sale & Marketing activities	0%	8%	0%	15%	0%
Spare parts production & after-sale service	0%	0%	8%	0%	8%
Other	0%	0%	0%	0%	0%

Table 3.44: Technology adoption in each activity, in percentage, in the Fashion sector

We found the highest value with the reference to robots in the production activities (23%), such as in the aggregate data. AM is equally spread in all activities (8%), except in production planning and spare parts production & after-sale service. Laser cutting technology is equally diffused in R&D, prototyping and production activities (46%). Interesting is also the presence of 3D scanner technology in R&D and prototyping (54%). Lastly, Big data – Cloud is equally employed in production activities, production planning and sale & marketing activities (15%).

3.5.10 Customisation process of the technological solutions adopted

In questions n°16 and n°17 the companies provided information about a potential customisation process and its detail level. In the first question companies confirmed, or not, the necessity of a customisation process for the technological solutions adopted. If the first question is affirmative, they had to provide detailed information regarding the level of the customisation process, in particular for the hardware component, the software component and the system integration with other existing technologies.

In the next table we summarised the outputs of question n°16. The total number of respondents is 121 and it is divided into 91 companies which have undergone a customisation process, and 30 companies that did not need to implement such a process.

	Customisation process	%
YES	91	75%
NO	30	25%
Respondents	121	100%

Table 3.45: Customisation process of technologies

For those companies which implemented a customisation process (75%), a further question (n°17) investigated on the detail level of customisation. Here below we displayed the aggregate results:

	Average
Hardware	2,93
Software	3,52
System integration	3,24
Respondents	121

Table 3.46: Average detail level of customisation

Companies indicated the detail level of customisation using five different expressions to which we assigned a different score: not at all (1), little (2), enough (3), a lot (4) and very much (5). We calculated the average for the three components and we obtained that Software is the most customised components (3,52), followed by system integration (3,24) and, finally, the hardware component (2,93). Hence, the first two components are between "enough" and "a lot", whereas the last one is just below "enough". From an operational and economic point of view, we supposed that these results are justified by the easiest and cheapest customisation of software components and, on the other hand, by the amount of time spent and expensive customisation of hardware components.

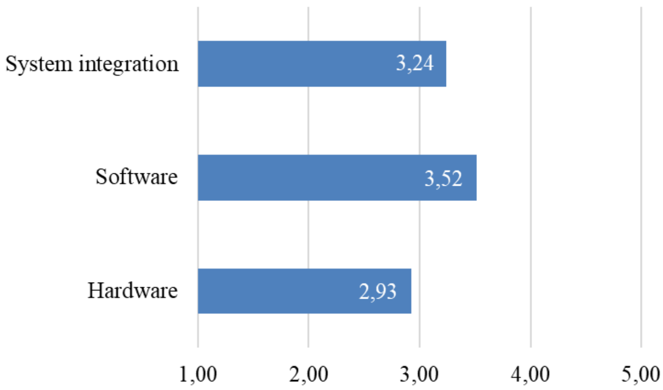


Figure 3.5: Average detail level of customisation

3.5.11 Support when choosing and implementing Industry 4.0 technology

A company that decides to invest in Industry 4.0 technologies needs support in the selection of the type of technology useful for it, but also in the implementation and configuration. In question n°18 we asked companies where they have found support when they decided to invest in Industry 4.0, in particular among Industry 4.0 technology suppliers, system integrator, plant & machinery suppliers, consultants, universities and research centres, technology transfer centres or other.

	Frequency	%
Technology transfer centres	4	3%
Other	4	3%
Universities and research centres	11	9%
System integrator	18	15%
Consultants	44	35%
I4.0 Tech. Suppliers	51	41%
Plant & machinery suppliers	82	66%
Total respondents	124	

Table 3.47: Supports when choosing and implementing Industry 4.0 technology

The results display that the more required support came from “plant & machinery suppliers” (66%), followed by that from “Industry 4.0 technology suppliers” (41%); more than one third of respondents (35%) asked support to “consultants” and the 15% to “system integrator”. Very few company required assistance to “universities and research centres” (9%) and “technology transfer centres” (3%).

3.5.12 Motivations behind Industry 4.0 investment

In question n°19 the survey asked companies to give a score to the listed motivations behind their investment in Industry 4.0; the scores range from 1 to 5, respectively based on the answers that range from “not at all” to “very much”. Hence, the higher score they selected, the higher was the significance of the motivation. After converting the expressions into numbers (using the same score as in question n°17), we computed the average and then we created a ranking of the motivations, ordering them from the less significant to the most significant.

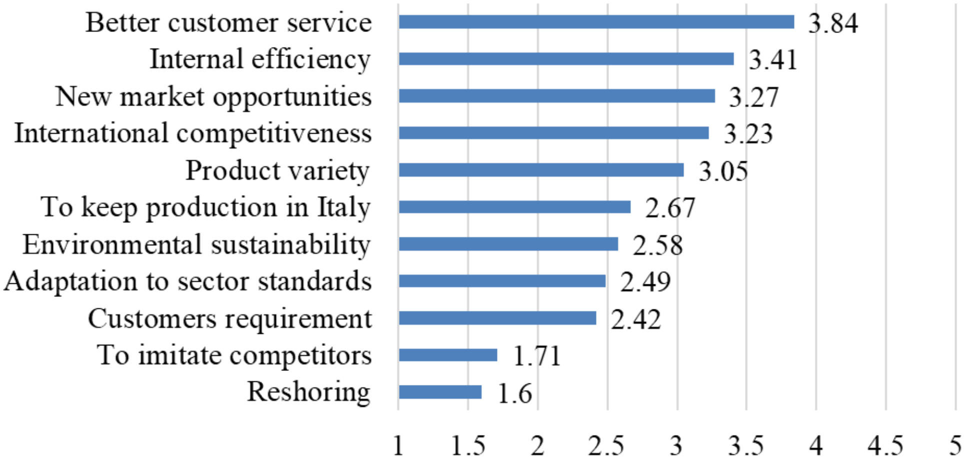


Chart 3.16: Ranking of the investment motivations

The chart above displays the results of the analysis: the main reason pushing companies to invest in Industry 4.0 is the commitment to improve the customer service, with an average score of 3.84 and so it has a strong significance. "Internal efficiency", "new market opportunities", "international competitiveness" and "product variety" are the answers following the first motivation, with a score never falling below 3.00; in the range from 2.40 to 2.70 we find other four motivations: "to keep production in Italy", "environmental sustainability", "adaptation to sector standards" and "customers requirement"; at the bottom of the ranking we find the following investment motivations: "to imitate competitors" (1.71) and "reshoring" (1.6).

Motivations	**Frequency of 4 and 5**	**% of 4 and 5**	**Frequency of 1, 2 and 3**	**% of 1, 2 and 3**
Internal efficiency	71	57%	53	43%
Product variety	51	41%	72	58%
New market opportunities	61	49%	59	48%
To keep production in Italy	39	31%	82	66%
Reshoring	4	3%	115	93%
International competitiveness	60	48%	62	50%
To imitate competitors	6	5%	114	92%
Better customer service	82	66%	39	31%
Environmental sustainability	33	27%	87	70%
Customers requirement	32	26%	88	71%
Adaptation to sector standards	27	22%	93	75%
Respondents	124			

Table 3.48: Analysis of scores (frequencies and percentages) for each investment motivation

In the previous table (Table 3.48), we highlighted (in red) the highest percentage for each investment motivation; in particular, we noticed that motivations with a higher percentage in the highest class of scores (4 & 5) are also the first three investments motivations, as we can see in the previous chart (Chart 3.16). Moreover, to confirm this fact, if we look at the two highest percentages in the lowest class of scores (1, 2 & 3), we can see that they correspond to the two motivations at the bottom of the ranking.

3.5.13 Impact on employment

In question n°20 the respondents provided information about the employment level after the investment in Industry 4.0 technologies (in particular, if it increases, decreases or remains stable).

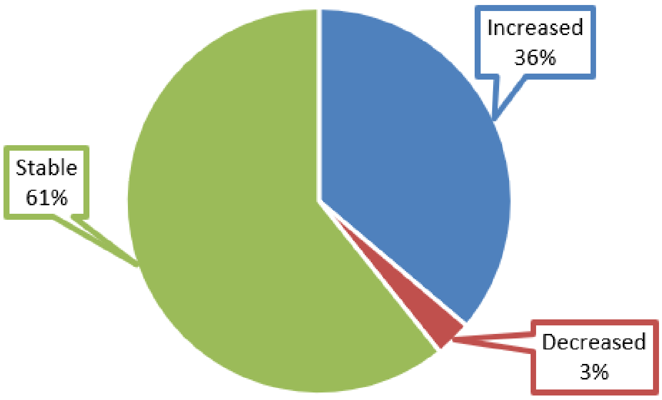


Chart 3.17: Percentages related to the impact on employment level

	Frequencies	%
Increased	47	36%
Decreased	4	3%
Stable	79	61%
Respondents	130	

Table 3.49: Impacts on employment level

As we could easily notice from Chart 3.17, the impact related to investment in Industry 4.0 technologies is null in the 61% of cases, positive in the 36% of cases and negative only in the 3% of cases. Hence, we can state that investing in Industry 4.0 does not imply, at a global level, an increase in unemployment, but, on the contrary, it guarantees most of times a stable employment level, and often an increase of it.

SECTOR	Increase	Decreased	Stable
Apparel	24%	6%	71%
Automotive	38%	8%	54%
Electric equipment	23%	0%	77%
Electric lighting equipment	25%	0%	75%
Furniture	58%	4%	38%
Glasses and Lens	42%	0%	58%
Jewellery	64%	0%	36%
Leather goods and shoes	23%	8%	69%
Rubber and plastic goods	0%	0%	100%
Sport goods	0%	0%	100%
Others	33%	0%	67%

Table 3.50: Variation of the employment level by sector

In general, the results of the analysis by sector are quite obvious; however, in two sectors, Furniture and Jewellery, the positive impact on employment level has been impressive, because it is far in excess of the percentages obtained in other sectors. Moreover, looking at the low frequency of a decrease in employment level, we thought that it is not strictly related to the adoption of technologies 4.0. We noticed that, in 7 sectors out of 11, the percentage of decrease is equal to zero, whereas in the remaining 4 sectors the percentages are very low (from 4% to 8%). We supposed that a possible reason of the decrease in the employment level could be the cyclical fluctuations that each sector faces.

3.5.14 Amount invested and results achieved

The data collected from question n°21 are displayed in the chart below.

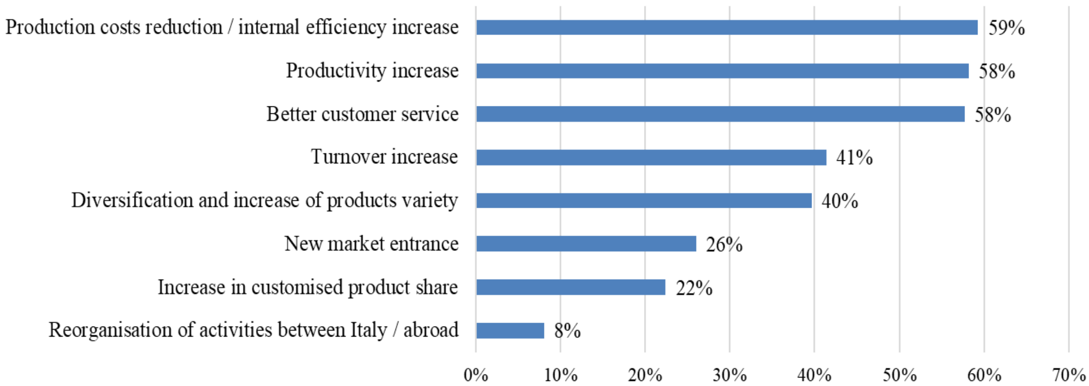


Chart 3.18: Results achieved after technologies implementation

We could notice that there are three main results achieved after the implementation of technologies 4.0: the first is the "production cost reduction / internal efficiency increase" (59%), followed by "productivity increase" and "better customer service" (both at 58%). Around 40% we find "turnover increase" and "diversification and increase of product variety". "New markets entrance" stands at 26%, whereas at 22% the "increase in customised product share". Lastly, we observed that two of the best results achieved by implementation, namely "internal efficiency increase" and "better customer service", correspond to the most relevant motivations behind the investment (question n°19), as reported in Chart 3.16.

	<1M	MICRO	SMALL	MEDIUM	LARGE
Turnover increase	11%	56%	37%	46%	20%
Production costs reduction / internal efficiency increase	44%	62%	58%	55%	100%
Productivity increase	67%	56%	58%	59%	60%
Diversification and increase of products variety	44%	41%	37%	46%	40%
Increase in customised product share	33%	29%	18%	18%	0%
Better customer service	56%	56%	65%	41%	60%
New market entrance	11%	38%	25%	18%	0%
Reorganisation of activities between Italy / abroad	0%	9%	4%	14%	20%
Total respondents	9	34	49	22	5

Table 3.51: Results achieved percentages by sector

In Table 3.51 we highlighted in red the results achieved with the highest percentage by each size class. In the large-sized class, all the respondents have achieved an increase in the internal efficiency; the same for micro-sized companies but with a lower percentage (62%). In the medium-sized class, the 59% out of 22 respondents, have achieved productivity increase; the same for companies with less than €1 million turnover, with the 67%. Small-sized class stated to achieve a better customer service in the 65% of cases. Moreover, we highlighted in blue the second best results achieved by each size class. Customer service and productivity increase have been achieved by three out of five size classes, even with similar percentages. Small and medium-sized class have both the increase in internal efficiency, as second best result achieved. Turnover increase has been achieved as second best result, only by micro-sized class.

Concerning the amount invested for the implementation of technologies 4.0, we collected the data from answers to question n°22 and we obtained that the average amount invested in respect to turnover is 10%, out of 118 respondents.

3.5.15 Italian Industry 4.0 plan's incentives

Only during the collection of data regarding the tanning and footwear sectors, the survey contained two more questions. Basically, in question n°23 and n°24 the survey asked respondents if they benefit from Italian government incentives provided for in the Industry 4.0 national plan. The collected answers are 11 out of 13: 6 respondents resorted to government incentives, whereas the remaining did not. For those that did not resort to government incentives, a further question (n°24) concerning the possibility/intention to resort to the incentives in the near future has been asked; given that 4 out of 5 answered, the results are the following: two will not resort, one will resort to incentives and the last one does not know the incentives provided for by the government.

3.5.16 Main difficulties in adopting technologies 4.0

In order to understand the difficulties faced by the companies in undertaking a significant change such as the adoption of Industry 4.0 technologies, we asked respondents to check off the level of significance of the following difficulties.

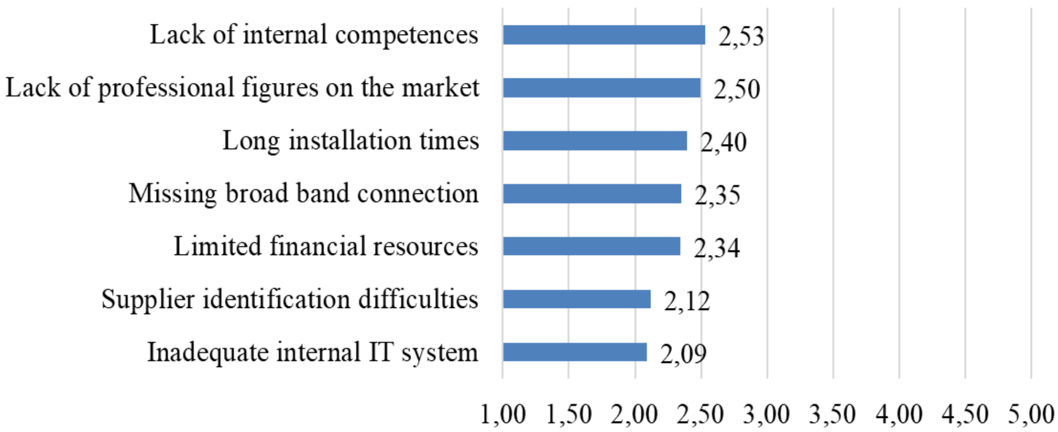


Chart 3.19: Main difficulties in adopting technologies 4.0

In order to collect the data relative to the relevance of each difficulty in quantitative terms, we used five different expressions to which we assigned a different score: not at all (1), little (2), enough (3), a lot (4) and very much (5). After analysing the collected data, we obtained the results displayed in Chart 3.19. The first aspect that we noticed is the range in which the average scores are, from 2,09 to 2,53; this means that the difficulties occurred in adopting technologies 4.0 had a low impact, on average. Indeed, companies declared that the relevance of each difficulty is considerable between "little" and "enough". Anyway, the three most significance difficulties are: "lack of internal competences" (2,53), "lack of professional figures on the market" (2,50), and "long installation times" (2,40). Then we have the problematic of a "missing broadband connection" (2,35) and the "limited of financial resources" (2,34), that can limit the type and dimension of the investment.

SECTOR	Lack of internal competences	Lack of professional figures on the market	Limited financial resources	Inadequate internal IT system	Long installation times	Supplier identification difficulties	Missing broad band connection	Total respondents
Apparel	2.90	2.64	3.50	2.80	3.00	2.80	2.64	13
Automotive	3.00	2.55	2.36	2.00	2.45	2.27	1.91	11
Electric equipment	2.44	2.78	1.67	1.56	2.11	1.89	1.44	9
Electric lighting equipment	2.56	2.69	2.19	1.94	2.25	2.44	2.88	16
Furniture	2.35	2.54	2.27	2.19	2.04	2.08	2.12	26
Glasses and Lens	2.64	2.55	2.55	2.18	3.00	1.82	3.18	11
Jewellery	1.91	2.27	2.18	2.09	2.09	2.00	2.45	11
Leather goods and shoes	2.36	1.82	1.73	1.91	2.64	1.36	2.09	11
Rubber and plastic goods	2.50	3.00	4.50	1.50	1.50	3.00	4.00	2
Sport goods	4.00	3.00	1.00	1.00	3.00	3.00	1.00	1
Others	3.50	1.50	3.00	3.50	2.50	2.50	2.00	2

Table 3.52: Difficulties by sector

In Table 3.52 we highlighted in red the highest scores for each sector. The result is quite impressive, due to the fact that the main difficulty occurred in a specific sector is basically different from the others. For instance, in apparel sector companies found more difficulty due to limited financial resources, such as in the rubber and plastic goods sector. Instead, the lack of broadband connection has affected the adoption of technologies 4.0 in three specific sectors: glasses and lens, electric lighting equipment and jewellery. Lack of internal competences has been the main difficulty for automotive and sport goods sectors. Whereas, the lack of professional figures on the market has been the most relevant problematic in electric equipment and furniture sectors. Lastly, the long times for the installation of technologies has been the main difficulty in leather goods and shoes sector.

3.5.17 Change in the working environment

The adoption of new technologies inevitably involves a transformation, more or less disruptive, of the working environment; in particular, we refer to different types of activities carried out by employees, different human-machine interactions, new tasks and competences, changing in production times and on-the-job training. With question n°26 of the survey, we wanted to gather more information about the change in the working environment in specific cases; we adopted the same method as in the previous paragraph, namely we considered five different expressions to which we assigned a different score: not at all (1), little (2), enough (3), a lot (4) and very much (5).

	Average score
Reduction of human-machine interaction	1,88
Higher problem complexity	2,09
More cooperation between production and suppliers	2,15
More collaboration among workers	2,30
More cooperation between production and other functions	2,43
Increase in training for the employees' competences development	2,85
New know-how for product improvement	3,14
New know-how for production improvement	3,28

Table 3.53: Changes in working environment

In the table above we ranked the average score representing the significance of each working environmental change listed in the question. Companies’ answers underline the relevance of new know-how requirements for product and production improvement. The “increase in training for the employees’ competences development” (2,85) is strictly connected to this. Then, the adoption required more cooperation and collaboration between production and other functions (2,43), among workers (2,30) and between production and suppliers (2,15). “Higher problem complexity” and "reduction of human-machine interaction" have recorded the lowest scores, respectively 2,09 and 1,88, signals of a low impact in the working environment.

Analysing by sector, we noticed that the results (in Table 3.54) do not change. In fact, the most impacting changes were those related to the know-how for product and production improvement. We found some exception in the leather goods and shoes sector, which considered the training of employees as the most impacting change, together with the know-how for production improvement. Lastly, rubber and plastic goods and sport goods sectors considered the reduction of human-machine interaction as a relevant change in the working environment.

SECTOR	Reduction of human-machine interaction	Higher problem complexity	More cooperation between production and suppliers	More collaboration among workers	More cooperation between production and other functions	Increase in training for the employees' competences development	New know-how for product improvement	New know-how for production improvement	Total respondents
Apparel	2,27	2,40	2,42	2,58	2,77	3,08	3,64	3,25	14
Automotive	2,08	2,67	2,17	2,67	2,42	2,67	3,08	3,67	12
Electric equipment	1,75	1,50	1,88	2,13	2,00	2,50	2,63	2,75	8
Electric lighting equipment	1,79	1,64	2,36	2,14	2,21	2,36	3,14	2,93	14
Furniture	1,62	1,92	2,04	2,38	2,65	2,96	3,38	3,23	26
Glasses and Lens	1,82	2,45	2,00	2,00	2,91	3,00	3,18	4,00	11
Jewellery	1,91	2,09	2,45	2,64	2,55	3,00	3,18	3,36	11
Leather goods and shoes	1,54	2,23	1,54	1,54	1,31	2,77	2,08	2,77	13
Rubber and plastic goods	4,00	3,50	3,00	3,00	3,00	3,00	4,00	3,50	2
Sport goods	4,00	1,00	3,00	3,00	3,00	4,00	4,00	4,00	1
Others	2,50	1,00	2,50	3,50	3,50	3,50	4,00	4,00	2

Table 3.54: Changes in working environment by sector

3.5.18 Consequences for product due to adoption of technologies 4.0

In question n°27 we tried to understand which consequences have occurred, from a product point view, after the adoption of technologies 4.0. We adopted the same method as in the previous paragraph, namely we considered five different expressions to which we assigned a different score: not at all (1), little (2), enough (3), a lot (4) and very much (5).

	Average score
More active role of the customer in product production	2,02
Different delivery procedure	2,06
Higher control over product utilization	2,45
More active role of the customer in product design	2,60
Higher performance through related services	2,76

Table 3.55: Main consequences for product

In Table 3.55 we highlighted the average score representing the significance of each consequence listed in the question. In particular, we obtained that companies adopting technologies 4.0 have a "higher performance through related services" (2,76). At the second place, companies have reported a "more active role of customer in product design" (2,60), and then, a "higher control over product utilisation" (2,45) because they can, for instance, do remote maintenance, gather more usage information, or end-of-life management. Lastly, companies have experienced less frequently a change in "different delivery procedure" and a "more active role of customer in production design".

SECTOR	Higher performance through related services	More active role of the customer in product design	More active role of the customer in product production	Higher control over product utilization	Different delivery procedure	Total respondents by sector
Apparel	2.55	2.23	2.08	2.45	2.09	13
Automotive	3.10	2.40	2.10	2.10	1.90	10
Electric equipment	2.75	1.88	1.88	3.25	1.88	8
Electric lighting equipment	2.93	2.36	1.71	2.64	1.79	14
Furniture	2.73	3.12	2.38	2.46	2.19	26
Glasses and Lens	2.75	2.67	1.75	2.33	2.58	12
Jewellery	2.64	2.91	1.91	2.36	1.91	11
Leather goods and shoes	2.46	2.08	1.62	1.77	1.54	13
Rubber and plastic goods	3.50	3.00	2.50	3.50	4.00	2
Sport goods	3.00	4.00	4.00	4.00	1.00	1
Others	3.00	4.50	2.50	4.00	2.50	2

Table 3.56: Main consequences for product by sector

In the table above, we analysed the average score by sector related to the consequences occurred after the adoption of technologies 4.0, from a product point view. We have noticed a variability among sectors, even if the most relevant consequences in several sectors are those of the first two columns.

3.5.19 Innovation capacity improvement

In question n°28 the survey wondered to companies if they have experienced an improvement of their innovation capacity. In the 88% of cases respondents stated that they have improved their innovation capacity, whereas only the 12% of respondents claimed otherwise. The results are displayed in Table 3.57 and Chart 3.20.

	Frequency	%
Yes	104	88%
No	14	12%
Total respondents	118	

Table 3.57: Improvement of innovation capacity

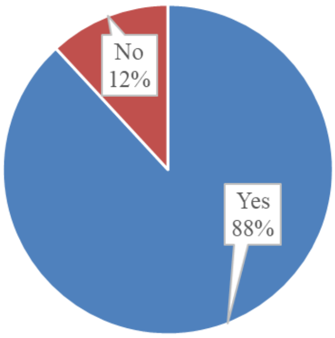


Chart 3.20: Improvement of innovation capacity

3.5.20 Environmental impacts

The research team decided to dedicate a part of the survey (question n°29) to the environmental impacts resulting from the adoption of Industry 4.0 technologies. The impacts listed in the question have been ranked from the one with the highest average score to the one with the lowest average one. We adopted the same method as in the previous paragraph, namely we considered five different expressions to which we assigned a different score: not at all (1), little (2), enough (3), a lot (4) and very much (5). The results we obtained are shown in the next chart.

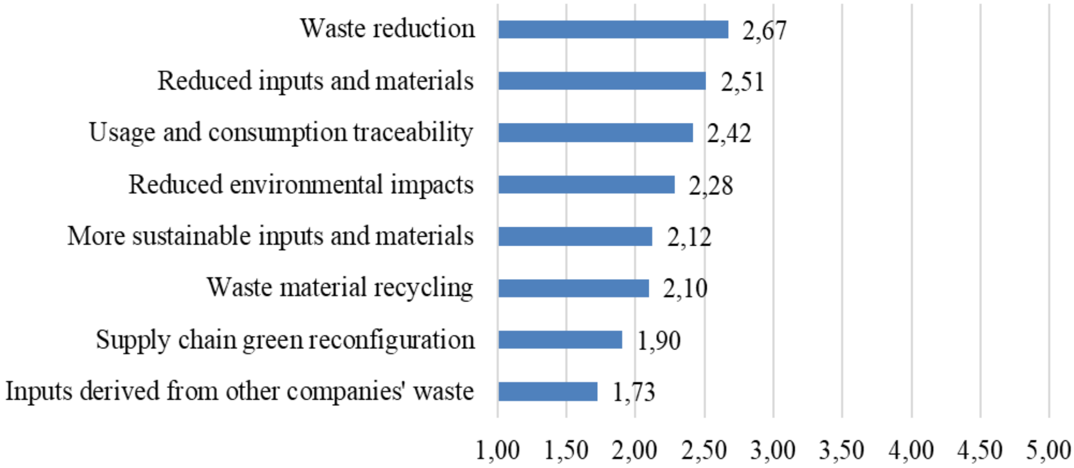


Chart 3.21: Ranking of the most relevant environmental impacts

First of all, we noticed from the chart that the average scores obtained by each type of impact are not high, since the range from 1 to 5. Hence, we can state that environmental impacts are considered by companies as limited, just sufficient. However, the results show that the most important environmental impact is the reduction of waste and of inputs and material. Moreover, it is interesting to see how the usage and consumption traceability exceed the average score of waste material recycling.

SECTOR	Waste reduction	Reduced inputs and materials	More sustainable inputs and materials	Usage and consumption traceability	Waste material recycling	Reduced environmental impacts	Inputs derived from other companies' waste	Supply chain green reconfiguration	Total respondents by sector
Apparel	2.50	2.67	2.18	2.27	1.82	2.36	1.91	2.18	13
Automotive	2.50	1.55	1.36	2.64	1.55	1.73	1.55	1.55	12
Electric equipment	2.00	2.22	1.89	1.89	1.78	2.00	1.78	1.78	9
Electric lighting equipment	2.64	2.29	2.21	2.50	2.07	2.29	1.79	1.71	14
Furniture	3.04	2.88	2.31	2.58	2.42	2.65	1.88	2.19	26
Glasses and Lens	2.67	2.42	2.42	2.42	2.75	2.42	2.00	2.08	12
Jewellery	2.18	2.55	2.09	2.00	1.91	2.27	1.64	1.73	11
Leather goods and shoes	2.85	2.62	1.85	2.23	1.85	1.77	1.31	1.46	13
Rubber and plastic goods	4.00	3.00	3.50	3.50	3.00	3.50	1.50	3.00	2
Sport goods	3.00	4.00	3.00	3.00	1.00	1.00	1.00	1.00	1
Others	2.50	3.00	2.50	3.00	1.50	3.00	1.50	2.50	2

Table 3.58: Main environmental impacts by sector

In Table 3.58, we highlighted in red the most relevant environmental impacts for each sector and the results are basically similar to those of the ranking (Chart 3.21): the impacts on the reduction of waste and of inputs and materials are more relevant in most of sectors (8 out of 10); whereas in the automotive sector, the most impact has been shown on the traceability of the consumptions (2,64). Lastly, the impact on the waste material recycling is more relevant in the glasses and less sector.

3.5.21 Final questions about customers, sectors, production and location

In question n°30 the survey asked respondents how much the first client weights in respect to the total turnover. The total number of respondents has been equal to 120. On aggregate, the average first customer's share of the total turnover has been about 28,5%.

In question n°31 the companies provided information about the sectors to which their products are addressed to. Below we list the main sectors cited by the respondents for each sector (Bragagnolo, 2017):

- Apparel: stockings, automotive, umbrellas and hospitality;
- Automotive: public transportation, agricultural machineries, industrial cleaning, industrial machineries, aviation, furniture and gardening tools;
- Electric equipment: generic machineries, industrial conditioning, construction companies, automotive, automatic doors, home appliances, furniture and interior design, lighting for banks and hotels;
- Eyewear: jewellery, orthodontic and motorcycle components;
- Furniture: hospital furniture, outdoor furniture and automotive;
- Jewellery: eyewear, luxury and fashion accessories;
- Leather goods and shoes: footwear, leather goods, apparel, furniture and contract;
- Rubber: automotive components.
- Sport goods: sky and trekking equipment and bicycle saddle stuffing;

In question n°32 we asked companies the percentage of product composition over the total production volume. They could choose among: “Finished goods for the end consumer”, “Finished goods for other companies”, “Components” and “Semi-finished products”. The resulting percentages are shown in next table:

	%	
Finished goods for the end consumer	50%	B2C
Finished goods for other companies	28%	B2B
Components	12%	
Semi-finished products	11%	

Table 3.59: Product composition

Moreover, in the next table, we summarised the same results by sector, highlighting in red the highest percentage for each sector.

SECTOR	**Finished goods for the end consumer**	**Finished goods for other companies**	**Components**	**Semi-finished products**
Apparel	74%	12%	0%	14%
Automotive	32%	39%	24%	5%
Electric equipment	32%	48%	2%	19%
Electric lighting equipment	58%	29%	11%	2%
Furniture	63%	27%	4%	6%
Glasses and Lens	28%	24%	32%	16%
Jewellery	48%	24%	6%	22%
Leather goods and shoes	33%	19%	31%	17%
Rubber and plastic goods	90%	10%	0%	0%
Sport goods	0%	0%	100%	0%
Others	50%	36%	1%	13%

Table 3.60: Product composition by sector

Most of sectors produce more of their products for end consumers (B2C) with percentages ranging from 33% to 90%. The automotive and electric equipment sectors produce more of their finished goods for other companies (B2B), respectively 39% and 48%. Instead, the glasses and lens sector has a quite diversified product composition, where components lead with the 32% of the total production.

Furthermore, considering the respondents of question n°32, we computed an aggregate analysis, distinguishing companies that produce only finished goods for the end costumer (B2C) from those that focuses their production to the other three categories, linked to a typical B2B product composition. In Table 3.61 and Chart 3.22 we noticed that the respondents are split almost equally between B2C and B2B.

	Frequency	%
B2C	62	51%
B2B	59	49%

Table 3.61: Frequencies and percentages of B2C and B2B

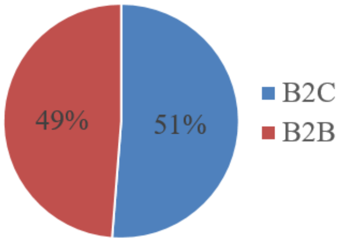


Chart 3.22: B2C and B2B composition

In question n°33 the respondents provided information about the location of their production facilities. On average, in the 60% of cases the production is located in the region where the company has the legal residence; in the 33% of cases the production facilities are located in Italy (other regions); and only in the 7% of cases production is situated abroad.

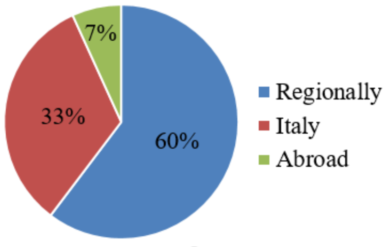


Chart 3.23: Geographical distribution of production facilities

In question n°34 the survey asked respondents where their suppliers are geographically situated, using the same distinction as in the previous question. The results displayed that suppliers located abroad are the 15%, those with legal residence in the same region of the respondents are the 37%, whereas, the majority of suppliers (47%) are located in Italy (other regions).

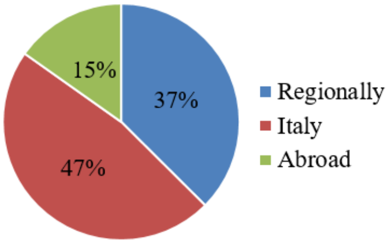


Chart 3.24: Geographical distribution of suppliers

In question n°35 the companies that claimed to have production facilities and suppliers abroad, specified the main countries in which they are geographically situated. The results highlighted that the majority is located in European countries (like Germany, Spain, Romania, France, Belgium, Albania, Switzerland and Poland) or in the USA. In the specific case of the apparel industry, Asian countries like China, Vietnam and Indonesia have been mentioned.

In last question (n°36) we asked companies to specify how their product manufacturing is composed, distinguishing among "standard / catalogue products", "customisable standard products" and "fully customised products". In the first case, respondents declared that the 41% of production is focused on "standard / catalogue products". In the second case, respondents stated that the 33% of production is based on "fully customised products". In the last case, respondents affirmed that the 26% of production is focused on "customisable standard products".

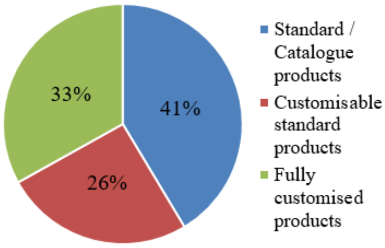


Chart 3.25: Standardised and customised production

CONCLUSIONS

The research was focused on three main objectives. The first one was aimed at examining how Italian firms have adopted Industry 4.0 technologies. The results have shown that the 14,6% of the companies have adopted technologies 4.0; in particular, in the footwear and tanning sectors, only the 3,9% have embraced Industry 4.0. During the interviews, most of entrepreneurs have underlined that, nowadays, their manufacturing processes present incompatibilities with such technologies. For instance, some companies have tried to implement laser cutting technologies in their manufacturing activities, but the raw materials (wood and leather) resulted damaged. In addition, they have claimed that specific steps of the manufacturing process require artisanal skills, hardly replicable by a robot. Anyway, the main technologies adopted in aggregate are robots, laser cutter, additive manufacturing and big data – cloud.

The second objective of the research was to analyse how Italian firms cope with Industry 4.0 technologies, in particular concerning the difficulties and the benefits found in the implementation. The results have displayed that, on average, the long installation times and the lack of internal competences and professional figures on the market did not have a significant impact on the implementation of technologies 4.0; however, companies have considered them as the most relevant problems encountered in the implementation. Concerning the benefits, about 60% of companies have underlined three main results achieved: a rise in the internal efficiency (or a reduction in production costs), an increase in productivity and an improvement in customer service. Furthermore, about 40% have experienced an increase in turnover and a rise in product variety. Hence, these percentages highlight the fact that, also from an economic point of view, the adoption of technologies 4.0 is the key to success in a rapidly changing industrial landscape.

The third and last objective was aimed at studying how Industry 4.0 affects production and innovation business activities. The results have highlighted that, on average, companies adopting technologies 4.0 achieved higher performance through related services, reported a more active role of customer in product design, and then had a higher control over product utilisation. Regarding the relation between Industry 4.0

and the improvement of innovation capacity, the 88% of companies have stated that they have improved their innovation capacity. This relevant result reveals that the efforts employed for innovation, repay with a greater ability to innovate.

“Innovation distinguishes between a leader and a follower”. With these words Steve Jobs expressed a concept that perfectly fits with Industry 4.0 revolution.

References

3Dprint.com. (2015). *Smart3D: Perceptron Releases Comprehensive, Portable 3D Laser Scanning System and Software*. Retrieved from 3dprint.com: https://3dprint.com/49306/smart3d-perceptron-scanning/

ABB. (2018). *IRB 14000 YUMI*. Retrieved from new.abb.com: http://new.abb.com/products/robotics/industrial-robots/yumi

ABB. (2018). *IRB 1600ID*. Retrieved from new.abb.com: http://new.abb.com/products/robotics/it/robot-industriali/irb-1600id

ABB. (2018). *IRB 360 FlexPicker*. Retrieved from new.abb.com: http://new.abb.com/products/robotics/it/robot-industriali/irb360

ABB. (n.d.). *Robotic Solutions for Welding Applications*. Retrieved from new.abb.com: http://new.abb.com/products/robotics/applications-by-industry/robot-welding

Adams, R. (2017, 1 10). *10 Powerful Examples Of Artificial Intelligence In Use Today*. Retrieved from www.forbes.com: https://www.forbes.com/sites/robertadams/2017/01/10/10-powerful-examples-of-artificial-intelligence-in-use-today/2/#5f5198303c8b

Anderson. (2012). *Makers. The new industrial revolution.* Crown Business New York.

Aniwaa. (2018). *3D scanning technologies and the 3D scanning process*. Retrieved from www.aniwaa.com: https://www.aniwaa.com/3d-scanning-technologies-and-the-3d-scanning-process/

Arbotist. (2017). *Types Of Robots In Automation Robotics*. Retrieved from www.arbotist.com: http://www.arbotist.com/types-of-robots.html

Assocalzaturifici. (2016). *Il settore calzaturiero italiano*. Retrieved from www.assocalzaturifici.it: http://www.assocalzaturifici.it/ancimain/doc.html?id=19305

Bekker, A. (2017, 9 6). *Customer big data analytics: an overview*. Retrieved from www.scnsoft.com: https://www.scnsoft.com/blog/customer-big-data-analytics-an-overview

Biagio, S. (2017, 10 15). *Industria: in Italia c'è un robot ogni 62 operai*. Retrieved from http://www.infodata.ilsole24ore.com: http://www.infodata.ilsole24ore.com/2017/10/15/industria-italia-ce-un-robot-62-operai/?refresh_ce=1

Bragagnolo, H. (2017). *Industry 4.0: from theory to practice. An empirical analysis of the factory of the future.* Padua.

Bricco, P. (2016, 8 10). *Il prodotto intelligente è la via americana all'Industria 4.0*. Retrieved from www.ilsole24ore.com: http://www.ilsole24ore.com/art/impresa-e-territori/2016-08-09/il-prodotto-intelligente-e-via-americana-all-industria-40-183247.shtml?uuid=ADjPC13

Cingolani, M. (2015). *Umani e umanoidi. Vivere con i robot.* il Mulino.

Condor, A. (2017, 5 8). *Industry 4.0*. Retrieved from biz.im2-platform.com: http://biz.im2-platform.com/2017/05/08/industry-4-0/

EU. (2017, 1). *Digital transformation monitor - Germany: Industrie 4.0.* Retrieved from https://ec.europa.eu: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Industrie%204.0.pdf

European Commission. (2003). *What is an SME?* Retrieved from ec.europa.eu: http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_it

European Commission. (2017, 5). *Key lessons from national industry 4.0 policy initiatives in Europe* . Retrieved from https://ec.europa.eu: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Policy%20initiative%20comparison%20v1.pdf

Flynt, J. (2015, 6 14). *3D Printing – Basic Overview*. Retrieved from http://3dinsider.com: http://3dinsider.com/3d-printing-basic-overview/

Francis, S. (2018, 1 3). *30 industrial robot manufacturers to watch in 2018*. Retrieved from roboticsandautomationnews.com: http://roboticsandautomationnews.com/2018/01/03/30-industrial-robot-manufacturers-to-watch-in-2018/15542/

Frost & Sullivan. (2014, 7 9). *The Rise of 3D Printing Market Insight.* Retrieved from www.slideshare.net: https://www.slideshare.net/FrostandSullivan/the-rise-of-3d-printing-market-insight

Gartner. (2017, 10 12). *Gartner Forecasts Worldwide Public Cloud Services Revenue to Reach $260 Billion in 2017*. Retrieved from www.gartner.com: https://www.gartner.com/newsroom/id/3815165

Global Metal srl. (n.d.). *LASER: NOZIONI DI BASE SUL TAGLIO LASER*. Retrieved from globalmetalsrl.it: https://globalmetalsrl.it/laser-nozioni-di-base-sul-taglio-laser/

Google Maps. (n.d.). Retrieved from https://www.google.com/maps/dir/Chiampo,+36072+VI/Arzignano,+VI/Montebello+Vicentino,+VI/@45.4953121,11.2934257,12.62z/data=!4m20!4m19!1m5!1m1!1s0x477f4ee9b2abe449:0xb1d15342fcbf2ee!2m2!1d11.2774926!2d45.5457622!1m5!1m1!1s0x477f48f66a63af4b:0xe146cdbae511

GrowthEnabler. (2017, 4). *Market Pulse Report, IoT.* Retrieved from https://growthenabler.com: https://growthenabler.com/flipbook/pdf/IOT%20Report.pdf

Hintze, A. (2016, 11 14). *Understanding the four types of AI, from reactive robots to self-aware beings*. Retrieved from theconversation.com: https://theconversation.com/understanding-the-four-types-of-ai-from-reactive-robots-to-self-aware-beings-67616

Hystory.com, S. (2018, April 19). *Industrial Revolution*. Retrieved from History.com: www.history.com/topics/industrial-revolution

ISO. (1995). *ISO/IEC 2382-28:1995*. Retrieved from www.iso.org: https://www.iso.org/obp/ui/#iso:std:iso-iec:2382:-28:ed-1:v1:en

ISO. (2012). *ISO8373:2012*. Retrieved from www.iso.org: https://www.iso.org/obp/ui/#iso:std:iso:8373:ed-2:v1:en

ISO. (2014). *Big Data Preliminary Report 2014.* Retrieved from www.iso.org: https://www.iso.org/files/live/sites/isoorg/files/developing_standards/docs/en/big_data_report-jtc1.pdf#page12

ISO. (2014). *Internet of Things - Preliminary Report 2014.* Retrieved from www.iso.org: https://www.iso.org/files/live/sites/isoorg/files/developing_standards/docs/en/internet_of_things_report-jtc1.pdf

ISO. (2014). *ISO/IEC 17788.* Retrieved from http://wiki.occc.ir: http://wiki.occc.ir/index.php?title=ISO/IEC_17788:2014#cite_ref-6

ISO. (2015). *ISO/ASTM 52900:2015(en)*. Retrieved from ww.iso.org: https://www.iso.org/obp/ui/#iso:std:iso-astm:52900:ed-1:v1:en:term:2.3.1

ISO, & Qavami, H. R. (2014). *ISO/IEC 17788.* Retrieved from ww.iso.org: https://www.slideshare.net/qavami/iso17788-v30

Kelly, J. (2015, 3 31). *Big Data Vendor revenue and market forecast 2011-2026*. Retrieved from https://wikibon.com: https://wikibon.com/executive-summary-big-data-vendor-revenue-and-market-forecast-2011-2026/

Kurfuss, T. (2014, 12). *Industry 4.0: Manufacturing in the United States* . Retrieved from ostaustria.org: http://ostaustria.org/bridges-magazine/item/8310-industry-4-0

Machine Design. (2016, 12 1). *What's the Difference Between Industrial Robots?* Retrieved from www.machinedesign.com: http://www.machinedesign.com/robotics/what-s-difference-between-industrial-robots

Magnaghi, G. (2016). *Stampa 3d: Terza Rivoluzione Industriale? Docente: ing. Giancarlo Magnaghi*. Retrieved from docplayer.it: http://docplayer.it/1664329-Stampa-3d-terza-rivoluzione-industriale-docente-ing-giancarlo-magnaghi.html

Magone, M. (2016). *Industria 4.0 . Uomini e macchine nella fabbrica digitale.* Guerini e Associati.

Manufaturing USA. (2018). *Institutes*. Retrieved from www.manufacturingusa.com: https://www.manufacturingusa.com/institutes

Micelli. (2016). *Fare è innovare. Il nuova lavoro artigiano.* Il Mulino.

MiSE. (2016, 6 15). *Audizione di Carlo Calenda - Industria 4.0.* Retrieved from http://www.sviluppoeconomico.gov.it: http://www.sviluppoeconomico.gov.it/images/stories/documenti/2016_6_15_AudizioneIndustria4%200_def.pdf

MiSE. (2018, 4 16). *ITALY'S NATIONAL PLAN IMPRESA 4.0 - Results from 2017 – Actions for 2018.* Retrieved from http://www.sviluppoeconomico.gov.it: http://www.sviluppoeconomico.gov.it/images/stories/documenti/impresa_40_risultati_2017_azioni_2018.pdf

National Institute of Standards and Technology. (2017). *FY 2017 President's Budget Request.* Retrieved from www.nist.gov: https://www.nist.gov/sites/default/files/documents/director/ocla/FY17-Budget-_NNMI_Combined.pdf

n-tech research. (2014, 9 8). *Power Sources for the Internet-of-Things: Markets and Strategies.* Retrieved from www.slideshare.net: https://www.slideshare.net/NanoMarkets/nano-741-ch1

Parmentola, S. (2006). *Società postindustriale*. Retrieved from www.treccani.it: http://www.treccani.it/enciclopedia/societa-postindustriale_%28Enciclopedia-dei-ragazzi%29/

Pathrotkar, P. (2018, 3 7). *Packaging Robot Market: Increased Production via Automation Driving Demand*. Retrieved from cmfenews.com: https://cmfenews.com/packaging-robot-market-increased-production-via-automation-driving-demand/

PCAST. (2012, 7). *Report on capturing domestic competitive advantage in advanced manufacturing.* Retrieved from www1.eere.energy.gov: https://www1.eere.energy.gov/manufacturing/pdfs/pcast_july2012.pdf

PCAST. (2014, 10). *Report about accelerating U.S. advanced manufacturing.* Retrieved from obamawhitehouse.archives.gov: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/amp20_report_final.pdf

Printspace3D. (2012). *Stereolithography*. Retrieved from www.printspace3d.com: https://www.printspace3d.com/what-is-3d-printing/3d-printing-processes/stereolithography_illustration-2/

Quora. (2018, 2 2). *The Difference Between Virtual Reality, Augmented Reality And Mixed Reality*. Retrieved from www.forbes.com: https://www.forbes.com/sites/quora/2018/02/02/the-difference-between-virtual-reality-augmented-reality-and-mixed-reality/#2f8431592d07

Roboticsbeta. (2017). *6 axis robot arm with non-perpendicular axes?* Retrieved from robotics.stackexchange.com: https://robotics.stackexchange.com/questions/12213/6-axis-robot-arm-with-non-perpendicular-axes

RobotWorx. (2018). *What Are The Main Types Of Robots?* Retrieved from www.robots.com: https://www.robots.com/faq/what-are-the-main-types-of-robots

Scanandmake.com. (n.d.). *Additive manufacturing*. Retrieved from scanandmake.com: https://scanandmake.com/additive-manufacturing

Society of Robots. (2014). *Robot arm tutorial*. Retrieved from www.societyofrobots.com: http://www.societyofrobots.com/robot_arm_tutorial.shtml

Statista. (2018, 1). *Facebook: annual revenue 2009-2017, by segment*. Retrieved from www.statista.com: https://www.statista.com/statistics/267031/facebooks-annual-revenue-by-segment/

Statista. (n.d.). *Size of the IoT market worldwide in 2014 and 2020, by industry (in $US billion)*. Retrieved from www.statista.com: https://www.statista.com/statistics/512673/worldwide-internet-of-things-market/

techdigg.com. (2017, 8 24). *The Battle for AR Technology*. Retrieved from https://techdigg.com: https://techdigg.com/2017/08/24/the-battle-for-ar-technology/

The White House. (2011, 6 24). *President Obama Launches Advanced Manufacturing Partnership*. Retrieved from https://obamawhitehouse.archives.gov: https://obamawhitehouse.archives.gov/the-press-office/2011/06/24/president-obama-launches-advanced-manufacturing-partnership

Treccani. (n.d.). *Seconda Rivoluzione Industriale.* Retrieved from www.treccani.it: www.treccani.it/export/sites/default/scuola/lezioni/storia/SECONDA_RIVOLUZIONE_INDUSTRIALE_lezione.pdf

Ulivieri, V. (2017, 9 25). *Distretti, qualità e specializzazione così si diventa leader mondiali*. Retrieved from www.repubblica.it: www.repubblica.it/economia/affari-efinanza/2017/09/25/news/distretti_qualit_e_specializzazione_cos_si_diventa_leader_mondiali-176517767/

Unione Nazionale Industria Conciaria. (2016). Retrieved from https://www.lineapelle-fair.it/uploads/market_trends_reports/Numero_57_Settore_conciario_italiano_2016.pdf

Wikipedia. (2017). *List of countries by GDP sector composition*. Retrieved from en.wikipedia.org: https://en.wikipedia.org/wiki/List_of_countries_by_GDP_sector_composition

Wikipedia. (2017). *Manufacturing USA*. Retrieved from https://en.wikipedia.org: https://en.wikipedia.org/wiki/Manufacturing_USA

Wikipedia. (2018). *Laser cutting*. Retrieved from en.wikipedia.org: https://en.wikipedia.org/wiki/Laser_cutting

Wikipedia. (2018). *Social media analytics*. Retrieved from https://en.wikipedia.org: https://en.wikipedia.org/wiki/Social_media_analytics

Wikipedia. (n.d.). *Fiera di Hannover (2011)*. Retrieved from Wikipedia: https://it.wikipedia.org/wiki/Fiera_di_Hannover#Fiera_di_Hannover_2011

Wübbeke et al. (2016, 12). *MADE IN CHINA 2025 - The making of a high-tech superpower and consequences for industrial countries.* Retrieved from www.merics.org: https://www.merics.org/sites/default/files/2017-09/MPOC_No.2_MadeinChina2025.pdf

XU, B. (2015, 5 2). *China Internet Plus Strategy* . Retrieved from sesec.eu: http://sesec.eu/app/uploads/2015/06/2015_05_SESECIII_Newsletter_April_2015_Annex02_China_Internet_Plus_Strat....pdf

Zanardini. (2014). *La Rivoluzione digitale nella manifattura.* Impresa&Città.

Zelinski, P. (2017, 4 8). *Additive Manufacturing and 3D Printing Are Two Different Things*. Retrieved from www.additivemanufacturing.media: https://www.additivemanufacturing.media/columns/additive-manufacturing-and-3d-printing-are-two-different-things

ZVEI. (2016, 4). *Reference Architectural Model Industrie 4.0 (RAMI 4.0).* Retrieved from https://ec.europa.eu: https://ec.europa.eu/futurium/en/system/files/ged/a2-schweichhart-reference_architectural_model_industrie_4.0_rami_4.0.pdf

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