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"IS THE INTERNET OF THINGS THE CATALYST FOR PRODUCT INNOVATION IN THE ITALIAN MANUFACTURING?"

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SUMMARY

INTRODUCTION

In recent years, the world is assisting at the dissolution of its physical boundaries, increasingly contaminated by the disruptive force of the digitization, that is permanently shaping the industrial system. The roots of the transformation are to be found in the so-called Fourth Industrial Revolution, the new manufacturing paradigm that, with its revolutionary nature, is affecting every aspect of human life, thus becoming a theme of great interest and not exclusively among experts. The key enablers of Industry 4.0 are a wide range of digital technologies, like Advanced Robotics, Augmented Reality, rather than Big Data, that are making digital ad physical systems increasingly interconnected, thus fuelling a radical transformation of the processes of value creation. The new paradigm enhances the relationships between human beings and machines which now collaborate side by side between tangible tools and virtual environments.

Among the technologies, is emerging the Internet of Things, that according to many will be the largest technology category of the next years for two reasons: the great potential of its uses and the low price due the cost decrease of the sensors that activate it. Coined by Kevin Ashton in 1999, the Internet of Things (IoT) is a network of dedicated physical objects (things) that contain embedded technology, like tag, sensors rather than QR codes, to communicate and sense or interact with their internal states or the external environment (Hung, 2017). The hype around this technology is linked to the extent of its strategic implications: the IoT, in fact, enables objects to gather, store and transmit data about themselves or what is happening around them. This data is real-time and updated and, once processed, become valuable insights for companies that can exploit it as the basis of their strategic decisions.

In a situation like the one of the Italian manufacturing, that after ten years from the financial crisis it is still struggling to hold its place as second manufacturing country of Europe, the technologies of Industry 4.0 are regarded as possible solution to revamp the competitivity of the manufacturing and lead the economic growth. By taking as reference point an ecosystem of small and medium enterprises, marked with an “insufficiently innovative” attitude, the objective of this work is to examine if and at which extent the Internet of Things influences the process of product innovation of Italian manufacturing firms that have deployed this technology in their offer. Specifically, it aims at investigating if the integration of a digital component within a product it is the catalyst of the achieved innovation.

The first section introduces the core theme of this work. The general characteristics of the so-called Fourth Industrial Revolution are presented, focusing on the concept of Cyber-Physical System. The section briefly describes the role played by the main technologies of Industry 4.0 in the phases of the circular process of value generation: The Physical-to-Digital-to-Physical Loop. Finally, it examines the challenges that an increasingly digitalized world poses to companies.

The second chapter presents a general overview of the impact of the Internet of Things when integrated within products. The four new capabilities of products are identified. It is then highlighted the emergence of new business models triggered by the IoT, which impact irremediably the sources of value creation.

The third part is an in-depth analysis of the process of product innovation when this becomes "smart" and "connected". The data-driven decision making process is presented to better understand the main key factor of the digital revolution, namely Big Data. It is clarified the meaning of innovation and it is then contextualized respect the new technological environment. A model that revisit the traditional process of product development is outlined and examined, in the light of the influence exerted by the Internet of Things. The chapter concludes displaying how the IoT changed the life cycle of products.

Chapter four opens with an overview about the current situation of the Italian manufacturing system; it follows a description of the Industrial Plan Industria 4.0 that aims at solving the productivity crisis of the Country, for then assessing the state of adoption of technologies of Industry 4.0 among Italian manufacturing companies. The IV paragraph presents an in-depth analysis of five case studies of Italian Manufacturing firms that have deployed the Internet of Things in their process of product innovation. The objective of the work is investigating if the IoT is the catalyst of the product innovation process, evaluating the extent of such influence and both the internal and external implications for the adopting firms.

CHAPTER 1 – THE IV INDUSTRIAL REVOLUTION

Starting from the end of the 18th century the industrial environment has undergone three profound changes, that did not stop at the industry but affected also the technological, economic, as well as the physical framework of the times in which have occurred in an irremediable way: for this reason they are called Industrial Revolutions. The first revolution started in 1784 in Great Britain and was characterised by the introduction of the power loom. The big technological change was the mechanisation of the production facilities with water and steam power, which led to the emergence of the first factory in the textile industry. At the beginning of the 20th century, with the introduction of the assembly line in slaughterhouses by Henry Ford, starts the second revolution which is driven by electrification: mass production permeates in a variety of industries changing like never before people's life. Between the '70s and the first years of the 21st century, the world saw the rising of the application of IT technologies and electronics, which inaugurated a new era characterized by the electronic automation of the production process: it is the beginning of the Third Industrial Revolution. The manufacturing becomes digital; clever software, novel materials, robots able to simulate the human movements, new processes (notably three-dimensional printing) and a whole range of web-based services show up and spread. The low cost of producing a wide variety of small batches allows the growth of mass customization. If the first two revolutions made the people richer and more urban (The Economist, 2012), this has opened the gate to the *ubiquitous computing*[1]. The Fourth Industrial Revolution represents what is occurring nowadays: differently from the past, manufacturing systems and the objects they create are not simply connected, namely they project physical information into the digital realm, but also communicate, analyse, and use that information to drive further intelligent actions back in the physical world to execute a physical-to-digital-to-physical transition (Sniderman, et al., 2016). So basically, it takes the reins of what was started with the third big change, with the adoption of computers and automation, and exponentially enhance it with smart and autonomous systems fuelled by big data and artificial intelligence.

[1] Coined by Mark Weiser at Xerox PARC in the 1990s, *ubiquitous computing*, or *ubicomp,* describes the trend of embedding the computing power (generally in the form of microprocessors) into all manner of everyday objects, to make them effectively communicate and perform useful tasks in a way that minimizes the end user's need to interact with computers as computers. The Internet of Things has its roots in the work done by Mark Weiser. (McEven & Cassimally, 2014)

1.1 INDUSTRY 4.0

The interrelation between the physical world and the digital world enabled by the ubiquitous connectivity is the basic scenario in which Industry 4.0 is conceived. The general consensus is that the relentless integration between human being and "machines" is so fast and explosive that makes uneasy to set the boundaries between one world and the other and to give a holistic picture. According to Laudante, *"in the current production environment a transformation called Industry 4.0 is in progress, a paradigm change whose boundaries and times are still difficult to define and will manage to involve the entire international manufacturing sector"* (Laudante, 2017). What seems certain is that the manufacturing sector will be the one most involved and the most subject to change. An article on Forbes magazine confirms this statement, by describing Industry 4.0 as a transition and a significant transformation regarding the way of producing products thanks to the digitisation of manufacturing (Marr, 2018). Summing up both, McKinsey defines Industry 4.0 as the digitisation of the manufacturing sector, with embedded sensors in virtually all product components and manufacturing equipment, ubiquitous cyberphysical systems and analysis of all relevant data (McKinsey & Company, 2015). Deloitte delves into its definition, not purely focusing on the operational aspect, but giving an idea of its considerably extensive applications and implications:

"Industry 4.0 signifies the promise of a new Industrial Revolution—one that marries advanced production and operations techniques with smart digital technologies to create a digital enterprise that would not only be interconnected and autonomous but could communicate, analyse, and use data to drive further intelligent action back in the physical world. It represents the ways in which smart, connected technology would become embedded within organizations, people, and assets, and is marked by the emergence of capabilities such as robotics, analytics, artificial intelligence and cognitive technologies, nanotechnology, quantum computing, wearables, the Internet of Things, additive manufacturing, and advanced materials"

(Cotteleer & Sniderman, 2017).

It is quite clear that Industry 4.0 is a phenomenon whose capability to create value does not stop at the industry level. The power triggered by its new digital technologies and the effect of the data generated is inexorably affecting everyone's daily life, "revolutionising" it.

1.2 THE SHIFT OF PARADIGM

Today can be found many synonyms for the description of the occurring process of innovation, which is widely spread globally. Indeed, Industry 4.0 has become a global concept and even if it takes many different names and forms, the overall meaning remains largely the same and encompasses the same technologies and applications (Cotteleer & Sniderman, 2017). *Smart Manufacturing, IV Industrial Revolution, Intelligent Factory, Factory of the Future* are all initiatives that define this shift of paradigm whose roots are identified in a technological break. For example, as highlighted by Cotteleer and Sniderman, in the United States the focus tends to be more on a holistic digital evolution, and many use the term *digital supply network*, while within Europe the focus tends to be more factory-based (Cotteleer & Sniderman, 2017). In Europe, the process of integration of the physical processes with digital technologies is defined as *Industrie du Futur* in France, *Fabbrica del Futuro* in Italy, rather than *Industrie 4.0* in Germany, which it can be defined as the "mother" of the revolution. In effect, the first time that the digitization of manufacturing reached a wide audience was 2011, at the Hannover trade fair, which is one world's leading events for industrial technology. A cyber-physical system, based on the integration of modern IT and communication technologies with the real world, was the answer found to strengthen the competitiveness of the German manufacturing industry and to support a reshoring from low-cost Countries. From 2013, *Industrie 4.0* is one of 10 "Future Projects" identified by the German government as part of its *High-Tech Strategy 2020 Action Plan*, aiming at technological innovation leadership of Germany and beyond.

Germany Trade and Invest (GTAI) defines Industry 4.0 as:

"A paradigm shift . . . made possible by technological advances which constitute a reversal of conventional production process logic. Simply put, this means that industrial production machinery no longer simply "processes" the product, but that the product communicates with the machinery to tell it exactly what to do." (Sharma & Troillet , 2019).

Industrie 4.0 integrates of modern information and communication technologies into production systems intending to enhance their flexibility, adaptability, and efficiency. That means it aims to increase the production capacity and product quality while reducing costs at the same time (Martins & Anderl, 2019). In this context, the service evolves as an intrinsic part of the offer and abandons the supporting role to the physical object: companies, by now, are selling services, not products. The latter becomes the mean through which manufacturers convert individual needs in profit by exploiting the new characteristics of connected and communicating products and endorsing mass customization. In the ever-changing environment pushed by technological disruptive forces, flexibility and integration between new digital technologies and managerial approaches, as well as well-established business practices, are the key elements to face the change. The shift of paradigm, thereby, has its basis in the digitisation of the entire manufacturing system and the consequent deep market segmentation, with a wide variety of smart connected products produced in little volumes. Industry 4.0 has expanded the possibilities of digital transformation, becoming a core element for the organizations' competitiveness. Its key contribution is to combine and connect digital and physical technologies, like artificial intelligence, the Internet of Things, additive manufacturing, robotics, as well as cloud computing, to drive enterprises towards more flexibility, responsiveness, and interconnection, as well as to make them capable of making more informed decisions (Daecher, et al., 2018)

Figure 1 – Expected Results from Industry 4.0 (Source: Personal Elaboration based on Bacchetti, Zanardini 2017 – Icons made from www.flaticon.com))

1.2.1 CYBER-PHYSICAL-SYSTEMS

At the core of the change there is the approach of the Cyber-Physical-System (CPS), which represents the integration between the physical and digital world and for this reason it can be referred as the realisation of the IV Industrial Revolution. Suitably, Industry 4.0 marks the transition from embedded system technologies, which were confined into a stand-alone device, to Cyber-Physical System (CPS) technologies (MacDougall, 2014). This kind of technology links the digital and physical world typically via sensors, affixed to physical devices and networking technologies that collect a huge flow of data over a network of systems. The network is composed of machines, physical products, virtual items, computing facilities and storage, communication devices that interact with each other and exploit the enormous potential of new technologies (Laudante, 2017). The big player is the massive flow of Big Data[2] produced by all these objects, which are increasingly pervading the surrounding environment, and from which begins the process of innovation and adaptation. The subsequent decryption of data into useful information together with the communication among all the actors of the network are the hallmarks of the CPSs. Such systems are affecting not only the manufacturing system but also people's daily life in ways so far unexpected. The shift from embedded systems to Cyber-Physical systems[3] has turn objects intelligent, able to collect and analyse data, integrating historical information and new information, communicate and interact among themselves, but also with the surrounding environment, enabled by networks over the Internet. The evolutionary development of embedded system paves the way for the "Internet of Things" (MacDougall, 2014). The omnipresence of smart connected products is such, that even the famous concept of ubiquitous computing seems to be already out-of-context: in fact, computing is not only ubiquitous and invisible, but pervasive, constant, and deeply embedded in people's everyday lives (Nish-Lapidus, 2014). Smart cities, home automation, traffic management, health sensors are just some of the many IoT applications that are already being put in place.

1.3 THE INTERNET OF THINGS IS LEADING THE REVOLUTION

As stated above, every aspect of the society, economy, and industry is today touched in some way by the internet and connectivity. The latter is not something new in the productivity process: in the 80s and 90s, during the second wave of the IT-driven competition, Information Technologies (IT) revolutionized for the second time the manufacturing system. Indeed, they enabled connectivity and integration across the value chain through the optimization of the supply chain, the increase of productivity and disclosure of the key role played by the customers' relationship management. What is happening now, instead, it is the integration of digital information along the entire process of manufacturing, which enables a continuous and cyclical flow of real-time data and intelligence between physical and digital worlds. The medium between the two is the so-called *digital thread*, which is a framework that allows real-time continuous access to data, supporting the entire product life cycle, from the design concept to the after-sale customer relation, which in turn supplies data useful for its redesign and maintenance. In so doing, the digital thread gets rid of the information silos, granting

[2] Large set of information that grow at ever-increasing rates. Big Data encompasses the volume of information, the velocity or speed at which it is created and collected, and the variety or scope of the data points being covered. (Source: https://www.investopedia.com/terms/b/big-data.asp)

[3] Cyber-Physical systems are composed of a complex network of machines, physical products, virtual items, computing facilities and storage, communication devices that interact with each other and exploit the enormous potential of new technologies (Laudante, 2017).

transparency from data complexity and allowing every function of the company to promptly exchange information, collaborate, communicate and react to, or even anticipate, obstacles and alterations. The resulting benefits are in terms of lower costs, shorter production times and better-quality products. The flow of information follows a circular path made of three steps, which make up the *Physical-to-Digital-to-Physical Loop*. The process describes how the organization uses information to generate value, by exploiting the physical and digital technologies of Industry 4.0.

<table>
<tr><th>Product Impact</th><th colspan="2">Application Technologies</th></tr>
<tr><td>Physical→Digital</td><td>▪ Augmented and Virtual Reality
▪ Simulation Technologies (touch interfaces)</td><td rowspan="3">▪ Big Data
▪ Cloud
▪ IoT
Connectivity & Communication</td></tr>
<tr><td>Digital</td><td>▪ Big Data Analytics
▪ Machine Learning</td></tr>
<tr><td>Digital→Physical</td><td>▪ Additive Manufacturing (3D printing)
▪ Advanced Robotics</td></tr>
</table>

Table 1 – Industry 4.0 Technologies (Source: Personal Elaboration)

The manufacturing process begins obviously with information, which is gathered from the physical world through sensors, wearables or through scanning of a physical object. Then it is moved in the digital realm through the creation of a digital record: *The Physical-to-Digital leap*. Afterwards, information is shared and analysed through advanced analytics, scenario analysis, rather than with Artificial Intelligence, which all uncover substantial insights to be communicated to the machines which will be executed the design: *The Digital-to-Digital leap*. The next step is crucial: algorithms and automation are applied to the digital information translating decisions from the digital world into actions that have the ability to change and influence the physical world: the leap from *Digital back to Physical* world. It is, therefore, the ability to act upon data and analysed information that constitutes the essence of Industry 4.0 (Cotteleer & Sniderman, 2017). Among the technologies 4.0 which are changing in profound ways the manufacturing system, such as additive manufacturing, advanced robotics, artificial intelligence, augmented reality, advanced material, and analytics, to name only a few, it can be stated that the Internet of Things is the most crucial resource of value. With the underlying goal of having access to relevant information in real-time (or at least near real-time), the IoT sensors, embedded in physical objects, transform analog inputs into digital signals, and hence create a digital reflection (*Digital Twin*) of what is happening in the physical world. This setup enables the development of intelligent applications and services and allows objects to be sensed and actuated across existing network infrastructures (Deloitte, 2018). Thus, the IoT enables the stage of act (Physical-to-Digital leap) in the sequence of value generation and links it to the one of creation (Digital-to-Physical). For this reason, Deloitte has pinpointed the relevance of the Internet of Things, because acting in synergy with the Industry 4.0 technologies, it integrates the two steps completing the physical-to-digital-to-physical cycle.

The series and sequence of activities through which organizations create value from information is captured by the IoT Information Value Loop (IVL) (Sniderman, et al., 2016).

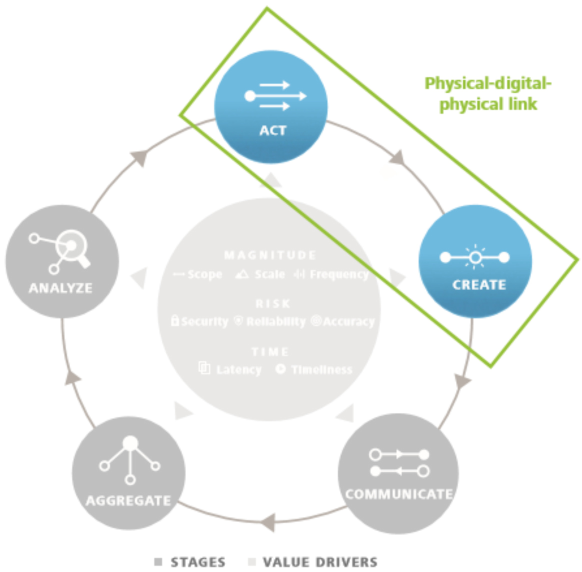

Figure 2 – The Physical-to-Digital-to-Physical Leap of Industry 4.0 in the IVL (Source: Deloitte, 2016)

1.3.1 CONNECTIVITY & COMMUNICATION: THE INTERNET OF THINGS

The developments in communication and information technologies have made the IoT the trend of future networking. Thanks to the leading role in the third wave of the IT industry, it can be stated that, among the *nine pillars* (Laudante, 2017), i.e. the enabling technologies of the fourth revolution, the Internet of Things represents the most powerful of the 21st century paradigms (V.K.Bairagi, et al., 2018). The term Internet of Things identifies the network of sensors, actuators and information exchange technologies installed in objects, products, and machinery, capable of enabling their traceability, coordination and remote control (Zanardini & Bacchetti, 2017). The embedded technologies enhance the capabilities of these objects, which can communicate and sense or interact with their internal states or the external environment (Hung, 2017). The IoT has its roots in the development of Radio-Frequency Identification technology (RFID) and related identification technologies. Although research on RFID technology dates back to after the Second World War, an ultra-high frequency (UHF) RFID system got boost just in 1990s, when at MIT, Massachusetts Institute of Technology, two professors, David Brock and Sanjay Sarma, changed the way people thought RFID in the supply chain (IEEE Internet Initiative, 2015). They found out a way of placing low-cost RFID tags on all products to track them through the supply chain[4]. Their idea was based on the placement of only a series of numbers on the tag to keep the price down; doing so, the solution to store little information in simple microchips, instead of complex ones, would have been way cheaper. The data associated with the serial number would be stored in a database accessible over the Internet. This achievement enabled the first networking technology that was working by linking the objects through the tag. Hence there was an evolution respect the simplistic information given by the bar code, that was only about the single product and the container it was stored in.. Nevertheless, the Internet of Things goes beyond the simple monodirectional communication technologies like those mentioned above. Indeed, it includes solutions based on the integration of information technology, which enables objects to actively comprehend the data they gather, process and communicate to decision-makers and other connected objects. These are even able to take decisions autonomously, with limited or no human intervention. The Internet of Things makes the Internet ubiquitous: it is estimated that the objects connected will be between 25 to 75.44 billion worldwide by 2025, generating a total potential economic impact of $3.9 trillion to $11.1 trillion per year (McKinsey & Company , 2015). What makes the Internet of Things an even more pervasive concept is the variety of "objects" embedded with sensors; even unexpected objects collect information and communicate with the ecosystem where are connected to other devices. The revolutionary wave, indeed, will not only involve high electronic devices such as vehicles or smartphones, but also objects of daily use like home appliances and food, rather than people and animals.

The drastic cost fall of the IoT nodes and sensors made possible their pervasive application. This consequently has led to vast improvements for processing power, as well as in achieving optimal levels of energy efficiency of sensors and batteries. Thanks to network benefits linked to this wireless connectivity infrastructures – such as LPWAN Zigbee, or Z-wave -, there have also been developments in device miniaturization (compactness) and into the rapid software development. A further technological conquest for the IoT system has been placed in 2012: The *Ipv6*. It is the sixth version of the Internet Protocol and allows us to uniquely identify "Things"

[4] It must be considered that at the beginning the focus was on retail and logistics applications.

as well as to guarantee connection to a potential infinitive number of devices since it has almost unlimited addressing capacity. Unlike the previous Ipv4 protocol, which could only address 4.3 billion total unique IP addresses and considering that by 2020 are expected 25 billion "Things" to be connected to the Internet (Hung, 2017); the scalability, strong security enablers and connectivity[5] offered by the future of internet protocols addresses are essential. Mike Kuniavsky captures a comprehensive overview of the aforesaid effects:

"[The IoT] ...is the combination of distributed information processing, pervasive wireless networking and automatic identification, deployed inexpensively and widely. The underlying technologies and the applications that are traditionally discussed don't matter much, because it is this combination of factors that deeply affects people and industries, and it does it by connecting people's immediate experiences to the power of digitally aggregated and 13qamai13r information. In other words, the Internet of Things turns physical actions into knowledge in the cloud and knowledge in the cloud into physical action in a way that's never existed before." (IEEE Internet Initiative, 2015)

The Internet of Things has power whereby the massive amount of data from different sources, which does not stop at databases but include also images, videos, emails, audio records (unstructured Big Data), is translated into knowledge which leads to resourceful insights. The decision takers for their part can turn them into decisions and actions that improve the business and the overall physical world. The impact of real-time data and intelligence enabled by technology innovation should not be underestimated. The data-driven decision-making exploits objective inputs given by hard data rather than relying on intuition, or on observation alone (Techopedia, s.d.). As a consequence, it leads to performance optimization, time savings, improved asset utilization, as well as quality of life improvement (e.g. by reducing accidents). The Cloud is "the big enabler" of this process because it acts as the central connection hub, power analytics, and provision of data storage (Hung, 2017), allowing the explosive growth of Internet-based services relying on these data (Rorato, 2019). The Cloud offers essentially services and applications that such quantity of data needs: robust storage and greatly extensible computing power at low cost. For this reason, is also defined as "software as a service". The two main advantages are: at first, it makes possible to pay in base of the usage, so without ulterior hardware requirements if there is the necessity to add storage capacity; secondly, Cloud services are accessible from any device with an Internet connection, with minimal or no local

[5] Source: https://www.link-labs.com/blog/why-ipv6-is-important-for-internet-of-things

software or processing power required, so they facilitate the ubiquitous connectivity and access to the system.

Big Data, Cloud and the Internet of Things, synergistically with Advanced Analytics, which will be discussed afterwards, could be comprised in the group of the “base technologies”. They are so-called because provide connectivity and intelligence to all the other “Smart” dimensions of the manufacturing system integrating them together; and because they have a part in the action of all of them. In consequence, it can be confirmed their role as enablers of Industry 4.0, differentiating the latter from previous industrial stages (Frank, et al., 2019).

1.3.2 PHYSICAL-TO-DIGITAL TECHNOLOGIES

Human-machine intelligent interfaces (HMI) combine the latest in human-centered design techniques with leading-edge technologies such as computer vision, conversational voice, auditory analytics, and advanced augmented reality and virtual reality (Cook, et al., 2019).

The omnipresence of smartphones, tablets, and smartwatches has enhanced the ways through which people interface with technology, making this act familiar and contextual. Simulation technologies include all the systems and solutions which virtualize a machinery/production system, with the objective of monitoring the remote operation; and test the impact of project choices and alternative planning on the production system, anticipating any problem (Zanardini & Bacchetti, 2017). Graphical interface allows everyone to monitor and control complex operations in real-time, simply through the touch screen of a smartphone, receiving back real-time, context-aware and automated feedbacks. In banks, ATM machines send inputs from the surface to the operator in case of problems, allowing real-time, remote, condition-based maintenance reducing maintenance costs by 10 to 40 percent (McKinsey & Company , 2015).

Virtual reality (VR) and augmented reality (AR) technologies integrate the user’s environment with digital information in real-time but they also improve decision making and work procedures. Despite they are at the infancy stage, their application is expanding. VR is defined as a *real-time interactive graphics with three-dimensional models, combined with a display technology that gives the user the immersion in the model world and direct manipulation*. (Mazuryk & Gervautz, 1999). Unlike virtual reality, which creates a totally artificial environment, augmented reality uses the existing environment and overlays new information on top of it[6], enhancing the real world. Google glasses was a wearable device connected to the internet which uses the same principle. The simulation of possible scenarios supports workers in terms of safety and efficiency because activate behavioural skills training which involves

[6] Source: https://whatis.techtarget.com/definition/augmented-reality-AR

processes of learning-by-doing. Through the information received, these can detect or predict problems, superseding if necessary. In addition, simulation technologies are increasingly being deployed for enhancing customer experience. For example, they involve customers by virtual product testing, like have done Ikea through its app which allows its clients to select from more than 2000 items that can be 'placed' into their home. Moreover, American Apparel is using AR in its stores with the scope of optimizing the decision-making process and increase post-purchase satisfaction.

1.3.3 DIGITAL

The amount of data to be collected, processed and exchanged has grown exponentially over the last 10 years. The number of smart devices equipped with sensors that generate and distribute data autonomously through an internet connection has exploded, feeding an enormous volume of different data that adds up to those generated by intelligent machines. Big Data are defined as *a collection of data so extensive in terms of volume, velocity and variety that specific technologies and analytical methods are required for value extraction"* (De Mauro, 2019). What the definition suggests is that the central function of Big Data is to give the best representation of reality and depending on this, Big Data Analytics is the process by which the large and varied data sets are processed and analysed in real-time with the scope to decode the complexity of reality. Conventional business intelligence (BI) and analytics programs are based on relational databases that are oriented to structured data sets, but with the growth of technological innovations, data are more and more encompassing semi-structured and unstructured forms, which need to update frequently, or even continually. Unstructured forms of data include internet clickstream data, web server logs, social media contents, like videos or pictures and texts from customers' email. From the interrelation of sources, Data Analytics technologies extract the most resourceful information content, uncovering hidden patterns, unknown correlations, market trends, and customer preferences. Big Data analysis is a form of Advanced Analytics which includes complex tools for sifting through data in search of pattern and relation (data mining); predicting and recommending courses of actions in uncertainty environments (predictive analytics); tapping algorithms to analyse large data sets (Machine Learning)[7]. Machine Learning[8] could be referred to as "the working horse"[9] in the new era of Big Data. It interacts with the complexity of the data, autonomously learning from the

[7] Source: https://searchbusinessanalytics.techtarget.com/definition/big-data-analytics
[8] Despite Machine Learning often is associated with Artificial Intelligence, they are not synonyms: indeed, AI is the broader concept of machines being able to carry out tasks in a way that people would consider "smart"; while Machine Learning is a current application of AI based around the idea that machine having access to data are independent learners and actors (Marr, 2016).
[9] Source: https://link.springer.com/chapter/10.1007/978-3-319-18305-3_1

surrounding environments and creating new knowledge; by this way, Machine Learning emulates the human intelligence and acts accordingly, performing specific tasks, predicting and adapting independently, without requiring human intervention. Pirelli accomplished predictive manufacturing using machine learning in its production process, benefitting of a reduction of failures and machine downtimes.

1.3.4 DIGITAL-TO-PHYSICAL

The conversion of the processed data into a physical object is realised by a set of flexible types of machinery and technologies which fall into the definition of Advanced Manufacturing. Among these, Additive Manufacturing (AM) is making its mark in the process of the product realisation, constituting the central pillar of the internal operational activities. Indeed, recent technology advancements have made 3D printers more affordable leading to an explosion in the commercial use of this technology (Ramakrishnan & Gaur, 2017). Implemented since the 1980s, Additive Manufacturing is a set of 3D printing technologies which make it possible to produce faithful three-dimensional prototypes and reproductions of a 3D digital model realized with a CAD (Computer-Aided Design)/ CAM (Computer-Aided Manufacturing) software, through the ordered overlapping of stratified material (e.g. layers), and subsequently sent to the 3D printer that reproduces them through the use of the material of a different nature (Zanardini & Bacchetti, 2017). The characteristics to produce layer-by-layer objects differentiate AM from the traditional manufacturing which is marked by subtractive techniques based on the subtraction of material from solid blocks of raw material. The gains accrued are many: first, the reduction of waste material and the associated advantages in terms of realization costs. Secondly, the speedup of the design process leads to the optimization of lead time production, as well as reduction of time-to-test and time-to-market, thus reducing supply chain interdependencies. Another advantage is given by the possibility to develop and test the product virtually: the sharing of information between colleagues and customers enables ongoing adjustments, bypassing design limits. The result are unique products, ready to sell and with complex geometric forms that cannot be obtained with traditional manufacturing. Besides the benefits, must be recognised some relevant limits: the realization of objects has dimension limitations which are contingent on the dimensions and speed of the printing machine. Further, the latter has still an elevated price: this represents a considerable obstacle for achieving the mass production customization promised by Industry 4.0. Furthermore, the materials employed for realising the products are still expensive and have limited variety which can be processed simultaneously in molding processes. A more cost-effective technology that is widely being applied, even beyond the industrial cage, is Advanced Robotics. Especially, *Collaborative*

Robots are set to be worth $135 billion by the end of 2019, arriving in sectors not traditionally accustomed to robotics or automation, such as healthcare and energy generation[10]. Collaborative Robotics, in contrast to traditional robots, interact directly and besides humans in a shared workspace thanks to their awareness of the surrounding environment. Thanks to advances in edge computing they have become easier to implement and often they require little or no programming, thus reducing integrating costs and maintaining anyway safety through sensors that respond to the human colleagues. Nevertheless, their key characteristics are the increased flexibility, which unlocks a wide range of new tasks and applications, often dangerous, intense and less ergonomic for the human operator, who performs only those which add real value.

1.4 ACTION PLAN TO NOT SUCCUMB IN THE CONNECTED WORLD

Despite the focus of the Internet of Things seems to be exclusively on technologies, the competitive landscape reveals that the manufacturing industry will play in a field where the challenges are more than always managerial than just about substituting assets. Decision-makers must carefully think and draw up action plans to face these challenges. The outcome can be double: whilst capitalize the opportunities offered by these determinants is the path to follow in order to take advantage of the Industry 4.0 technologies; the lack of digital transformation and alignment across all the functions of the company can be fatal. Moreover, while some challenges will occur at an organizational level, others will impact the entire ecosystem.

1.4.1 ORGANIZATIONAL CHANGE

The integration of IoT technologies at the organizational level crosscuts all the areas of the organization: this has led to new challenges for companies that have to cope also inside the organization with change, cultural, behavioural and structural.

First, the implementation of the IoT-based systems requires that everyone within the organization is aligned with the new organizational structure which is based on data, integration of systems and processes and which requires decisions based on information that comes from a wide range of different sources. The ever-changing, complex and unpredictable environment requires the workforce to be flexible, fast in reacting to changes and able to work in abstract contexts and to convert quickly into valuable decisions and actions the information generated by data. According to a study conducted by the MIT Centre for Digital Business and the McKinsey Business Technology Office, companies that were in the top third of their industries

[10] Source: https://www.machinedesign.com/robotics/robots-extend-their-reach

in making data-driven decisions were, on average, 5 to 6 percent more productive than their peers. (McKinsey & Company , 2015). The principal figures who will perform vital tasks for the new organization mixes technical know-how with business acumen besides having outstanding digital capabilities like software engineers, data scientists and most of all the CIO (Chief Information Officer) will be the one who will cover a key role. The latter is the so-called "techie" of the company and has an in-depth understanding of the overall processes of the production chain. Moreover, due to his outstanding ability to adapt his vision, decision making and capabilities to orchestrate the IoT world, the CIO will be asked to set up and lead all the unforeseen and novel opportunities and threats surfaced by the expansion of the IoT, thus making her the "CIO of Everything" (Hung, 2017). The integration of functions within the company will require cross-functional teams with complementary knowledge, therefore increasing the demand for skills like the design, sale, service of smart connected products. Although skilled workers are on the rise, the shortage of talent is still persistent mostly due to the variety of competencies required; accordingly, new training needs are essential to ride the competitive wave. To fill the gaps manufacturers are increasingly establishing a physical presence in hot spots such as Boston and Silicon Valley, which combine a presence in advanced manufacturing with academic centres, makers of B2B[11] hardware and software, and emerging producers of smart, connected products (Porter & Heppelmann, 2015). Other partnering experiences are settled with universities, high schools, organizations, and technical colleges with the aim of accelerating and improving learning; for instance, Italy and India governments have established joint industrial research projects, for the development of innovative products or processes for specific market needs or challenges[12].

1.4.2 CONNECTING ECOSYSTEMS

The cooperation among peer consortiums, IT companies, industry associations and governments bodies does not stop at organizational level but expands at a broader-ecosystem level. To fully exploiting the potentialities and value of modern technologies, it is necessary first to integrate data and processes from outside the company; then, to develop a common set of technology standards that is open and accessible by all the actors of the global digital value chain. When competitive advantage is based for the most part by the value of data, companies need to have access to information inside and outside the company itself, in real-time and during the all the product life cycle, even beyond. On one hand, standards are indeed essential to

[11] Business to Business (B2B)
[12] Source: https://www.aise.it/maeci/italia--india-bando-per-la-raccolta-di-progetti-di-ricerca-industriale-congiunta-2019/125529/2

manage competitively the massive amount of data and integrate resources, as well as capabilities, when for example are too expensive to be developed internally or it is the best solution to outsource. On the other hand, developing its own standards will incur for companies in high development and production costs. Thus from suppliers to customers, to third parties must cooperate to create common operability standards, which link through the IoT nodes all the stakeholders enabling them to share and integrate information, make more holistic decision and also predict potential failures that would not be detected if not with combined data from different sources. This enable the constant stream of data from the different devices to be exploited in every point of the digital thread and to realize the main goal of the Internet of Things, which is *"…to enable things to be connected anytime, anyplace, with anything and anyone ideally using any path/network and any service"* (Patel & Patel, 2016). According to McKinsey, interoperability can capture from 40 to 60% of the total potential value of IoT, embodying the precondition for and catalysts of the digital transformation (KPMG, 2017). Telemar, a telecommunications company headquartered in Vicenza, has created a LoRaWAN™ network for the creation of a global network dedicated to the Internet of Things[13]. Via LoRa transceivers embedded in sensors and gateways, the network captures and transmits data over long distances using minimum energy. As soon as a global operative standard like LoRa will be developed, all the manufacturers will apply it to their products driven by the pressure created by the customers who increasingly will adopt solutions able to communicate with one another.

1.4.3 CYBERSECURITY, DATA RIGHTS & PUBLIC POLICIES

In the absence of an operative standard, as the estimated number of ecosystem-related devices is likely to increase, so does the IoT systems security become more vulnerable.

Since the use and ownership of information produce value by guiding product improvement and increasing efficiency within the supply chain, it becomes a duty of the top management to ensure appropriate security, privacy, and control over the data and to their owners.

Internet has been the first disruptive force toward privacy and security. In fact, as a massive open publishing platform made everything visible and traceable. The IoT also adds new risks to existing concerns about cybersecurity since introduces new levels that need protection from IT technologies: device, network, and cloud increase the "surface area" available for breaches, enhanced by the enabled interoperability which expands the scope for potential attacks and points of entry for possible hackers, as well as the ease with which damages propagate within the system. Every smart connected product can be a point of access and most of them have little

[13] Source: https://www.tiot.it/

or no protection at the software and infrastructure levels (Hung, 2017). Furthermore, there is the need to link the new devices with those which have been in use for years which need as well to be protected, especially in areas such as industrial automation. It follows that when happens an intrusion targeting specifically the IoT devices, such as that one which occurred in 2016, which affected routers and appliances as well, the extent of the damage is more severe. Companies like Amazon, Twitter and Netflix were unprepared and suffered considerable damage. Accordingly, security is not only a matter of technological vulnerability but also a lack of caution among those who use IoT devices (Patel, et al., 2017).

Another concern is related to the data that smart devices in one way or another collect without authorization, which arises issues related to their ownership. Customers are constantly giving information, acquiring the status of "data subjects" which means that they are the subjects of the data collected, even if they are not the owners. For the above reasons, customers are becoming more wary of sharing personal information burdened by the misuse of their private and personal data. In order to protect them, governments are enacting legislation which attribute huge responsibilities to companies in their action of data management belonging to the citizen: examples are the General Data Protection Regulation (GDPR) in Europe and the recently enacted California Consumer Privacy Act of 2018 (CCPA). Indeed, the US in addition to national privacy or data security law has hundreds of privacy and data security among its 50 states and territories, such as requirements for safeguarding data, disposal of data, privacy policies, appropriate use of Social Security numbers and data breach notification[14].

All the functions of a company are called to adapt strategies to the "pervasive digital presence" to address security issues (Hung, 2017); a firm's ability to provide security is becoming actually a source of value and potential differentiation (McKinsey & Company, 2015) and to succeed managers have to consider it already during the first phase of product design. Transparency on data collection and use and strong end-to-end security are the basis from which address these issues (McKinsey & Company , 2015). Governments and institutions as well must draft policies that strengthen the protection toward privacy and property rights of business and consumers, along with regulations of the new forms of activity in the public spaces.

[14] Source: https://www.dlapiperdataprotection.com/?t=law&c=US

CHAPTER 2 – SMART CONNECTED PRODUCTS

The third wave of the IT revolution has changed the product in ways before unimaginable. Physical objects, by embedding sensors, have gained those characteristics belonging to the technologies, like programmability, sensitivity and communicability. The break-off of the physical component with its information and service specification has, in turn, affected the capabilities of the product, bringing benefits inside and outside the company. In the first case for example by improving business operations (e.g. productivity improvements and risk reduction) and outside the company by boosting revenues (e.g. incrementing old sources and creating new ones) and engaging customers through long-term relationships. Nevertheless, smart products do not only refer to physical objects but to the entire universe of products and services, which are enabled by digital technology […] and which are internet-connected, as well as able to directly communicate with each other (Turber, et al., 2014). Many scholars agree on the layer-based structure of the connected objects (Porter et al. 2014; Turber et al. 2014; Abdmeziem et al. 2015; Patel et al. 2016)). Regardless of the number of layers of the different models, the key feature common to all of them is the modularity and "de-couplebility" of content, devices and information infrastructures which allows multiple stakeholders to contribute across the layers in an unforeseen way – interoperability provided (Turber, et al., 2014). Following the logic of interoperability itself, the actors of the ecosystem can act over them turning them into sources of value creation, laying the foundation of new business models.

2.1 TOWARDS PRODUCT AUTONOMY

Porter and Heppelmann suggest that smart connected products have three core elements: physical components, "smart" components and finally the connectivity ones, whose joint action results in a virtuous cycle of value improvement, the so-called IoT Information Value Loop (IVL). The mechanical and electrical parts of the product constitute the physical parts; while sensors, protocols, microprocessors, data storage, controls, software, embedded operating system, and a digital user interface constitute the smart part of the product. The latter amplifies the capabilities and value of the physical components. Connectivity first allows the exchange of information among the actors of the network, secondly enables some functions to exist outside the "thing" using a cloud. This is made possible by its components which amplify smart components and comprise ports, antennae, protocols (e.g. Ipv6), and networks. Connectivity, in turn, takes three forms:

• *One-to-one*: It allows an individual product to connect to the user, the manufacturer, or another product through a port or other interface;

• *One-to-many*: A central system is continuously or intermittently connected to many products simultaneously;

• *Many-to-many*: Multiple products connect to many other types of products and often also to external data sources[15].

The new products require a new architecture for making the system work: The *Technology Stack*. It is made up of a series of layers, including new product hardware, embedded software, connectivity, a product cloud consisting of software running on remote servers, a suite of security tools, a gateway for external information sources, and integration with business systems. (Porter & Heppelmann, 2014). It allows to manage the massive flow of data inside and outside the product, assuring security and identity to the system, enabling connection and communication with other business systems. The result is both digital and physical support that guides the transition from information to action between the two worlds, directly influencing them. A well defined IoT architecture is still not established, but of course generally, companies look for the fastest, cheapest and most reliable solution among the endless variety of IoT applications available. However, the most well-accepted technology stack consists of three layers, each based on an enabling technology: Perception Layer, Network Layer, and Application layer.

The *Perception Layer* is based on sensing and communication technologies, such as Wireless Sensor Networks (WSN)[16], GPS and radiofrequency identification (RFID) that allow to gather data. This layer perceives the physical properties of objects belonging to the IoT system; then converts the information into digital signals that are transmitted in the network.

The *Network Layer* processes the information received by the Perception Layer, transmitting them to the Application Layer. The transmission of data is enabled by various network technologies, such as wireless/wired networks and Local Area Networks (LAN). The main media for transmission includes FTTx, 3G/4G, Wi-Fi, Bluetooth, Zigbee, UMB, infrared technology, and so on (Abdmeziem, et al., 2015). It requires the disposal of a sound middleware to automatically store and process the flow of data and Cloud Computing represents the main

[15] The core elements of the IoT and their explanation are based on the web article of Porter and Heppelmann: *"How Smart, Connected Products are Transforming Competition"* (Porter & Heppelmann, 2014).

[16] Sensor networks allow RFID systems to better track the status of things (e.g. their location, temperature, movements, etc). Doing so, WSN are able to augment their awareness of the environment. Hence, they act as a further bridge between the physical and the digital world (Abdmeziem, et al., 2015)

technology in doing so. It offers a reliable and dynamic interface to the end-user, in addition, it is highly flexible and adaptive.

The *Application Layer* makes use of actuating technologies for providing the required tools for developers of IoT solutions. The pervasive application of these technologies in "smart" environments allows exploiting the potential of IoT, enhancing objects with processing and communication capabilities.

In an article for the *Harvard Business Review*, Porter and Heppelmann list ten strategic choices that must be considered when defining a unique company's strategic positioning and the ways to create value for customers. The first bullet point concerns the range of potential features and capabilities to include in the smart connected product. Intelligence and connectivity will allow smart products to be able to execute a different set of actions, according to their surroundings and the tasks they are designed for. The new capabilities have the potential of altering every activity of the value chain, from research and development to after-sales service. They exploit kinds of sources which differ from the traditional ones, gathered from surveys, research and other external sources. Indeed, enriching information about customers, demand, costs and product's functioning is gathered from the data collected by the smart connected product itself. The product's capabilities can be grouped into four areas: monitoring, control, optimization, and autonomy. Each is valuable in its own right and sets the stage for the next level. At the core of each stage, there are data, the most valuable asset, perhaps the decisive one (Porter & Heppelmann, 2015).

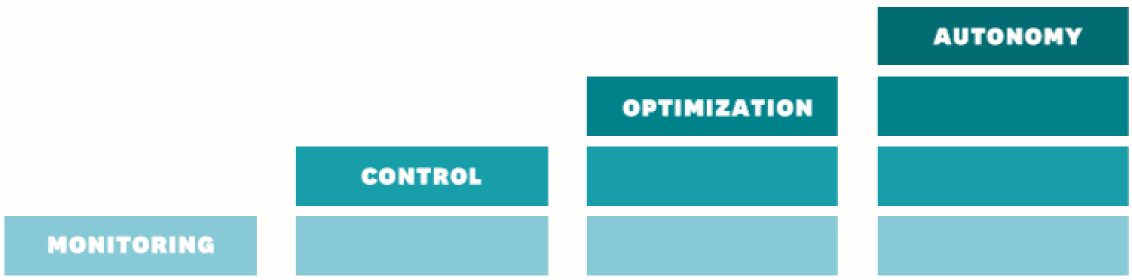

Figure 1 – Capabilities of Smart, Connected Products (Source: Porter, Heppelmann, 2014)

2.1.1 MONITORING

It refers to the simplest object's capability enabled by the spread application of sensors: communicating information about the surrounding environment and especially about itself, making it possible to have real-time information about the product's condition, usage, maintenance status, and history. Consequently, monitoring allows us to perform tracking and

alert functions, ensuring control and correction of malfunctions in the performance of the object. These functions are relatively easy to deploy because do not require advanced analytics, complex algorithms, or data-science capabilities. The most common usage is the application of sensors in food packaging to track their location throughout the supply chain.
Data constitute the raw material to detect new customer segments, thanks to information about customers' usage. This also enables digital product-service-systems (PSS), in which manufacturers can offer additional services with the product and even offer the product as a service (Frank, et al., 2019). Furthermore, data can enhance labour productivity, for example by improving the first-time fix rate, or guaranteeing real-time safety monitoring of both workers and equipment.

In the health-care ordinary medical devices, when connected to the Internet, can collect invaluable data, give extra insights on symptoms and trends, enable remote care and generally give patients more control over their lives and treatments. In recent years Continuous Glucose Monitoring (CGM) devices have made monitoring as their core value. Apps like *Eversense* and *FreeStyle Libre* allow patients affected by diabetes to continue to send data on blood glucose levels to an app on iPhone, Android or Apple Watch, allowing the wearer to easily check their information and detect trends.[17] A smart monitoring system, as *CYCORE*, has been adopted to facilitate the remote control during radiotherapy of patients with head or neck cancer; it sends updates to patients' physicians on symptoms and responses to treatment every weekday, improving patient's life and doctors' performances.

Figure 3 – FreeStyle Libre Device (Source: https://www.freestylelibre.us/)

2.1.2 CONTROL

With the adoption of remote commands and algorithms, intelligent machines can elaborate information so that they act upon the realization of certain conditions or environments. Control

[17] Source: https://econsultancy.com/internet-of-things-healthcare/

embedded in the product or cloud coupled with cost reduction has enabled the achievement of a high degree of customization of product performance translated in vast possibilities for tailoring the human-device interaction.

With the aim of supporting the growth of more sustainable lifestyles to reduce global energy consumption and at the same time achieve efficiencies, *Phillips Lighting* has applied IoT the connected LED lighting.[18] The result is *Phillips Hue*, the wireless and intelligent lighting, which promises to revolutionize the Smart Home and Smart Cities; in the first case, by ensuring total control of the lighting system from a simple smartphone, changing the relationship with environment and improving the lifestyle's quality. On the other hand, by improving the quality of life and services of the citizens and granting important efficiencies in terms of cost and energy savings.

2.1.3 OPTIMIZATION

The flood of data generated by the smart connected products gains value just when algorithms and data analytics handle the data stream applying insights automatically and in a timely manner. Thanks to Artificial Intelligence (AI) firms can optimize service by performing *predictive maintenance* which allows manufacturer to face uncertainty through the identification of anomalies before they cause equipment shutdowns and power outages (McKinsey & Company , 2015), the accomplishment of remote repairment and the dispatch of repair personnel (Porter & Heppelmann, 2014). Addressing the roots of the problem, rather than its symptoms (Sniderman, et al., 2016) drives maintenance revenues, reduce first-time fix rates as well as service costs. Schneider Electric, a global specialist in energy management and automation, estimates that predictive maintenance offers millions of dollars in potential savings along with far fewer days of equipment downtime, as well as improved workplace safety[19].

2.1.4 AUTONOMY

The previous capabilities, when combined, allow products to achieve unattainable levels of efficiency whose main goal is to minimize user intervention. The result is an Autonomous System (AS) defined as *an intelligent system, or system of systems where data acquired by sensing or monitoring capability is utilized in an overall autonomic decision-making process.* (Ashraf & Habaebi, 2015). From this perspective, with the expansion of connected products within the system, proportionally the value generated increase. The potential benefits rely on

[18] Source: https://www.internet4things.it/smart-building/philips-lighting-cambia-smart-home-e-smart-city-grazie-alliot/
[19] Source: https://www.schneider-electric.us/en/product-range-download/64263-predictive-maintenance-solutions/#/documents-tab

both cost and risk reduction, especially in challenging areas or where human beings are exposed to high risks (Aerospace, Aviation & Defence (ADD) - Knowledge Transfer Network, 2012), and on the facilitation of operations in remote locations (Porter & Heppelmann, 2014). Thanks to algorithms that link data about the products and the entire ecosystem, human intervention is limited or even unsolicited.

If the well-known vacuum cleaner *Roomba*, the iRobot which maps your house ensuring order and cleanliness, represents the most classic example of autonomous objects, more sophisticated devices are hitting up the market. They can act autonomously learning from the surrounding environment and taking actions on their own initiatives, by communicating with other technologies within the system and in respect of users preferences.

Figure 4 – The vacuum cleaner Roomba (Source: https://www.irobot.it/26qamai/)

2.2 SERVITIZATION AND SMART PRODUCTS: THE BENEFITS OF THE IOT AND BIG DATA TO CREATE NEW BUSINESS MODELS

The pervasiveness of the Internet of Things has overcome its influence on the sphere of the products and services and has involved likewise business models. Indeed, connected products are transforming both business and consumer markets landscapes, making space for brand new data-based service-oriented business models (Porter and Heppelmann, 2014 and 2015).
In this sense, the business model is extremely important in the ever-changing digital environment because it is the "recipe" to define how the company intends to create and increase value for its shareholders (Boesso & Pastega, 2018) and consequently, capture it. It is a document that illustrates the strategic aims that relate to the company's competitive strategies, the actions that will be carried out to achieve them, the evolution of the key value drivers (KVDs) and the expected results[20].

[20] Source:https://www.borsaitaliana.it/azioni/mercati/comequotarsi/guideallaquotazione/strategicplan.en_pdf.htm

According to what has been explained above, two transformations of the market dynamics greatly influence business models: on one side the entire network of collaborations and partnerships on digital platforms, that vanishes the firm-cantered lens. On the other side, the customers' enhanced role as value co-creator by providing user data (Turber, et al., 2014). These pose the fundamentals for a new marketing paradigm which drives the action of the actual business models and is based on the increasing role of services in the manufacturing offer: The Service-Dominant Logic (SD). As interoperability becomes the key to obtaining great part of the value from the Internet of Things, the relationships among the actors of the ecosystem build the "value creation network"; the company has still a central role as "organizer" of value, but is the network to catch the attention in the SD logic and constituting its cornerstone. The other distinctive aspect that breaks with the logic of the past is the active role of the consumer, which becomes indispensable as a co-producer and creator of value. This brings to the disruption of the concept of the value chain as theorized by Porter which is based on the linear production of a consumer offer, which transforms raw materials into outputs. Taking chances by the integration of smart connected products and data-driven services have come to light new business models which indeed are built on a high degree of specialization, offerings solutions driven by the SD logic and on new services (McKinsey & Company, 2015).

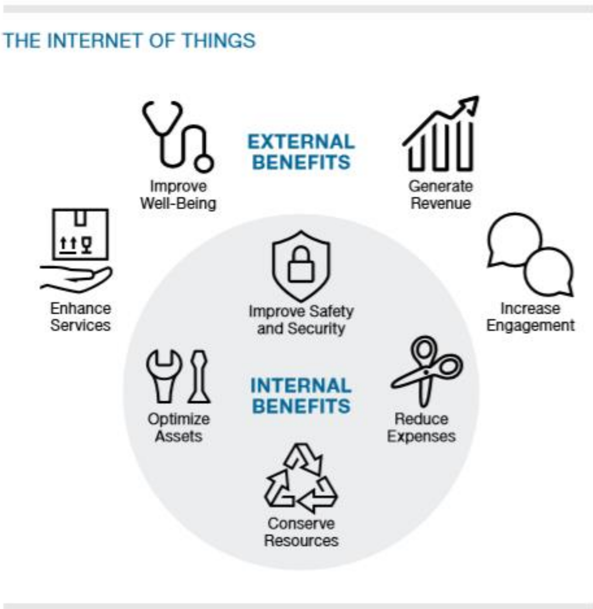

Figure 5 – Internal & External Benefits Triggered by IoT (Source: Gartner, 2017)

2.2.1 DATA-DRIVEN BUSINESS MODELS

These business models rely on the value of data generated by smart products. Most of them are exhausted data, in the sense that they are not used in the production process; this can trigger a virtuous cycle whereby data are capitalized becoming direct and indirect centres of profit. Companies like LinkedIn or Facebook provide users with value, collecting a huge amount of data, but at the same time, they sell the valuable ones to third parties which use that information to advertise their products and service. For this reason, such models are also referred to as *Monetization Business Models* referring to their potentiality to generate revenues associated with the exploitation of data. In fact, one company's exhausted data can be a gold mine of another (McKinsey & Company , 2015).

2.2.2 AS-A-SERVICE BUSINESS MODELS

The transition to intelligent manufacturing has changed radically the nature of the physical product until making it even disappearing. The Internet of Things enables the "*Everything as a Service*", which means that every kind of product potentially can be sold as a service, so the user pays for the time in which he will enjoy the product-related service and not for its ownership. Many kinds of companies, such as technological and automation providers, may shift from selling physical products to services related to those products, enabling *As-a-Service models* and related flow of service-based revenues.

By and large, the resulting strategy is the so-called "Servitization" which dissolves the distinction between goods and services and makes the physical objects as a medium to provide the latter: the offerings become inputs feeding the process of value creation. This new market paradigm goes hand in hand with IoT technologies and makes services at the core of the supply. At the root of the servitization, there is an intimate relationship between customers and companies, increasingly strengthened by the exchange of information and data. The customer experience has a role of relief and benefit not just the end-users but the companies as well. Maurizio Svaluto, Sales Director Manufacturing and Resources di Microsoft Italia recalls that 86% of consumers are willing to pay a premium price for a better user experience and for greater transparency. However, even at producers' level there is a growing awareness that the product as a service is something positive for businesses. This kind of product has the potential to create new value, in fact, as sustains Svaluto, more than 80% of manufacturers believe that "product-as-a-service" can increase revenues. Right in this direction he believes that lies the development of the "modern agile factory".[21] In an edition of Business Harvard Review of 2014 Porter included in his description of new trends associated with IoT a variation of product-as-service models: *The Product (or Asset) Sharing Business Models*. They are associated with the concept of the "share economy" and involve the share of products or assets and paying just for the usage time. This is crucial especially when it must deal with equipment which requires huge

[21] By the speech of Maurizio Svaluto during the Microsoft Innovation Summit 2019.
(Source: https://www.industry4business.it/industria-4-0/ecco-come-lintelligent-manufacturing-ci-porta-nella-data-economy-con-iot-connected-product-e-servitizzazione/)

investments and there are concerns about exploiting in full their maximum capacity. So, companies sell their extra capacity in the market, maximizing the use of IoT products across different customers. That way, each customer pays a reduced price and companies are able to get faster market penetration, compared to when a single customer has to pay for the complete product[22].

Another example belonging to this family is given by the *Pay-per-Usage* model. The IoT enables usage-based pricing by leveraging the easy access to data about customer usage and charging them accordingly. So, the bill is respecting the amount of time you actively use the product and is not given by its ownership. Zipcar is a business success that mixes both the models explained above. In the early '00s, it was one of the first companies to apply pay-per-use to cars: by providing cars with sensors, GPS ad other location-specific wireless technologies, the American company exploited the benefits of car sharing thanks to technology.

Finally, though the list is not exhaustive, are taking place *Subscription Models*. These offer the customer an ongoing service in exchange for the payment of a fee, allowing companies to recoup the costs, such as development costs, maintenance, hosting costs and at the same time to make a profit by charging the fees for their services (McEven & Cassimally, 2014). Netflix and Spotify constitute glaring examples of the application of this model.

2.2.3 NEW PRICING MODELS

The countless sensors and tags, placed in any place with which people interact, capture relentlessly information about the ways they interact with the surrounding environment, their habits, preferences, as well as the use made of smart products. It is easy to understand that the massive streams of data are useful to companies to microsegment their offer and getting insights about the willingness to pay of the customers, providing benefits for both. These models are often applied in the field of insurances: for instance, Metromile is a pay-per-mile company based in the US, which offers a usage-based insurance charging its customers according to the travelled distance.

The adoption of IoT technologies and related business models would require a drastic revolution of the value generation. However, currently, most of the companies are not ready to manage such a change, preferring to gradually integrate the technological features into their historical business models. Following this approach, they improve the performance of current operations, taking advantage of the opportunities given by Big Data and Advance Analytics and react to the customers' need for personalization of services. The new competitive landscape is

[22] Source: https://danielelizalde.com/monetize-your-iot-product/

likely to be driven by small and innovative companies, highly specialized and more agile than larger, established companies to adapt to the complexity and dynamics triggered by the Internet of Things. Within the industrial scene, companies must be ready to embrace challenges posed by the shift of the competitive forces, which include, inter alia, the entry of incumbents from outside the manufacturing arena.

2.3 FINAL CONSIDERATIONS

"Industry 4.0 is a global leadership topic that should be on top of the CXO agenda. Unless top-level management is involved, companies will not be able to successfully transform into a digital company. In 5 to 10 years' time digital will be the foundation of every business. Many companies are starting to understand this, but they struggle to transform while maintaining daily operations. Industry 4.0 is just as much about innovation as it is about effectiveness"
Lars Zimmermann, CEO at *hy* GmbH

Even though, Industry 4.0 has created great promises and expectations and many manufacturers have already seen first results, most of them did not take the call from the technologies 4.0. The hype around the fourth revolution is trapped in the significant gap between executive ambition and transformative action (Gates & Bremicker , 2017). It is a fact now that the transition to digitalised manufacturing will likely to be gradual rather than disruptive. Decision-makers are now cautious towards new investments since they are fighting for return on investment as they scale. KPMG suggests that for scaling the market an approach driven solely by data and technologies is not enough: manufacturers must focus on value boosters, business results, and performance. In addition, investments will not involve the replacement of the equipment in the smart factory (about 40-50%) but will require more an upgrade of the machines with sensors and connectivity. In comparison to this, the automation process of the third revolution required the replacement of 80 to 90% of the tooling equipment with new machines (McKinsey & Company, 2015). Furthermore, research carried out by Mckinsey emerged that most of the data collected are not used at all and that the ones used are not entirely exploited. For instance, in the oil industry, less than 1 percent of the data being generated by the 30,000 sensors on an offshore oil rig is currently used to make decisions. And of the data that are actually used—for example, in manufacturing automation systems on factory floors—most are used only for real-time control or anomaly detection (McKinsey & Company , 2015), rather than prediction and optimization. Some scholars suggest that this could be because as humans, individuals prefer to consult other people for advice or to look back on our own experience when making decisions. Although hard data from IoT devices are more complete and objective, people tend to assign them less value. (Patel, et al., 2017). This implies that a valuable exploitation of proprietary data and capabilities, as well as those to be developed in and outside the company, is essential to exploit the advantages offered by decision-making processes, which can lead to competitive advantages sustainable and lasting.

Figure 6 – The McKinsey Digital Compass (Source: Mckinsey, 2015)

To try of capturing the remaining value Mckinsey proposes a tool (Fig. 6), the *McKinsey Digital Compass*, to help companies focus on key value drivers with the aim of enhancing business performance and achieving operational effectiveness. Decision-makers will have to face the greatest challenges, starting from reimagining the corporate purpose. They will have to learn how to extrapolate value from data and adjust processes in real-time; to be more responsive and proactive and enable the organization to possibly avoid operational downtimes and other productivity challenges (Cotteleer & Sniderman, 2017). It will be necessary to understand the change magnitude and adapt the organizational setting, incorporating the capabilities that reinforce its competitive positioning and shifting the mindset of the entire organization. New talent and expertise are required, and with the increasing flow of data, a cybersecurity system is critically important. Entrepreneurs will have to rethink the process of product development since, along with inventory management and condition-based maintenance (e.g. operations optimization) has the largest impact on performance. The value generation needs innovation at the core of the process which in turn has customers, rather than technology, at its centre. Therefore, companies must understand how to manage the massive amount of information generated by the smart connected products, if they want to reach customers and outperforming in the challenging competitive environment.

CHAPTER 3 – IOT AND PRODUCTS: THE PATH TOWARDS INNOVATION

In this chapter an analysis of the influence of the Internet of Things over the process of product innovation is carried out. Innovation in Industry 4.0 maintains its role of the main driver of growth and can be considered as the main mean to reach customers' satisfaction and realize their needs and desires, granting economic success to the company. Moreover, innovation plays the role of productivity driver, in the way that the innovation produced by one actor in the value network becomes part of the innovation input to other companies, triggering a self-sustaining value generation cycle. The Moore's Law has described this process by foreseeing the rate of adoption of innovation in the semiconductors market, but can be applied to what is happening now: indeed, its theory is supported by the fact that the high rate of innovation in semiconductors, in turn, has helped to drive the innovativeness of the PC business, which fed back as a driver of the PC business and so on (Reguia, June 2014). There is no doubt that the IoT has permanently developed and changed the concept of product, now "smart" and "connected". Despite new technologies are completely rewriting the rules of competition, impacting the entire business model of the company, it is crucial to understand the role of the Internet of Things as an enabler of innovation in the manufacturing system and as the building block of the new product. As a matter of fact, innovation starts from changing business models, even if nowadays it is also used for describing the transformation of products or even technological concepts (Reguia, June 2014). Indeed, innovation may concern every aspect of the organization: processes, products, organizational structure, marketing, etc. The definition of "innovation" given by the Organization for Economic Cooperation and Development (OECD) in the Oslo Manual – the foremost international source of guidelines for the collection and use of data on innovation activities in industry (OECD & Eurostat, 2005) – implicitly limits innovation to four types – product, process, business model and organizational: *an innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations.* The manual characterizes the four types of innovation as follow:

- *Product*: the introduction of a good or service that is new or significantly improved concerning its functional characteristics or intended uses (e.g. technical specifications, components and materials in the embedded software).
- *Process*: implementation of a new or significantly improved production, technology, software or delivery method.

- *Marketing*: the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing, with the scope to increase customers satisfaction, creating new markets or new, more favourable market position for production companies to increase sales.
- *Organisational*: implementation of a new organisational method in the firm's business practices, workplace organisation or external relations.

Notwithstanding, among all the types, the innovation of products[23] has a key meaning because the product is the direct link between the organization and consumers who are further and further the focus of every company's core business.

3.1 DATA-DRIVEN DECISION MAKING: THE INFORMATION THAT GIVES VALUE TO THE COMPANY

Thanks to the *technology stack*, every object is potentially capable to collect, store and transmit a huge amount of data to a network of various appliances. Hence, it becomes a leading priority for decision-makers to let themselves be guided by data itself in the decisional process and learn how to exploit and convert it into valuable and profitable information. Data is becoming a key measure of whether a company will remain relevant through the digital revolution (Albert Opher, 2016). Thus, the only way to have a decisive competitive advantage is by considering it as a core asset and perhaps, in some companies, the decisive asset (Porter & Heppelmann, 2015). Data, through raising performance, offering more user-centric products and services and fostering innovation, often allows companies to leave decades-old competitors behind (EPSC Strategic Notes, 2017). Recent research shows that even limited use of big data analytics solutions by the top 100 EU manufacturers could boost EU economic growth by an additional 1.9% by 2020 (EPSC Strategic Notes, 2017). Indeed, the potential from IoT applications arises from how the data are analysed and applied to decision making, improving operations, and enabling new lines of business (McKinsey & Company , 2015). So, the optimization of data-driven approaches to decision making, which places at the centre the analysis of data rather than pure human intuition, must be conceived as the starting point to extrapolate added value. Many studies have proven that companies can exploit relevant economic benefits by using big data. Firms that adopt data-driven decision-making have been found to have a 5-6% higher output and productivity (EPSC Strategic Notes, 2017).

[23] Product is intended both as good and service.

The traditional sources of data, given by internal operations and transactions across the value chain (e.g. order processing, interactions with suppliers, sales interactions, customer service visits, and so on) and integrated with surveys, researches or other external sources, for the first time are being supplemented by another source: the product itself (Porter & Heppelmann, 2015). This, in the form of a complex, connected system that combine sensors, software and digital user interfaces is creating a value shift (EPSC Strategic Notes, 2017) from the product as such, to the opportunities that information and knowledge generated offer to manufacturers and consequently also to users who can enjoy of the tailor-made services they can provide. Sure enough, far from the past, the product informs manufacturers about its functioning, integrating this information with the one about customers, demand, and costs. The product itself is able to examine and select useful information and consequently take decisions autonomously, identifying hidden patterns of knowledge and action, even creating new knowledge, putting in place the most innovative capability of smart connected products, which is autonomy.

Nevertheless, the data they generate are still not completely exhaustive if cannot be converted into insights and real product improvements. As matter of fact, its value increases exponentially when it is integrated with other data, such as service histories, inventory locations, commodity prices, and traffic patterns (Porter & Heppelmann, 2015). In this regard, companies that base their decisions on exploitation of data, leverage other connectivity technologies, such as advanced analytics – algorithms that can interpret and act on the flow of real-time data from many machines (McKinsey & Company , 2015) – and machine learning, so that the raw data is translated into valuable insights. Both in the public and private sector, data analytics will soon be indispensable to any economic activity and decision-making process (EPSC Strategic Notes, 2017), since it turns information into outcomes that help decision-makers. Indeed, a synergy between new analytic tools and software solutions would allow companies to reach optimization and prediction, as well as overpass machine failures; for example, thanks to preventive maintenance, unplanned and unpredictable downtimes could be avoided. Conventional approaches to data aggregation and analysis, such as spreadsheets and database tables – which are ill-suited to managing a wide variety of data formats from different IoT systems – are being substituted by emerging solutions. Among these, there is the “data lake”, a repository in which disparate data streams can be stored in their native formats (Porter & Heppelmann, 2015) and studied by the analytic tools: the result is an overall maximization of the benefits of the IoT-based systems. This digital optimization builds on an end-to-end information flow, in short, the information passes through the “digital thread” that goes with the entire product life cycle as its digital representation. As already mentioned before, the digital thread starts with the digital design of the product, passes on through the digitally steered and controlled manufacturing process, leads to the digital monitoring of the end product in operation (e.g., for maintenance purposes), and finally ends in the recycling of the product, where digitally stored information can help identify parts for reuse (McKinsey & Company, 2015). The optimization of the digital thread through the exploitation of the capabilities of smart devices allows the right information to be available to the right decision-maker in a timely manner, as well as the elimination of marginal activities that do not generate adding value for the business. For this to be possible, it is necessary that valuable information do not get lost somewhere in the value chain: in fact, optimizing the digital thread is all about making the best use of information (McKinsey & Company, 2015).

To harness the potential power of such a system – by increasing transparency and efficiency along the entire digital thread -, organizations will need to adapt. Determining the right balance between automation and human intuition becomes a critical decision for decision-makers. Teams performing analysis must be linked with teams making operational decisions and with those on the ground that are responsible for implementation (McKinsey & Company , 2015). Different departments of the firms and, broadly viewing, all the actors of the value chain (from suppliers to customers) must thus communicate and be open to share information within the organization and also with the connected ecosystem, acting in real-time in order to get rid of critical nodes and information leakages. In other words, the manufacturing process evolves from linear, sequential business operations to an interconnected, open system (Cotteleer & Sniderman, 2017), which completely integrates the production process upstream and downstream. In conclusion, if on one side adopting data-driven decision making can overpass the barriers created by the human bias, on the other the human intervention remains still necessary, as starting point for initiation of a change in product feature (Ramakrishnan & Gaur, 2017) and in those actions which require workforce to derive actionable information and recommendations. The conversion of data into knowledge must be a practice integrated and implemented by all the actors of the value network, both humans and machines, at any level of the manufacturing process and moreover, it must be shared as this has been recognized as the key to innovation.

3.2 INNOVATION

The technological change triggered by the new technologies has placed companies in front of a challenging economic scenario. This requires them to re-align themselves both, internally and externally, in order to beat back threats and take advantage of the opportunities offered by the actual competitive environment. Innovation is, therefore, becoming a leading priority for companies under any aspect. In a landscape that requires organizations to be flexible, reactive, efficient and systematically innovative, enterprises struggle for keeping market share, rather than facing aggressive competitors, as well as differentiating in order to achieve a sustainable competitive advantage (Shanmuganathan, 2018). Furthermore, Reguia (2014) sustains that companies are imposed to carry out research and development as a basis of organizational method. Through innovation and creativity, as mental set-up shared by every department, enterprises can discover new innovative ideas that can distinguish them from competitors. In the last 30 years, the concept of innovation has gradually evolved its meaning, diverging from the too simplistic "creation of something new" and covering the role of panacea term for the solution of a board range of problems (Kotsemir, et al., 2013). Indeed, innovation is no longer a concept limited to scientific laboratories but has become also a management concept, slogan, buzzword used by policymakers, marketing specialists, advertising specialists, and management consultants. Independently by the type, scholars over the years have developed a wide variety of definitions and classifications of the term "innovation". To give an idea of this heterogeneity and complexity, as well as its broad and in-dept meaning, below are reported some of the most significant definitions[24] selected by (Kotsemir, et al., 2013) and (Reguia, June 2014). In their analysis of the scientific literature about the innovation issue, innovation has been outlined as something new, rather than as a conduit of change, or as a value driver, just to name a few of them. Anyways, the common ground to any kind of innovation is represented by the element of "novelty" and "change". Are excluded slight modifications in the make-up and delivering of products, for instance in the form of extension of the lines (*ibidem*). Further, innovation comes to life only when applied and perceived as such by adopters.

"Innovation refers to the economic application of new ideas that will be transformed to the commerce".

"Innovation is the commercial or industrial of something new: a new product, process or method of production, a new market or source of supply, a new form of commercial business or financial organization".

"Innovation means making new products and offering new services or adding new value to existing ones. It's based on the results of new technological developments, new combinations of existing technology or the utilization of other knowledge acquired by the company".

[24] See the work of (Reguia, June 2014) for the references of the definitions given above.

“Innovation is the implementation and the application of a new idea related to a new product or service, a new marketing method, a new organizational method in business practices, workplace organization or external relations”.

“Innovation is the degree to which value is created for customers through enterprise that transform new knowledge and technologies into profitable products and services for national and global markets. It covers a wide range of activities to improve firm performance, including the implementation of a new or significantly improved product, service, distribution process, manufacturing process, marketing or organizational method”.

It is, therefore, appropriate to distinguish innovation from the other two terms with which go hand in hand and that are often combined and inappropriately confused (and/or overlapped) with it: creativity and invention. The combination innovation-creativity can be seen as two sides of the same coin, while creativity means the creation of new ideas which does not exist before in order to solve problems, innovation is the implementation of these new ideas (Reguia, June 2014) and the following conversion of them into something profitable. In this respect, creativity precedes innovation and constitutes its sub-set. Being creative in order to “ride the innovation wave” means for companies to stimulate and incorporate creativity as part of organizational culture (Shanmuganathan, 2018). To notice as creativity is a necessary condition for realizing innovation, but this does not apply vice versa. Similarly, the invention is related to the first occurrence of an idea for a new product (or process), or a new method or device, while innovation represents its realization through practical application of that idea. Already Schumpeter, an economist of the first half of the twentieth century, in 1939 has strengthened this logic distinguishing the practical adoption of the innovation from the invention, seen as an act of “intellectual creativity”. In the most common sense, the people are associating the term invention with a new product or device, while innovation is associated with a change or improvement of an existing product (Roxana & Cornescu, 2019).

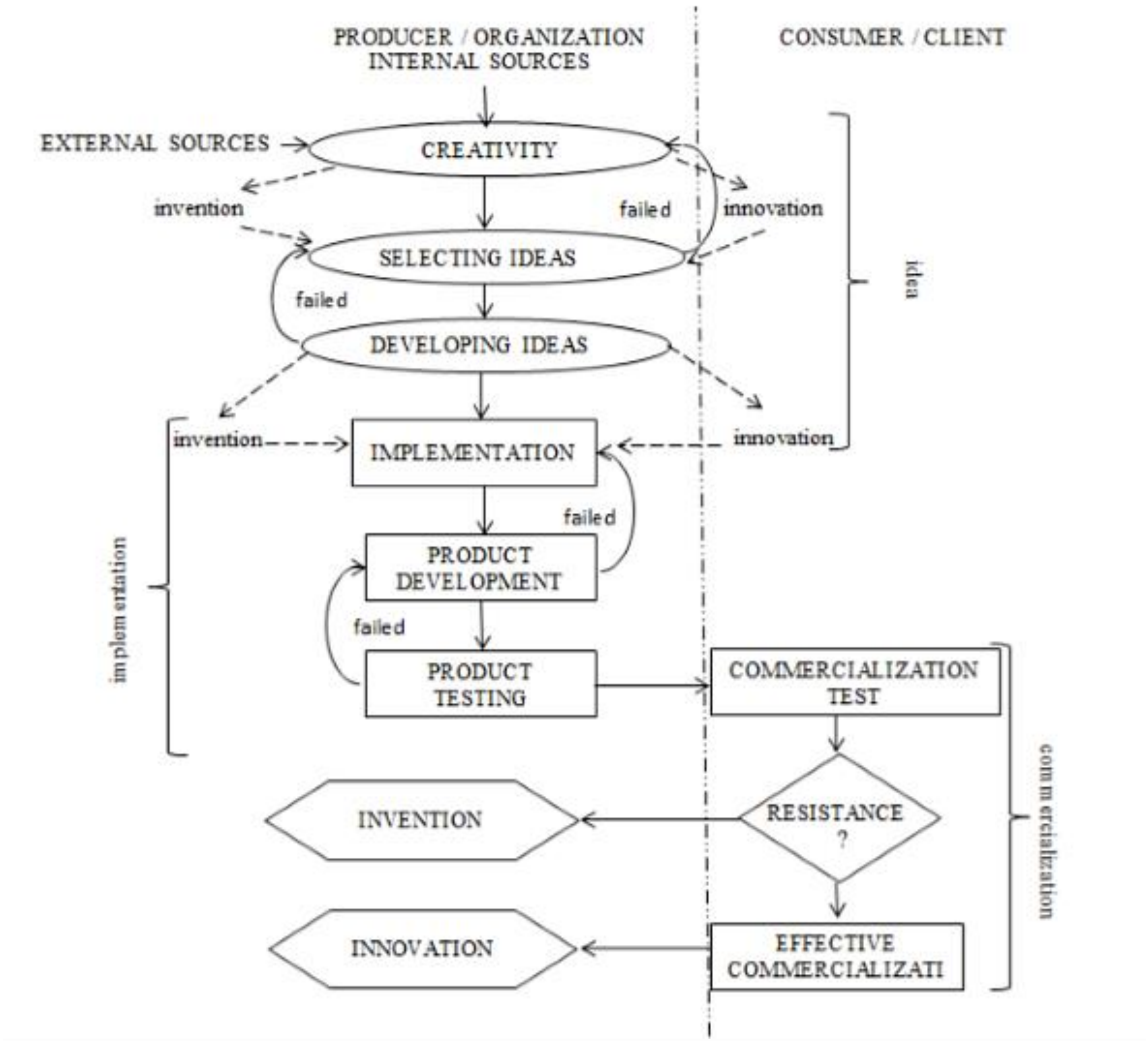

Figure 7 – The Innovation Process: Invention vs Innovation (Source: Adam R., Cornescu V., 2019)

Another important distinction comes from the sources of innovation which in turn influence the method of innovation, the ways it occurs and the effects on the market's equilibria:

- ***Technology-driven and/or Research-driven Innovation*:** R&D division is acquiring more and more important in the logic of technological innovation and companies, aware of its importance, are more and more investing in the internal activity of research and/or, alternatively on strategic partnerships with research centres and universities. Indeed, companies adopt this approach for extrapolate value investing in knowledge, focusing on the substitution of existing technology with a better and differential one, with the scope to sell in the market the innovation achieved.
- ***User-driven Innovation:*** the innovation is developed by the company for in-house use, usually because it cannot find the products it needs in the market. Innovation is a result of on-the-job practices that involve the exchange of experience and other sources between many actors involved in the production process. For this reason, this approach

relies more on the implementation and use of actual technologies and products which are already part of the routine activities.

The consequence of this is that innovations emerged from the *R&D-driven* approach tend to reverse the market for the degree of the innovation reached, creating that discontinuity in the market for which they are regarded as *Revolutionary, Breakthrough or Disruptive Innovations.* The result is a market penetration of a product or technology which is new-to-the-world. The consumers perceive a high added transformative value and their needs, which are often hidden, are satisfied; they shift immediately from competitors' obsolete products to the ones of the company which innovated successfully. If a radical innovation succeeds has powerful effects on brand image, moreover, it creates sustainable competitive advantage than ordinary products and produce significant financial reward (Kotler & Keller, 2016).

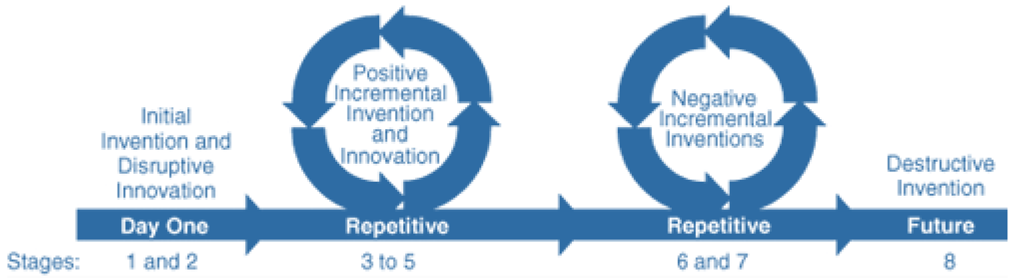

Figure 8 – Innovation Life Cycle (Source: "Innovate the Future: A Radical New Approach to IT Innovation", David Croslin, 2010)

On the other hand, organizational practice tends to provide moderate technological achievements, which actually lead to more incremental improvements of the products rather than radical changes (*Incremental Innovation*); for example, in terms of new design or further functionalities or features to the foundational product. However, often the boundaries between radical and incremental innovations are blurred and difficult to define.

Nowadays, the massive amount of data and new knowledge generated by IoT applications, has pushed companies toward the tendency to adopt incremental innovation. Embedding IoT sensors or tags within products allows a fast and over time constant improvement of the integrated systems through remote, free-costs updates. The outcome is a higher perceived value of existing products and the possibility to expand business opportunities, especially improving existing products through services (As-*a-service product*). As matter of fact, considering the actors of the competitive environment, the path mostly taken by affirmed companies consists in introducing minor changes to the core product, through an on-going process of readjustment and development of its capabilities. So, they tend to not adopt a "revolutionary" approach, due to the rigidity of the production processes. It is the opposite the trend followed by small and newer companies, as well as by start-ups, that instead tend to experience a more radical innovation in order to enter the market. These enterprises are favoured by cheaper, faster, as well as more flexible and efficient organizational architecture; in addition, they heavily invest in R&D.

Finally, is emerging another type of innovation which is the fruit of the *servitization* and is related to the user-driven approach: in fact, user-innovators often decide to trade their achievements in exchange for other innovations. It can also happen that these innovations are adopted by their suppliers or are freely revealed through open-source[25]: supported by the digital thread which transport a ceaseless flow of information throughout the value network, from suppliers to customers and third parties, innovation bypasses the company's boundaries and involve users or communities of users which can further develop technologies and reinvent their social meaning just by sharing of ideas.

- It is the so-called ***Community-driven Innovation*****:** this approach is based on the use of products, services or processes, which triggers a cycle of knowledge exchange and creation of new knowledge vital for "digital companies". The community-driven approach has its roots in the concept of *Open Innovation*, which captures value, and thereby enable the achievement of competitive advantage through knowledge sharing, rather than keeping it secret. Nonetheless, knowledge production and sharing have been recognised as the key to innovation (Shanmuganathan, 2018). This approach clearly deviates from the traditional concept of innovation, based on the protection and ownership of knowledge as intellectual property of the company. It is enabled by the benefits supplied by IoT and I4.0 technologies, such as large volumes of data, software which give meaningful insights and open platforms where companies can know their consumers and directly communicate with them. Doing so, they greatly improve the effectiveness and speed of the manufacturing processes, especially the one of product development, as it will explained in the next paragraph.

However, as emerged by a survey fielded by Deloitte (2018)[26], companies in their rush toward digital transformation, are focusing on massive investments and efforts to fulfil current goals

[25] Open source refers to any program whose source code is made available for use or modification as users or other developers see fit. Open source software is usually developed as a public collaboration and made freely available (Source: https://whatis.techtarget.com/definition/open-source).
[26] In order to indagate how companies are investing in Industry 4.0 to enable digital transformation, Deloitte has fielded a global survey of 361 executives across 11 countries. It is focused on manufacturing, power, oil and gas, and mining companies and examines how and where they are investing—or planning to invest—in digital

and improve actual processes. Indeed, it is more likely that digital transformation is going to be driven by productivity goals (e.g., improved efficiency, 50% of respondents) and operational goals (e.g., reduced risk, 47% of respondents), rather than the desire of innovation (23% of respondents). Notably, the authors found out that companies driven to digital transformation by a desire for innovation report realizing almost as much ROI as those that are driven by productivity/operational goals (Daecher & Sniderman , 2018).

Productivity goals (e.g., improved efficiency)	**57%**
Operational goals (e.g., reduced risk)	**56%**
Employee demand	53%
Increased desire for innovation	**51%**
Shareholder engagement/demand	51%
Supplier requirements	51%
Internal strategy focus	45%
Regulatory pressure	45%
Customer requirements	44%
Competitive pressures	41%
Partner requirements	32%

Figure 9 – The percent of respondents in each category who reported realizing significant ROI (Source: Deloitte Industry 4.0 investment survey, 2018)

Opportunities in innovation exist and nowadays it is mandatory for companies to consider innovation as part of their strategy at a global level. For not being left behind by competitors they must understand the factors which influence innovation and before pass to action, they must shift the organizational culture into the new "innovative" vision. Improving current processes is a sound approach in the short-run and can create a firm foundation for future innovations. Moreover, doing so can illuminate key opportunities for innovation, by creating a clear map of what the organization currently does, highlighting adjacencies, and thus creating an informed, more targeted path for innovation (Daecher & Sniderman , 2018). However, even if it looks risky, uncertain and undoubtedly costly, in a long-term perspective innovation must

transformation; some of the key challenges they face in making such investments; and how they are forming their technical and organizational strategy around digital transformation (Daecher & Sniderman , 2018).

become a prerogative in the decision-makers' action plan, insofar it is an essential element of differentiation from competitors.

3.3 THE "IOT EFFECT" ON PRODUCT INNOVATION

The exploitation of the IoT's benefits throughout the process of product development constitutes a key activity and a key source of value for achieving a competitive advantage in a market hungry for innovation. In fact, the IoT world offer companies able to incorporating and analysing data gathered by connected devices, opportunities never seen before which enable them to outperform competitors, accelerate innovation and meet increasing consumer expectations. Sensor generated data translate stimuli and perceptions of the physical world into better and new products, that have evolved to the point of identifying themselves with the services they offer. Combined with Industry 4.0 technologies, they help companies to build intimate relationships with consumers, founded on their deeper knowledge and on the transparency of the product itself.

The product is the reflection of its company and, as such, it follows that a successful business is strictly related to the success of the products it launches on the market, which are supposed to comply with the increasing performance expectations of customers, dazzled by the advantages of technological innovation; and to its ability to offer new products and services.

Reguia (2014) focuses on the evolutionary/"revolutionary" nature of product innovation, defining it as *the development of new products, making changes in the current product design or using new techniques and means in the current production methods, in other words, it focuses on existing markets for existing products, differentiating through features and functions that current offers do not have*.

Shanmuganathan (2018) instead, values the entire system of activities involved, defining it as a *process that includes the technical design, R&D, manufacturing, management and commercial activities involved in the marketing of a new (or improved) product.*

It is important to not confuse this process with the one of *production innovation*, which instead describes an on-going re-engineering processes and a core-organisational culture in itself (Romero, et al., 2017).

3.3.1 IOT & SOURCES OF INNOVATION

Despite exist many ways to categorize the types of product innovation, e.g. considering the relation between market and technological innovation (Fig. 10), in this work it is defined taking as reference point the sources of the product change. This, in fact, may result from two different sources, one internal and the other external and thus can be:

- *Supply-pushed:* it relies on the availability of new technological improvements and thus new knowledge, which drives innovation. These can "push" the natural development of existing technology resulting in an improved product, or the one of "invention", so driven by new scientific knowledge or resources, enhanced capacities, which leads to a completely new product (or service). This type of innovation usually triggers a radical innovation and often involves collaboration among organizations, universities, research centres, and technology institutes.
- *Demand-led:* also known as *Demand-pull* or *Design Thinking*, depends on the external side of the company, that one which considers consumers' needs, but also the owners' expectations. Social needs and market requirements are the drivers of innovation. Companies analyse and segment the market, offering solutions that interpret the "customer's voice" or directly attend his demand.

Although there is no unanimity in considering whether product innovation is triggered more by technology improvements or customers' requirements, the role of an emotional state influencing customers' purchase behaviour is commonly recognized:

- Therefore, *Design-driven innovation* is an approach based on the customers' tendency to buy "a meaning", and not products or services. It differs from user-centered innovation, which is market-oriented, and it is more about the management of design, the "making sense of things", rather than the creativity process linked to the design concept, which associates the latter with the product shape. Roberto Verganti, Professor of Leadership and Innovation at the School of Management of Politecnico di Milano, sustains that design-driven innovations do not origin from the market; they create new markets. They don't push new technologies; they push new meanings (Verganti, 2009). Performance, convenience, modularity, and practical functionality requirements fade into the background leaving space to the unexpected value that potential users attribute to a certain product. In doing so, customers are increasingly pushed by socio-cultural, emotional and psychological factors when choosing what to buy.

	Improving existing knowledge	Creating new knowledge
Creating new markets/segments	**Market Innovation**	**Basic Innovation**
Retaining existing markets	**Incremental Innovation**	**Technological Substitution**

Figure 10 – Innovation Typology based on Technological Knowledge and Target Market (Source: Christensen J. F., Innovation-concepts, process and strategies, 2007)

Looking at the sources of innovation, IoT have an in-depth impact on all the three approaches mentioned above: in fact, the Internet of Things sensors embedded in customers' appliances and wearables can constantly monitor the devices, enabling updates and real-time remote-assistance, which in turn allows to significant improvement of the new products, e.g. updating the software and boosting product performances. In the former case, product versions will roll out faster with a very high level of transformation and value addition as compared to the previous versions. This will be in deep contrast to the current slowly evolving product life cycle where each major upgrade is predominantly incremental and not radically different from the previous release (Ramakrishnan & Gaur, 2017). On the contrary, (IBM Corporation, 2015) considers that the application of IoT technologies leads to more incremental innovations due to the ability of objects to learn from their operational environment and improve constantly through transparent software updates. In the second case, when occurs a breakdown, IoT sensors transmit such information along the digital thread, automatically enabling a proactive process of maintenance services which delivers quick adjustments which do not require human intervention; again, when the user is misusing the device, that same can alert him/her, for example providing instructions or tips for a better usage. To achieve this, the hi-tech clusters (e.g. Silicon Valley) play a crucial role in the research and development of new technologies, both as radical and incremental innovations.

The *supply-pushed* approach can exploit the amount of real-time information triggered by product-usage of IoT devices, by giving key insights on customers' preferences, trends, and purchase behaviour. On the contrary, earlier the company-customers interaction was limited up to the point of sale and information about device durability and customer satisfaction was gauged from field engineers with post factor reports, random survey and product returns (Ramakrishnan & Gaur, 2017). For this purpose, an example is given by *Coca-Cola* which uses data from its Freestyle, an innovative touchscreen vending machine that allows you to choose from over 100 drinks, for improving its offer. RFID enabled, the soda machine allows Coca-Cola to gain insights into their customers' purchasing pattern including where, when, and how they are consuming their products. Customers can select a base product and supplement it with additional flavours which provide insights for the company to launch new products of the most popular flavours in many locations as a derivate of the customer insight[27].

Finally, the new capabilities of smart connected products play a central role even in the *design-driven* approach. (Kotler & Keller, 2016) define design as the totality of features that affect the way a product looks, feels and functions to a consumer. For this purpose, products are imbued of functional and aesthetic benefits that affect both the rational and emotional sides of customers. Indeed, brands can transmit and enhance their positioning in the market and in the consumers' minds by conveying "meanings" and emotional features to their customers, offering high tailored products based on the data gathered. The product, and the offered service, emotionally involve the user who establishes a more "personal" relationship with the physical object, that can reply and foresee his most hidden needs, like a custom-made suit.

Thanks to the support of technologies, such as 3D printing machines or Augmented Reality, the Internet of Things gives shape to a powerful synergy driven by Big Data and Analytics which impacts the process of innovation of the product from end to end. Actually, the primary advantage of IoT can be seen in its ability to create situational awareness and enable applications, human beings, and machines to better understand surrounding for timely informed decisions in a dynamic daily changing environment (Ramakrishnan & Gaur, 2017).

3.3.2 THE DIGITAL TWIN: THE DIGITAL DNA OF THE PRODUCT AT THE BASE OF EACH STEP OF THE INNOVATION PROCESS.

In order to understand the functioning of the New Product Development (NPD), it is presented a tool, which was originally conceived by the *Défense Advanced Research Projects Agency* (DARPA) and that now is increasingly being deployed in manufacturing as a 3-D virtual-reality replica of a physical product (Porter & Heppelmann, 2015), in short: The Digital Twin.

However, its definition does not stop just at the product level, indeed a digital twin *is a dynamic digital model of a product, process, or person, which analyses existing business system data*

[27] Sources: https://www.coca-colaitalia.it/storie/coca-cola-freestyle-arriva-in-italia & https://en.wikipedia.org/wiki/Coca-Cola_Freestyle

combined with real-world data[28]. Thanks to the data gathered by the IoT-embedded devices, this tool allows to simulate the environment in which the product interacts or could interact. In real-time it informs the company about the status, conditions, and functionality of the product, monitoring how the user interacts with it, or if it has been altered by the environmental conditions to which has been exposed. Nonetheless, without requiring any physical proximity between the manufacturer and the product, producer and consumer stay always in touch.

The Digital Twin, by providing monitoring and timely remote assistance, opens a business space based on the offer of services. Furthermore, once data are "aggregated", it plays a crucial role in the development process of new products, thanks to its capability to provide new insights about how products can be better designed, manufactured, operated, and serviced (Porter & Heppelmann, 2015). Further, the Digital Twin eases to better explain the impacts of changes in one node on the rest of the network (Cotteleer & Sniderman, 2017), thus speeding up the process of decision-making. Especially in the phase of ideation and implementation, the use of the "twin" allows to change underway the design of products, but also of the manufacturing processes: this enables an ongoing testing in a real use situation and a continuing refinement of the product. Considering that today every product includes a relevant software component, the company, improving the software, can update the product on ongoing basis. Businesses, alternatively, can also offer a paid upgrade when improvements are provided.
Indeed, the digital twin practically shifts the overall design of the product from the perspective of atoms to that of bits, obtaining advantages of cost, time-to-market, safety, and efficiency. An example is given by the deployment of the digital model to make durability tests. These tests can be performed by speeding up the flow of time in order to evaluate the number of years of operation in a few hours. In the case of wear detection of certain parts, if a problem occurs, the designer can "slow down" the time so he can observe what happens in seconds or even milliseconds intervals. The data contained in this "product's avatar" (Porter & Heppelmann, 2015) go to make up what can be defined as the "DNA" of the products, i.e. all the information which identify the profile of the object during its life cycle and localize it throughout the value network. On this matter, (Gates & Bremicker , 2017) from KPMG found out that:

"*In Industry 4.0, there are no longer any "naked" products. Instead, all parameters, norms and standards are already clearly and automatically documented as part of the virtual product development. The workpieces thus possess a "memory" that is understood by the machinery and in which the blueprint as well as information on the customer order, production and*

[28] Source: https://www.ptc.com/en/product-lifecycle-report/digital-twin-technologies-driving-adoption?utm_source=twitter_free&utm_medium=social_corp&utm_campaign=blog_DTadoption

assembly, are filed. Furnished with a product DNA, the workpieces can move semi-autonomously through a production environment. Additionally, the data stored in the DNA of various products can be aggregated and evaluated over the economic life – as a basis for the continual optimisation of the product development. Increasing computing power, high-resolution visualisations and the virtually exponentially increasing availability of data will make the issue of product DNA ever more important".

From the claim, it can be also deduced a link between the concepts of digital thread and Digital Twin: in fact, the digital thread allows for a much better use and deployment of the Digital Twin, nurturing it of those information that enable its analysis performance: the result is an optimization of the whole business and a substantial improvement of the company's offer.

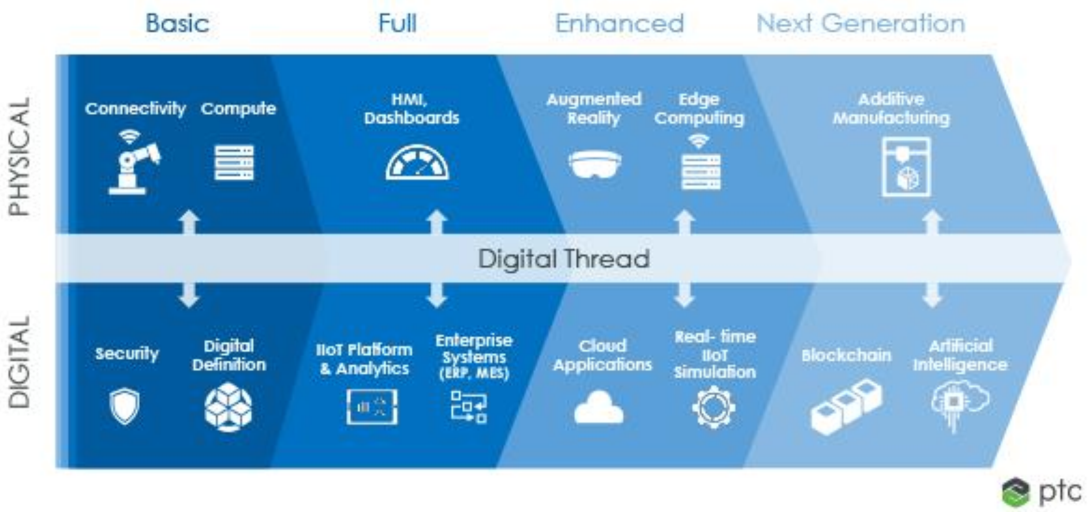

Figure 11 – The Digital Twin Architecture (Source: ptc.com, 2019)

The digital twin becomes indispensable above all in those sectors where producing pieces to test would become incredibly expensive and would lengthen the process of product development and realization, with considerable loss of efficiency and safety. For example, in the airline industry for several years *Boeing* has been designing its aircraft (starting from model 777) using the digital twin throughout the entire production chain, from operations to supply network. Its suppliers receive the "bit" specifications of the parts with which their component will interface, be it a rivet or a flight management system, and in turn will provide Boeing with a bit representation of the future component. Boeing performs bit-level integration, runs tests and simulations and, when it is convinced that everything is in place, activates its own and its suppliers' production.

Anyway, to conclude, companies that want to exploit and maximize the benefits offered by the Digital Twin will have to collaborate for the creation of a partnership ecosystem, which supports the right mix of technologies 4.0 to adopt and which will require a high degree of expertise for the management of this challenging feat.

3.3.2 CUT TO THE CHASE: THE NEW PRODUCT DEVELOPMENT STAGES

Over the past generation, companies relied heavily on marketing information to guide them in new products development; the next step has been relying on new products ideas inferred from the customers by capturing their current needs and desires (the above mentioned "customer's voice) (Goldenberg & Mazursky, 2002). Nowadays, bringing the product from ideation or concept stage to the market depends largely on data and capability of translating them into useful insights. Solid data management effectively ties upstream processes, to downstream production, and enables the creation of the digital twin for each product (Cline, 2017). This has been shown by (Ramakrishnan & Gaur, 2017):

"NPD teams are continuously dependant on data for product improvement and not hearing the voice of the consumer cause products to fail. Transforming data to actionable insights is the key to success in NPD scenarios. Embedded sensors in products are generating statistical dumps of data generated by actual consumer usage in a real-world scenario and are much more realistic than laboratory experiments in controlled environment. These data will provide all departments of a business such as manufacturing, quality, and logistics a tool to make critical decisions."

Another factor to consider is the increasing consumers' need for products that not only are highly technological and efficient but also aesthetically pleasing and attracting, as well as with a shortlist of complementary services. As a matter of fact, design plays a central role in the new manufacturing environment, where ergonomics is the focal point for the improvement in terms of product and production process with a focus on the well-being of the user and for his safety (Laudante, 2017). Consequently, data and connectivity require a completely new design of the product, starting with the fact that the latter more and more identifies itself in a service offer. Product design and variations are planned both on organizational and technological terms so that all the departments of the company are involved in the interdisciplinary process.

Even if there is not a holistically accepted model for product innovation -the most well-known is the *Linear* and the *Stage model*- there are some stages that are common to all of them. On the basis of these, the presented model has been built. It consists of three main phases, the *Ideation* phase, the *Product Implementation* and the *Commercialization* phase, which in turn include other organizational activities:

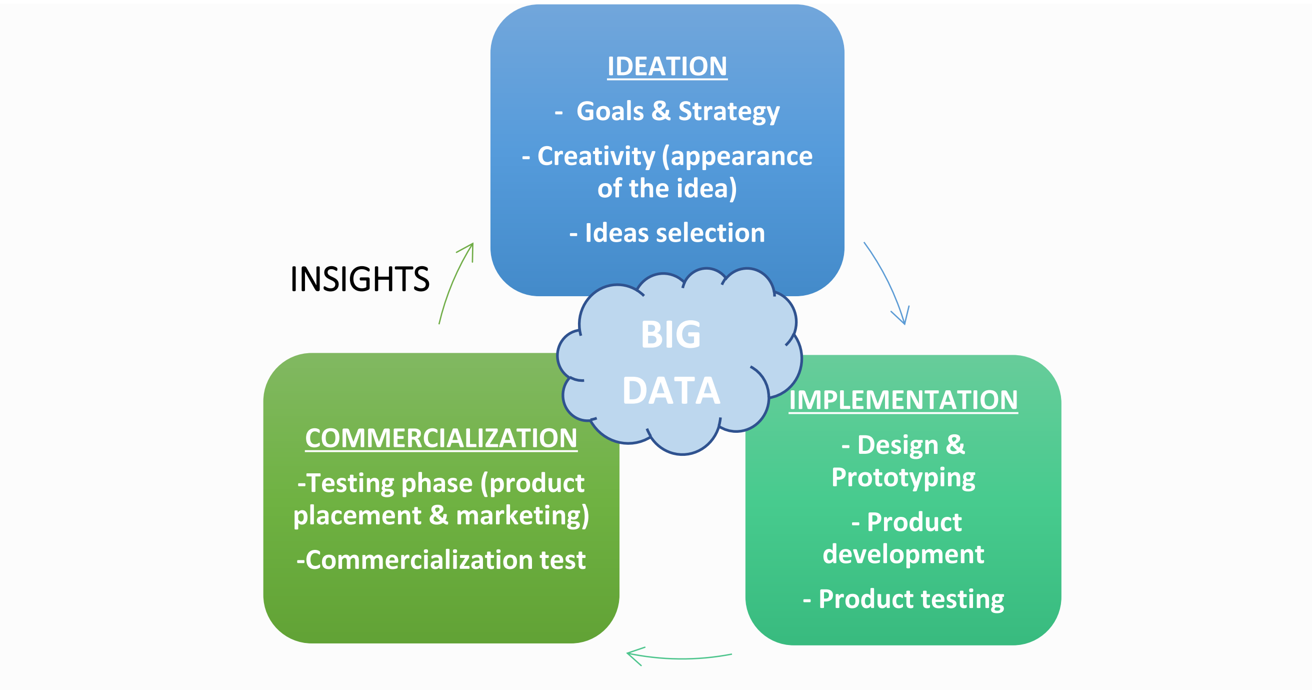

Figure 12 – The Process of Product Innovation (Source: personal elaboration, 2019)

3.3.3 THE IDEATION PHASE

The process of the New Product Development starts defining which and when the new product will be developed, so first is set out the product policy, namely the boundaries of the strategy and the relative goals, followed by the generation and selection of the best ideas. To be able to capitalize on the advantages of a "smart product", which is frequently a hybrid of physical device and service provision (Charlier, et al., 2015), and draw up a targeted evolutionary path, it is necessary to have a clear idea of the investments to do, the R&D policy, the sales plan, etc. However, the decision about the market to penetrate, with its opportunities and threat and the kind of product the company is going to manufacture are the core of the product-market strategy.

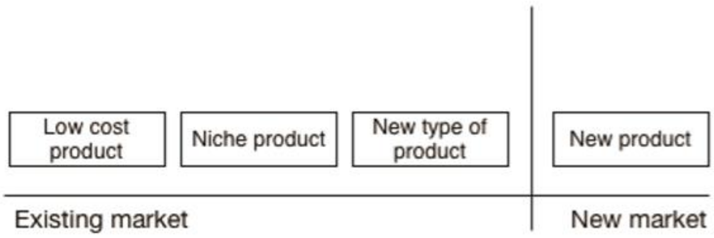

Figure 13 – Types of market in which a product can operate (Source: Charlier M., Goodman E., Lui A., Light A. & Rowland C.: Designing Connected Products, 2015)

IoT and intelligence are creating such a range of *new classes of products* that the companies involved are contributing to the emergence of *new markets* all the time. Businesses that look at the innovation are finding fertile ground by proposing offers that solve problems consumers did not realize they had or had accepted as "the way things are" (*ibidem*).

A way companies may decide to enter an *existing market* is by competing with a totally new offer, which differs from those of competitors because it disposes of better features, performances, conformance, as well as style and customization possibilities that embody the best the solution to a problem. IoT devices can offer many ways for differentiating, particularly within the context of services, evolving the familiar physical device with new opportunities of configuration, which can meet all the kinds of needs of the user. These IoT services and devices can be considered as tools because offer a general-purpose that doesn't have much value for the user. Indeed, they gain value once applied to solve a particular need, e.g. warning if you forgot to take your medicine for diabetes or turning power to home appliances on and off remotely, from your smartphones whenever you need it. Another possibility of innovation in this strategy can be to integrate a technological improvement in the device that changes customers' experience, e.g. *Apple's iBeacons* technology offers to airline passengers to have in-context information and directions within airports, so that they can maximize this experience, both from the side of the customers and the one of the airline company.

Even *low-cost entrants* have found a place in existing "market 4.0" thanks to the falling costs of embedded computing, catching up target customers who before were out of reach and those that companies convince to switch from more expensive solution because they are offering the same added-value at a way lower cost. These embody one of the main risks for already established companies.

A highly growing market, thanks to the advent of the IoT is one of the *niches*. Indeed, companies can decide to target a specific niche with a specialist interest; the IoT devices are equipped of own intelligence which allows the device to gather information about customer's needs and offer tailored solutions. In doing so, companies are able to address previously unmet user needs, creating a wide range of new opportunities for businesses.

However, as result of the product strategy of the business, it should be also considered that the product creation process extends all the way to manufacturing, indeed, it encompasses the strategic product planning, product development and process development (KPMG, 2017). Once outlined the strategy, there is a brainstorming phase in which are generated all the ideas to develop the new superior and unique product. In marketing practice, creative ideas are highly valued and rewarded, and exploring new ideas is part of the daily activities (Goldenberg & Mazursky, 2002). Indeed, creativity requires the same consideration as technical knowledge in order to create the perception of an added value in the public, who will then be encouraged to choose that commodity over competitors (Di Maria & Bettiol, 2014). From the creative process, a response to the stimuli perceived by the organization, opportunities emerging from research processes and/or the need to grow at the level of competitors evolve the new ideas (Roxana & Cornescu, 2019). More precisely, they can arise from two sources:

> ***Intrinsic*** – they include ideas coming from the organization's expertise, such as operative departments, decision departments, top management, other employees, suppliers, or alternatively from creative thinkers, historical data, company's website and brand communities, etc. (Kotler & Keller, 2016) report the example of LinkedIn, which launched an in-house incubator that allows any employee to organize a team and pitch a project to a group of executives; it also organised "hack days" for the implementation of new ideas.
>
> ***External*** – they come from market data, customers and client's feedbacks, competitors and competition state (as well as customers' opinions about competitors' products), scientists, commercial laboratories, stakeholders, open-source platforms, marketing and advertising agencies, crowdsourcing[29], etc.

The IoT embedded devices, by gathering data about their product-usage, enable a deep knowledge of customers, whose needs and wants are the logical place from where starting the search (Kotler & Keller, 2016); consequently, the selection of ideas speeds up, especially for those players which already have products in the market. The increased transparency of the products allows the company to drop faster the poor ideas, thanks also to the continuous flow of data in real-time, which in fact has brought the company closer to the customer. The relationship company-customer is no longer limited by contact only at the store level, on the contrary, the new relationship between them has promoted the user as *co-creator* of the new product. The most promising and criteria-fitted ideas are selected, sometimes suggested by the product itself, and then formulated into a draft for the product designers.

3.3.4 THE IMPLEMENTATION PHASE

The implementation phase translates the idea first into a concept, a "prototype", then into a product ready to be launched in the market, after it has passed some previous tests. The first part of the process is the one of Design that acts as a crucial interface between strategic product planning and product development (KPMG, 2017). It leads to the development of the prototype of the product, which is its primitive version.

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[29] Crowdsourcing involves obtaining work, information, or opinions from a large group of people who submit their data via the Internet, social media, and smartphone apps.
(Source: https://www.investopedia.com/terms/c/crowdsourcing.asp)

When a business wants to implement a digital product offer, it can decide to turn products into sensors or embed them into a previous generation product, in order to enhance it by providing data-based evidence for product engineers and also for better customer service (Ramakrishnan & Gaur, 2017). This is also crucial because to support the Internet of Things is required a different architecture and networking technology respect to the ones of traditional products. The first difference is due to the massive volume of data which calls for a robust and cost-effective network in order to cross the digital thread. On the other hand, design engineers must consider that IoT-data is transferred at much higher interval than the traditional networks and require an efficient interoperable system that links data from different types of sources (*systems of systems*). Further, they have to incorporate the additional instrumentation required by the connected services, such as software which manages data, diagnostic features that monitor product health and performance and remotely warn service personnel of failures (Porter & Heppelmann, 2015). Last but not least, engineers must also consider the preservation of data security and users' privacy throughout the design stage (and even further). For these reasons, the new product development process requires the pro-active involvement of all the organization's departments, even if the management and engineering departments which include R&D, design and product development, can be considered as the main players. As support of the entire implementation phase, takes part the digital twin, which simplifies the heterogeneity and complexity involved in the IoT infrastructure and manages data in a more robust method for users to easily identify required reports, simulation results or historical performance of devices […] Furthermore, it helps manufacturers to simplify design, simulate, validate, optimize, streamline and debug the manufacturing process (Vijayakumar, et al., 2019). Assembling physical, mechanical and electrical data together with detailed information about the product (and processes, as well as the entire manufacturing system), the digital model perfectly simulates states and future conditions of devices, and it supports the digital operators by giving insights about any layer of the product, by relying on an intelligent software-based network that projects the physical world into the digital reality.

In the first instance are developed the product's category concept and positioning that define the product's competition (Kotler & Keller, 2016), then the product' brand concept. Follows a testing phase in which a preliminary prototype of the product is presented to target consumers, physically or symbolically, to get their reactions.

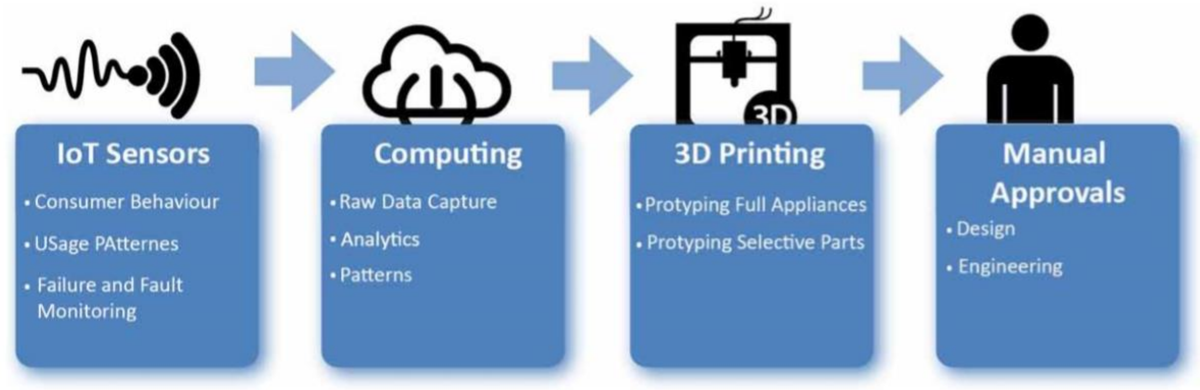

Figure 14 – Iterative prototyping improvement model based on the IoT and 3D printing (Source: Ramakrishnan R., Gaur L., 2017)

Acting interdependently with a mix of other technologies of Industry 4.0, such as 3D printing machines (additive manufacturing), CAD/CAM software, robots, AR & VR, etc., IoT devices first enable rapid prototyping; secondly shift this process and the one of testing into the virtual world; finally, allow a better forecasting on future consumers' preferences.

Actually, 3D printing machines convert IoT-data into physical prototypes: they make three dimensional solid objects from a digital file using specific raw materials which can vary from plastic to metal. 3D printing starts with providing a virtual design of the object to be printed in a Computer-Aided Design (CAD) file format (Ramakrishnan & Gaur, 2017). At this point, the prototype embodies all the customer's preferences and desired attributes and its preliminary design is their representation. Are carried out as many prototypes as necessary in order to improve the product in accordance with the needs of customers.

Then, the production operator further optimizes the product's design interfacing with the digital version of the object and testing it through virtual reality programs that simulate the product-usage in any kind of possible situation and environment. Artificial intelligence can help to estimate first and then govern risk factors, it can indicate the probability of certain events or their size and impact, providing decision-making tools based on a view and on an increasingly complete reading of the data that contribute to the correct development of the business[30].

The operator so far amends based on customers' real-time data, which are then converted into the primitive physical version of the product: the prototype comes to light. These procedures allow manufacturers to develop an "Evergreen design", which means that, differently from the past where products were produced in discrete generations, the IoT products can be continually upgraded via software, often remotely; moreover, they also can be fine-tuned to meet new customer requirements or solve performance issues (Porter & Heppelmann, 2015). The process

[30] Source: https://www.industry4business.it/industria-4-0/ecco-come-lintelligent-manufacturing-ci-porta-nella-data-economy-con-iot-connected-product-e-servitizzazione/

of continuous verification is called "On-going Quality Management" and can help engineering teams balance quality and speed, so they can deliver products faster without sacrificing features (IBM Corporation, 2015).

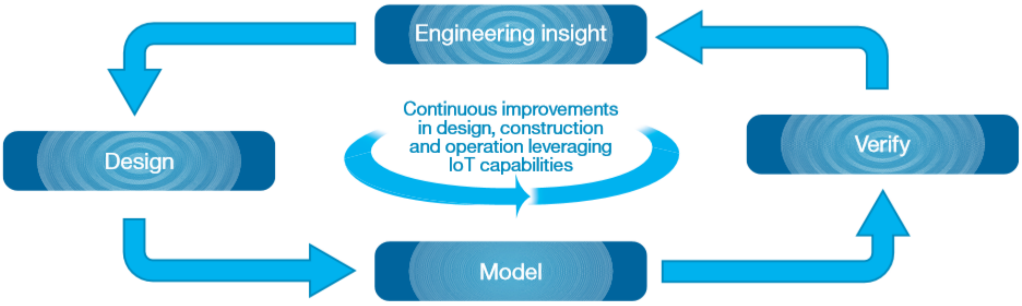

Figure 15 – Continuous engineering enables closed-loop product development, increasing the pace of innovation through continuous iterations (Source: IBM, 2015)

Doing so, companies reduce environmental unpredictability and breakdowns, improving at the same time the quality of aesthetics features. Besides, using supercomputer analysis makes also possible to do forecasts on future consumers' preferences, eliminating tedious trial and error, allowing companies to know real-time what is successful and what has low acceptance and leading to better product usage, whose data generated are crucial to design the product's prototype (Ramakrishnan & Gaur, 2017), but also to improve future products. Not a coincidence that companies for managing this complexity strategically reuse design information like in a *virtuous cycle of value*. With strategic reuse of common design elements, engineering organisations can quickly customise IoT products for specific markets at a reasonable cost, schedule, and quality (IBM Corporation, 2015). As a result, the process of product design (and adoption) gains efficiency and speeds up, becoming more and more automated, flexible, autonomous and networked. Indeed, human intervention is minimized since the process can be performed also in remote.

At the *testing* stage, the company will need to evaluate and predict the future of innovation after the product launch (Roxana & Cornescu, 2019). The traditional testing phase is performed by carrying out several costly tests aimed at eliminating all the possible defects, bugs and inefficiencies of the product before its launch. Often, is also tested the market reaction through the placing on small areas of the market, i.e. in the user's real environment, of small batches of products before releasing the product officially into the market. In contrast to the traditional testing stage, the IoT technologies enable a reduction of costs arising from the functional and customer's tests, as well as a substantial limitation of damages and reduction of risk linked to the product's launch. Informed decisions based on real-time analysis of test data allow engineers to base their decision on quantitative information and to release new features work-in-process (*proactive approach*). The continuous monitoring of real-world performance data allows companies to identify and address design problems that testing failed to expose (Porter & Heppelmann, 2015). The product is never totally finalized, defects are tracked on an ongoing basis so that it might be adjusted at any moment. Finally, test automation also makes it more efficient to validate and verify product performance against requirements, throughout the design life cycle to help reduce errors and achieve faster time to quality (IBM Corporation, 2015).

	Current Methods for Design	IoT and 3D Printing-Driven Design
When it is initiated	• Before Product Launch • Based on market feedback • Based on technology evolution	• Real time customer behavior analysis • Real time based on complaints, failures and usage patterns
How it works	• Usually prototyping happens by design engineers and then a pilot launch happens which helps assess market response. • Next design change is more technology driven rather than customer driven and happens less frequently	• Real time design changes possible based on continuous usage data transmitted across networks and with rich analytical engines supporting and suggesting findings. • Human intervention in design is more of commercial and technical validation.
Benefits	• Leverages on human experience which further learns from past mistakes.	• Design is rich interpretation of customer desire and preferences and may lead to perfect design
Limitation	• More reactive than proactive. • Based on majority views • Suffers from customer accepting a feature since no credible alternative possible • Feedback mechanism seldom reaches design team and customers settle for the best of the worst approach	• Each customer may have his own perception and style of operating leading to tailor made recommendations at even individual level. • Less standardization • Commercial feasibility, safety or other unstated customer low priorities may be ignored • Product may have hundreds of evolution cycle.
Application Areas	Across industries: • More real time in case of food items. • Rarely used for automobiles this goes with expert opinions.	Across industries: • Consumer electronics TV/Fridge/White goods. • Automobiles and transportation. • Apparels and clothing.

Figure 16 – Comparison of the current methods for design and the IoT and 3D printing-driven design (Source: Ramakrishnan R., Gaur L., 2017)

3.3.5 THE COMMERCIALIZATION PHASE

Commercialization consists of all those actions that lead to the new/improved product launch and the development of the marketing campaign. It is the stage that marks the distinction between invention and innovation, during which is added the economic value that distinguishes the first phase from the other. When a company is about to launch the new product, it has to deal with the high risk and massive costs which this phase entails. In fact in this stage, there is the risk that customers, whose behaviour now dictates the future of the product (Roxana & Cornescu, 2019), refuse the innovation taking it to drop off from the market, with grave financial consequences. However, companies, exploiting the IoT-data power, can “tailor” their strategies offering personalised offers (and services) to individual segments and targets, respecting also their willingness to pay (see *New Pricing* business models). Still, from data-driven insights they know before the launch campaign if the product added with value-increasing elements will success in the market and increase brand awareness, enhancing the company's competitive advantage. Still, in the case of flaws occurrence the product and the production system can be constantly being optimised on the basis of all evaluated data, and subsequently adjusted only with occasionally significant follow-up costs (KPMG, 2017). Moreover, RFID sensors, just to give an example, gather data about product localization besides the one on usage, performance and customer preferences. This grants a better localization of support centres which in turn enhances the customer's experience and satisfaction, as well as the brand reputation. Another advantage given by the Internet of Things is that the company drastically reduces the time-to-market, speeding up the passage from the product idea to market entry which satisfies the increasing expectations of customers who ask for more and more innovation in the shortest time.

3.4 CONCLUSION: THE EVOLUTION OF THE PRODUCT LIFE CYCLE

"Industry 4.0 will impact the whole product life cycle end to end – from design to production, the actual usage phase until end-of-life – and cannot be attributed to one single department of the firm. The digital transformation is a cross-functional effort that needs to be addressed by the whole company."

(Reinhold Achatz, Head of Corporate Function Technology, Innovation & Sustainability at *ThyssenKrupp Corporation* (McKinsey & Company, 2015))

The change in the product life cycle is one of the most important consequences of the complexity of connected and digital products. For this reason, the interest of experts and industry players around this issue is still keenly focused on the necessity of understanding the renewed life span of the product, its evolution (thus, its pattern) and management, with the aim of reaping the benefits promised by the high ROI projections connected with the IoT deployment.

The traditional product life cycle model takes life with the introduction in the market of the innovate product and develops throughout the four stages of its life – Introduction, Growth, Maturity & Decline – depending on volume of sales/profit (vertical axis) as a function of time (horizontal axis). Its utility for marketing and positioning strategy is mainly proven during the launch period, which is distinguished by a high degree of uncertainty. Indeed, it supports companies in managing the progress of their offerings from introduction to decline, showing where they are situated with their offer and where instead they should be according to projections. The following table sums up all the relevant aspects of the traditional PLC model.

Charactris-tics/ PLC	Introduction	Growth	Maturity	Decline
Sales	Low sales	Rapidly rising sales	Peak sales	Declining sales
Costs	High cost per customer	Average cost per customer	Low cost per customer	Low cost per customer
Profits	Negative	Rising Profits	High Profits	Declining profits
Customers	Innovators	Early Adopters	Middle Majority	Laggards
Competitors	Few	Growing Number	Stable number beginning to decline	Declining Numbers
Marketing Objectives				
	Create product awareness and trial	Maximise market share	Maximise profit, while defending market share	Reduce expenditure and Milk the brand
Strategies				
Product	Offer a basic product	Offer product extensions, service, warranty	Diversify brands and item models	Phase out weak products
Price	Charge cost plus	Price to penetrate market	Price to match competition	Cut price
Distribution	Build selective distribution	Build intensive distribution	Build more intensive distribution	Go selective : phase out unprofitable outlets
Advertising	Build product awareness among early adopters and dealers	Build awareness and interest in the mass market	Stress brand differences and benefits	Reduce to level needed to retain hard core loyals
Sales Promotion	Use heavy sales promotion to entice trial	Reduce to take advantage of heavy consumer demand	Increase to encourage brand switching	Reduce to minimal level

Figure 17- Characteristic of the traditional Product Life Cycle Model (Source: https://www.businessmanagementideas.com)

The actual competitive market and the trend toward digitalization of the manufacturing system has reduced the product life cycle pressured by customers' requirements and expectations, that ask for complex product, but at reduced development and production time, as well as costs cutting, maintaining at the same time high product quality, performance and aesthetic features. The IoT deployment has flipped the market equilibria: far from the tunnel vision of the old model, that implicitly implies a limited life of the product, i.e. designed to decline, the Internet of Things, through *servitization*, has given firms the possibility to propel their products backwards or forward in the lucrative growth phase (Moon, 2005). Thanks to the ongoing quality management and software updates, companies are able to refine their offers by adding services to the basic product inexpensively and almost always automatically. Besides, as sustained by Miragliotta[31], director of *Internet of Things, Industry 4.0 and Artificial Intelligence Observatory* of the Politecnico di Milano, the IoT overcomes the ambiguity of the planned obsolescence, which over the years has undermined the development of relationships of trust between customer and producer. On the contrary, now the manufacturer undertakes a direct responsibility report on the offered service because has every interest in engineering and

[31] Source: https://www.industry4business.it/industria-4-0/ecco-come-lintelligent-manufacturing-ci-porta-nella-data-economy-con-iot-connected-product-e-servitizzazione/

managing products so that they are always at their maximum performance. Doing so, he innovates the product on an ongoing basis by adding end-to-end value throughout all the stages of its life cycle and embedding brand value into stakeholders' psyche, thus enhancing the user experience. Further, Miragliotta theorizes that in some sectors this same evolution opens to the scenarios of the *In-Things Purchase* that allows the management of purchases directly during the interaction with a connected intelligent object, so as to be able to activate extra-functionality or extra-services that they are in a position to increase their utilization value. On the other side, firms can exploit the IoT benefits also with historical products in decline, anticipating this phase, thus extending the consolidated product's life cycle. Indeed, planning a digital innovation in time, firms can create a breakthrough in the bell-shaped model and enter a new phase of growth. From this perspective, the Product Lifecycle Management (PLM), defined as the process of managing the entire life cycle of a product, from ideation phase to supply chain management, will gain increasingly upscale role within organizations. Likewise most of the Best-in-Class[32] - i.e. top-performing companies – consider it as the enabler of the digital thread across all stages of the product development life cycle (Cline, 2017). The new product management takes the form of an integrated solution which acts as a flexible innovation platform for digital transformation (*ibidem)*; this new approach better fits to change which is involving companies, products, and business models, because enables a better and more efficient management of the company's knowledge, both pre-existing and produced. Indeed, PLM solutions in synergy with a cultural and educational commitment of the internal organization, enable decision-makers to effectively manage the change with an interconnection capacity that must be able to combine machines, people and data.

[32] *Aberdeen*, an international intent-driven marketing company, defines as *Best-in-Class* those companies of its research sample that consistently outperformed their peers in all five performance metrics: product quality, product launch dates met, product cost targets met, product revenue met, and change in length of development time (increase or decrease). (Sources: https://www.aberdeen.com/)

CHAPTER 4 – IOT AND PRODUCT INNOVATION: EVIDENCE FROM STUDY CASES

Chapter 4 opens with an overview of the economic context in which our reference companies operate. Before analyzing the case studies of Italian manufacturing firms which embraced the Internet of Things is necessary to understand internal and external factors that in the former case, make unique the nature of Italian manufacturing system as compared with other developed countries; in the latter, these companies are placed in front of a completely changed competitive environment that requires them to deeply question their routines, structures, and activities. Despite the contraction in the activity levels suffered in the years of the crisis, Italy is still the seventh industrial manufacturing power in the world, and in Europe it is second only to Germany[33]. However, the Italian manufacturing system keeps struggling to change its reputation of country with a "flat growth" and regain competitiveness by achieving productivity growth levels similar to those of American and Asian competitors, as well as those of the neighbouring European states. What emerges instead, is that it is revealing itself as a country that after ten years from the beginning of the international financial crisis, still has evident and large wounds. As a matter of fact, there remains a significant gap with foreign countries with regard to education and training of the workforce, as well as the backwardness of infrastructures and the speed of digital transmission of data and information. According to experts, in the light of the "era 4.0", Italian firms and government will be challenged in adopting a long-term perspective that focuses on innovation and new technologies, seen as central players of the renewal of the manufacturing system.

4.1 THE ITALIAN MANUFACTURING: AN OVERVIEW

The structure of the Italian manufacturing system is something unique in its nature: the territory is mostly occupied by small and medium enterprises, which together account for about 99 per cent of the active companies[34] and make it the first country of EU28 for employment in Micro-Small enterprises (Zanardini & Bacchetti, 2017). Among them, the major role is covered by micro-firms employing less than 10 people. Large companies (250 or more employees) account only for 0.1 per cent in terms of the total number of companies, accounting for 20.6 per cent of employment, lesser than the European average of 40 per cent. The leading role of the manufacturing sector gained in the second post-war period has been undermined by structural features of the production system exacerbated by the internal economic context of the country.

[33] For added value and output at current prices. Data of 2018 (Confindustria, 2019)
[34] Istat data referred to 2005 (Istat, 2018)

In the last fifteen years, the manufacturing sector has fallen behind showing a feeble productivity growth both by historical standards and compared with the other main euro area countries. In terms of GDP, it moved from 18.5% to 14.7% of GDP and observed a reallocation of the resources that gave more importance to the services sector, which currently accounts for 66.3% of GDP[35]. Companies have found themselves unprepared to take full advantage of the new opportunities offered by technological innovation and world and European economic integration that were taking place in the second half of the ‘90s, so contributing to the Italian growth failure. Indeed, unlike the USA, which has seen their output and labour productivity growth through the adoption of the Information and Communication Technologies (ICT), Europe has hesitated in the field of innovation and in particular, Italy has exploited with chronic delay the benefits offered by the new technological paradigm associated with the ICTs. As a matter of fact, taking full advantage of the possibilities offered means for companies to adopt more efficient organizational forms. Italian firms are mostly small family businesses, so characterized by hierarchical structure, rigidity of centralized decision-making and risk aversion because corporate assets often coincide with the family ones: this has led to a certain diffidence towards the adoption of new technologies and less likely to bear the risk and the cost of innovative projects. Moreover, such background has often coincided with a lack of managerial and financial knowledge and resources that have not allowed them to grasp the economies of scale inherent in technological innovation. It has been shown by (Bugamelli, et al., 2018) that overly pervasive family management is associated with worse management practices, less efficiency, and a lower propensity for internationalization, innovation and therefore growth, with repercussions on the economy as a whole. This may explain the scarcity of investments in R&D pursued by the Italian businesses; indeed R&D, as well as product and process innovation and the adoption of new technologies are central to ensuring efficiency gains at the firm level and hence the growth of an economy (*ibidem*). On the contrary, data on R&D are ill-suited to describe the innovative approach of the Italian small and medium enterprises (SMEs), which show low specialization in high-tech products, but a high sectorial specialization in the traditional ones, like textile, leather, shoes, and clothing. In fact, in Italy takes place the so-called paradox of “innovation without research”, that perfectly describes the conduct of Italian firms which don’t explicitly invest in R&D to grasp innovation but use informal channels for realizing product and process innovation, like knowledge management, or the chance and ability to benefit from spillovers (Bugamelli, et al., 2018). Moreover, the paradox refers to the fact that innovation is mostly done on its own: only 19.8% of innovative

[35] Source: https://www.agi.it/fact-checking/italia_francia_manifatturiero-5315219/news/2019-04-13/. The comparison is made in reference to the period 1992-2017 (Data are from Eurostat).

companies have activated forms of cooperation with other subjects, compared with about a third for the EU (Istat , 2018).

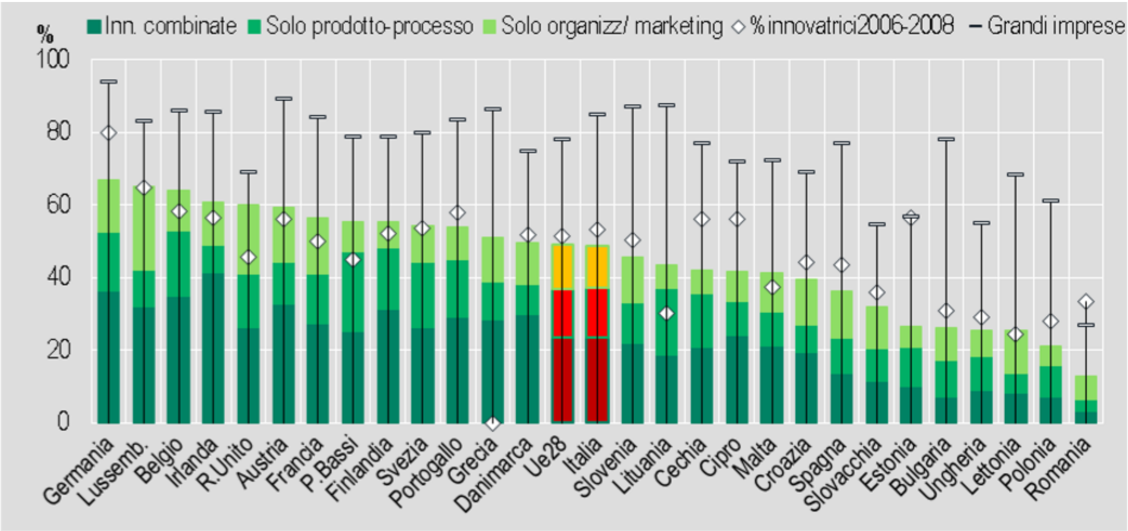

Figure 18 – Innovative Companies in EU Countries, by type of Innovation and Size. Years 2012-14 and 2006-08 (% of total companies) (Source: Eurostat, Community Innovation Survey (Cis 2014; Cis 2008))

During the 1990s, Italian manufacturers suffered also the increasing competitive pressure posed by globalization: the opportunities offered by the lowering of trade barriers, however, have not proved enough to compensate for the threat coming from the emerging economies, which include big players, such as India and China. These have harshly worn down the competitiveness of Italian firms, that have been hit harder than the competitors since many of them have specialized in those activities of the "made in Italy" heavily threatened by the low prices of new competitors. At the beginning of the last decade with the integration of markets on European soil first, and subsequently, with the introduction of the Euro, the competitive capacity of the Italian manufacturing industry has been further challenged. On one hand, Italy lacked the possibility of resorting to devaluation or depreciation of the currency to face the loss of competitiveness, on the other hand, it started to act in a wider and more aggressive competitive environment. Finally, it had to face a phenomenon of manufacturing reallocation to Countries with lower costs of labor which have further exacerbated the rivalry based on price advantage.

Despite the deficit in spending is concentrated in the private sector, a great responsibility in the approach to innovation is held by those who from below have the responsibility to influence the development directions of companies, as well as the composition of domestic demand: notwithstanding a strong commitment (especially since 2011) by the Government, Italy still lags behind the other advanced European economies in terms of resources allocated for innovation, thus generating a lower innovative output. Indeed, in the last decade, the aggregate investment dynamics have heavily suffered from the crisis, on the other hand giving way to the conspicuous growth of expenditure on intellectual property products and other forms of intangible investment (Istat , 2018). This is demonstrated by the amount invested in R&D: after almost 10 years from the start of the crisis Italy invest in research an amount equal to 0.8% of GDP, a much lower figure than the European average of 1,3%[36].

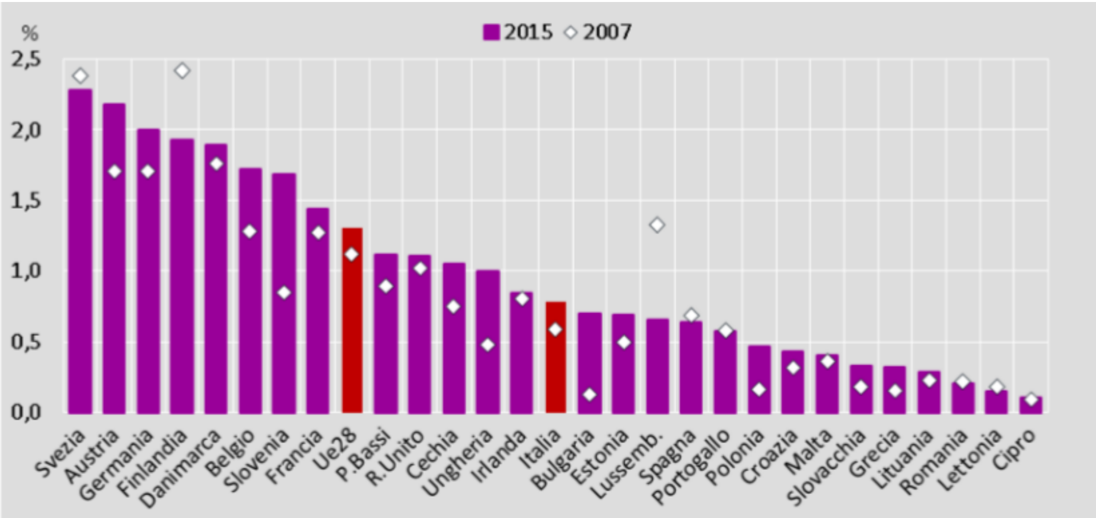

Figure 19 – Spending on Research and Development of enterprises in EU countries. Years 2015 and 2007 (% of GDP) (Source: Istat, 2018)

However, the Italian industrial system – characterized by industrial districts made up of small firms patchily scattered in the Country – has responded to the call made by innovation and globalization in order to keep its competitive position. Into this kind of clusters, contrary to the claim above, are exploited forms of cooperation, i.e. small and medium businesses (SMEs) are generally involved into innovative projects of an incremental nature, contributing each with complementary activities and with the goal of sharing resources and knowledge (Romero & Martínez-Román, 2011). In order to make that, it has been particularly fostered by its clusters characteristics: *division of labour*; *transparency of information in exchanges*; *training and accumulation of professionalism* linked to sectoral specialization and based on what Marshall calls "industry secrets" (or tacit knowledge); and the consequently *innovative processes* (Antonelli & Marino, 2012).

[36] Data referred to 2015 (Source: (Istat , 2018))

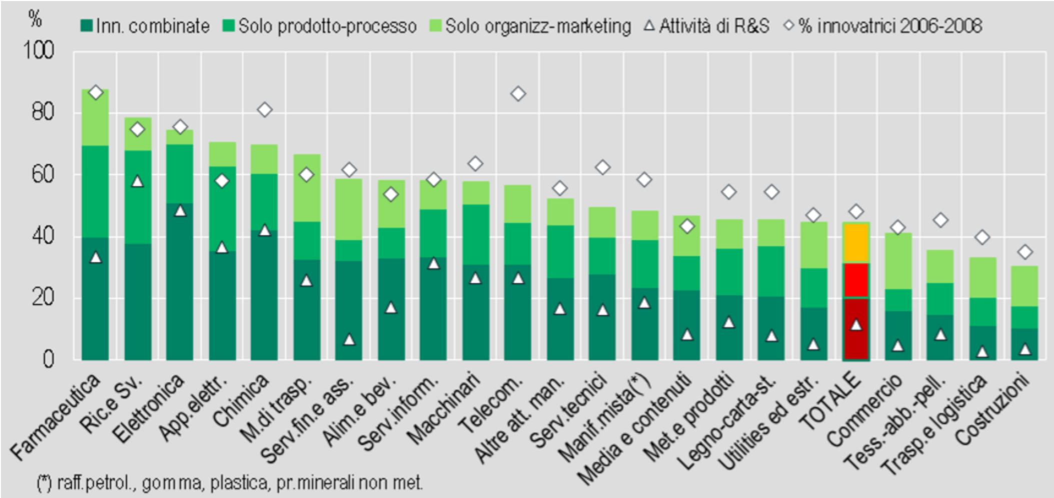

Figure 20 – Innovative Companies for Economic Activity and Type of Innovation. Years 2012-14 and 2006-08 (% of total companies) (Source: Istat, Innovation Survey in Enterprises. Years 2012-2014 and 2006-2008)

Indeed, many Italian firms invested in open innovation, strategic partnerships aimed at increasing research and developed those advanced specific competencies that are essential for fully embracing the new technological paradigm. As stated by the new government program proposed by the current prime minister Conte, there is nowadays the awareness that in order to survive in the fast-changing world, "a large industrial country like Italy must set technological innovation as its goal vector of economic growth" (Canna, 2019).

4.2 INNOVATION AND DIGITALIZATION AT THE BASIS OF ECONOMIC AND CULTURAL GROWTH: THE PLAN "INDUSTRIA 4.0"

The underperformance of Italy's aggregate productivity characterized both the pre-crisis (1995-2007) and the crisis periods (2007-13) and also during the recovery (2013-16), when the others main euro-area countries were able to manage a constant level of TFP[37] (Total-Factor Productivity) or at least limit its decline during the crisis, Italy's growth gap remained negative with a collapse of -0.9 percent per year on average (Bugamelli, et al., 2018). An exception of this tendency is given by those firms that in the period between 2000 and 2006 started a process of restructuring to cope with the previous-mentioned increased competitive pressure. They registered positive performance in terms of turnover, employment and investment, but this has been the exception of few "good firms" rather than the rule. According to an analysis pursued by the Banca d'Italia in 2009, the overall above negative picture has been interrupted in the two-year period prior to the explosion of the financial crisis and the long period of recession. Indeed, some Italian firms started a process of innovation of the product – which involved

[37] The Total-Factor Productivity (TFP) is a variable that approximates the development of innovative and organizational capabilities that determine the efficiency of the production system, with negative consequences on export competitiveness. The prolonged weakness of these indicators is a symptom of profound structural defects in the production system.

activities upstream and downstream of the value production chain – based on high standards of quality and development of intangible features: the result has been a wider offer of value-added products, with consequent benefits deriving from growth of productivity and exports and therefore, of profit margins. This strategy, although hampered and mitigated by the crisis that exploded in the summer of 2007, was maintained even after the crisis by a significant part of the Italian production system, which undertook the path of qualitative upgrading of the manufacturing offer to respond to the growing price competition coming from the emerging countries, moving to market segments with greater added value (Centro Studi Confindustria, 2019). However, this attempt to revamp the manufacturing decadence at that time was not enough to overcome the distressing condition in which the whole system poured, and which had far more profound and entrenched implications. Sure enough, as found by (Bugamelli, et al., 2018), the limits of the competitiveness of the Italian manufacturing, in terms of innovation and adoption of new technologies, should not only be investigated into the sector specialization of the Italian firms, which is cause and effect of low investment in research and development. Although, these limits must be researched in the high fragmentation of the productive fabric, strictly related also to the firms' dimension (*composition effect*). As a matter of fact, the heterogeneity within sectors, rather across sectors, can better explain the underperformance of Italy's aggregate productivity. This causes the typical polarization of the Italian productive system that juxtaposes, on one hand, many micro and small enterprises, which are on average old, have a limited attitude to innovation, to the adoption of advanced technology and to internationalization, are ineffective in their management skills and practices and have a vulnerable financial structure; for such reasons were severely affected first by globalization and then by recession. On the other hand, there is a small set of firms, mostly medium- and large-sized, whose efficiency, performance and strategies (in terms of innovation, technology, and exports) are comparable to their most successful European competitors. They have been able to cope with the negative shocks that hit the Italian economy – by adopting the above-mentioned *qualitative upgrading strategy* – thus strengthening innovation, investing in new technologies, upgrading product quality, and opening up the financial structure to equity capital. Are these firms that are currently supporting growth (*ibidem*).

Technology is the main trigger for innovation (Andersen, et al., 2019), at the same time its main hurdle is the cultural resistance which limits the companies' positive attitude toward the benefits of new technologies and therefore their adoption. The latter is strictly related to the perception firms have about the risk associated with innovation, uncertainty surrounding the demand for new goods and services, as well as access to technical skills or government support. Under this perspective, data-driven innovation is nowadays a precondition to be competitive worldwide, so a radical cultural change in the approach to digital organization must be at the basis of the restructuring process. If implemented by a relevant number of companies, the synergy of such factors – high tech approach, organizational restructuring, and competitiveness on a worldwide scale - have the potential to reduce the growth gap accumulated in the past (Bugamelli, et al., 2018). For this purpose, most of the researchers have given much attention to the analysis of a knowledge-based approach, aimed at enhancing education and development of the skills and capabilities, especially those technical, crucial for the attainment of sustainable competitive advantage in the fast-paced digital world. This is based on the belief that any kind of knowledge – personal or business, deriving from the development of new projects or completed ones, whether structured or unstructured – must be managed and transferred to create added value and to be a basis for innovation and product development[38]. As stated by (Romero & Martínez-Román, 2011), a company that aims to achieve a path of long-term growth and competitiveness must be driven by knowledge since it is a fundamental factor in innovation and assimilation of new technologies. Consequently, it is widely recognized that the ability to innovate and continuously learning become the basis of business success.

Since in order to achieve the digital transformation companies, especially small and medium, cannot rely on themselves, are required multi-level supports of industrial policy, which favour investments in technologies, a closer link between the world of research and industry, training and the continuous updating of skills. For compensating the lack of implementation of digital technologies and instead taking advantage of them, the Italian Minister of Economic Development under the Renzi-Gentiloni Government, Carlo Calenda in September 2016 has announced the launch of a medium-long term policy strategy in line with international best practices: *The National Plan Industria 4.0*. The plan is the solution adopted by the Government in order to increase long-term competitiveness of the Country and achieve sustainable growth: the scope is to increase the relevance of the manufacturing system in terms of GDP given its strategic significance also in relation to other sectors, such as the one of services, especially the high-tech ones (Istat, 2018). It provides ad-hoc measures tailored to the needs of the Italian economic structure which help businesses to digitalize their production processes and adopt the new technological paradigm at the entire enterprise level. The core of the plan aims at triggering the technological change in the manufacturing system, sustaining firms in their innovative scale-up through an increase of investments, both through the development of skills and competences in the field of new technologies and R&D activities. The original version of the

[38] Source: https://www.cadtec.it/2017/07/17/gestione-della-conoscenza-e-innovazione/

Plan essentially targeted small and medium firms operating in the manufacturing system, but in the autumn of 2017, the scope of its intervention has been extended beyond manufacturing, under the name of *Impresa 4.0*. Indeed, the provisions contained in the recent Plan are directed to all the enterprises, independently of size, sector or territory. However, the involvement of SMEs[39], given their central role in the Italian manufacturing structure, remains the main objective of *Impresa 4.0*. The measures for the 2017-2020 period provide for public investments for 18 billion euros and mostly consist of fiscal incentives that encourage private investment in new technologies and innovative processes and facilitate enterprises access to credit. If in the first version the plan's economic incentives were focusing on enabling the purchase and upgrade of machinery and software, in the version of 2018 the Italian government pointed out the importance of skills and training of the labour force, thus has also introduced measures to develop capabilities needed to manage the company's digitalization. Far from providing just a technological upgrade, *Industria 4.0* becomes a mean which endows firms with instruments for successfully competing in global markets. For this purpose, I4.0 has launched three platforms: «Punti Impresa Digitale», Innovation Hubs and eight Competence Centres. The purpose of these platforms is to put together public institutions, companies, investors and research centres to support and facilitate investment plans, with the general objective of increasing the manufacturing contribution from 15 to 20 per cent of GDP (Istat, 2018), basically making this sector the driving force of Italy's economic growth. Competence centres are of particular relevance since their objective is to create a national network of excellent centres supporting Italian firms for technology transfer (MiSE, 2018). As matter of fact, they finance the establishment of fruitful collaborations between leading Universities and big private players in order to further contribute to the empowerment of the workforce skills, particularly necessary for the Italian small and medium enterprises. The Competence Centres provide training, live demos, presentation of best practices, technical advisory services for SMEs, launch, and acceleration of innovative projects and technological development (European Commission, 2017). Their purpose is to increase awareness of Industry 4.0 in Italian entrepreneurs[40]. In Budget Bill 2019, there has been a resizing of the Plan changing the course taken in the previous years. The downsize has affected especially the incentives regarding the purchase of new machinery and software, not offset by an enhancement of one of the other pillars on which the Industry 4.0 plan is based: skills, work, governance[41]. Regardless, the remodelling

[39] SME: Small & Medium Enterprises
[40] Source: https://tecnologia.libero.it/industria-4-0-necessari-investimenti-per-banda-larga-e-formazione-12393
[41] Source: https://www.agendadigitale.eu/industry-4-0/industry-40-tutto-quello-che-c-e-da-sapere-su-piano-e-attuazione/

disadvantaged large firms, which probably took advantage of incentives in previous years, while continuing to facilitate SMEs.

4.3 INDUSTRIA 4.0: THE STATE OF THE ART

A snapshot of the current adoption level and grip of the technologies of Industry 4.0 has been presented by a research of the Digital Manufacturing Lab of the Department of Economics and Management of the University of Padua, with the aim to shed light over benefits and outcomes gained by companies that introduced these technologies in their production processes. The research, issued in 2017, has also investigated the flip side of the coin, i.e. the hurdles which prevent companies from the adoption of the new technological paradigm and it also provides an in-depth analysis of the impact on the manufacturing organization at geographical level and on the front of environmental sustainability. The sample consists of 1020 Italian manufacturing firms operating in the sector of the "Made in Italy", active mainly in Northern Italy (Piedmont, Lombardy, Veneto, Trentino Alto Adige, Friuli Venezia Giulia, and Emilia-Romagna) and generating a turnover greater than One Million euros. Although 95% of Italian companies have heard of IoT at least once (Salvadori, 2019), the study revealed that in reality, those that have effectively adopted industry 4.0 are only 1/5 of the total sample.

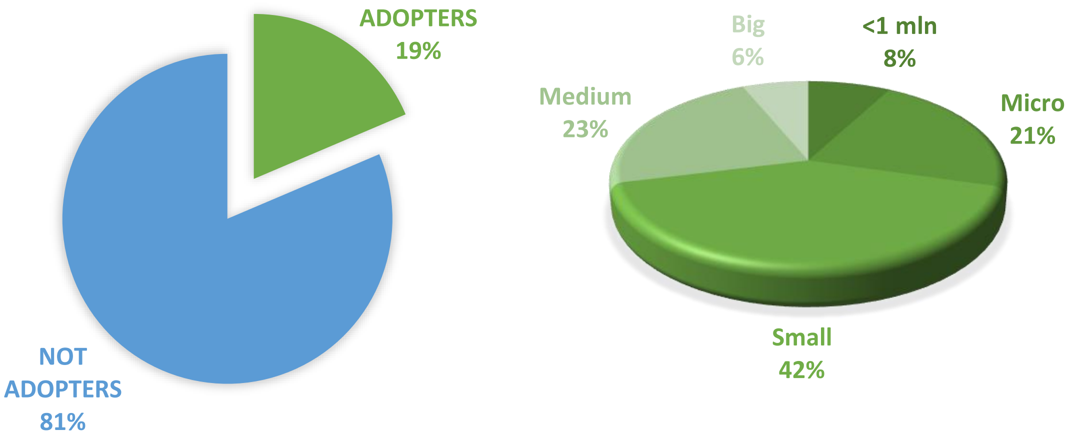

Figure 21 - Adoption of technologies of Industry 4.0 in Italy and Adopters' Size (Source: Digital Manufacturing Lab, 2017)

The reason behind these data has strategic and cultural roots rather than financials: actually, more than 65% of not adopters have declared technologies of Industry 4.0 of being not interesting for their companies, while less than 15% of respondents believe the lack of investment is linked to limited economic resources.

Among the firms that adopted Industry 4.0, the large share is held by small and medium enterprises, with respectively 41.6% and 22.6% of adopters, thus reflecting the taxonomy of the

Italian manufacturing structure. It is precisely when it comes to SMEs that there is substantially a lack of knowledge about the IoT, indeed only 5 out of 10 know the meaning of the term "Internet of Things" and recognize the importance it carries within modern business contexts (Salvadori, 2019). These enterprises, complying with the EU Regulation no. 651/2014, generate a turnover between two and fifty Million euros per year. Despite the limited size in terms of turnover (< 2 mil), the study found that also micro-firms invested in new technologies with a significant representation of 21.6%. Tendentially these companies are innovative, characterized since ever by an open vision towards digital improvement, as evident from data relating to their previous investments in ICTs which show a positive relationship between ICT's envelop and 4.0.

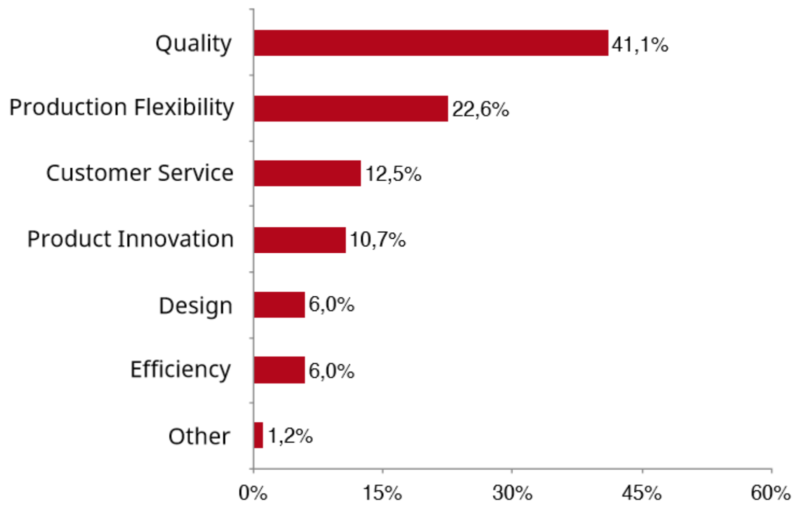

Figure 22 – Competitive Advantage Factors: almost 11% of the Respondents base its Competitive Advantage on Product Innovation (Source: DML, 2017)

The rationale of the investments is mainly linked to market dynamics: providing a better service to customers is the main reason why 75% of firms declared to have undertaken a project *Industry 4.0*. Below, the research for a way to improve the internal efficiency (65%) and investments pursued with the scope to increase competitiveness throughout the global market and looking for new market opportunities as well (respectively 58% and 52% of respondents). Less weight has been given to customers' satisfaction (30%) and to adapt to industry standards (23%), while 32% of investments in Industry 4.0 were driven by willingness to convert the internal activities from the perspective of environmental sustainability.

Greatest results have been achieved by the companies in terms of reduction of production costs and an increase in internal efficiency (60%), whereas 54% of respondents highlight to have profit from increased productivity. Only 39% of them have achieved an increase in turnover, but even less impact was attributed to gains in competitiveness and environmental sustainability (~20%).

Those firms that aimed at achieving a wider range of products (44%) have been able to diversify and increase it for 37% and 20% of them added new personalized products in their offer. Among the adopters that aimed to provide better customer service, 53% achieved positive feedbacks, thus satisfying the reasons for which they had invested. These aspects become furtherly important, considered that 66,6% of the "adopters" sample realizes customized products and only 33,9% standard products. Indeed, one of the main reasons that resulted in the adoption of Industry 4.0 technologies has been the possibility to have machines capable of offering almost illimited ways of customizing products and thus widening its own offer. The adopters pointed out that technologies enabled an increased monitoring of users during their interaction with products (30%), while 26% of them mentioned an increase in the product performance thanks to the adding of related services. Approximately one-third of firms assert the co-participative role gets of customers, both in design (27%) and production (12,5%).

Certainly, investments in Industry 4.0 had a different impact according to the type of technology used: Big Data and IoT have been the means through which companies enhanced their control over customers and consequently, thanks to data from the product usage, were capable to improve the product's traceability, performance and offer better services. Companies that have implemented Big Data have had also access to different distribution processes. Among those that adopted robots, or additive manufacturing, as well as laser machines have been achieved positive results in terms of increased productivity and maintenance of international competitiveness. From the product perspective, these technologies have powered the closer relationship between firms and customers, primarily by increasing the degree of customization of products. Basically, firms remarked an increase of the enterprise innovativeness and more broadly, an increase of the product value as a whole.

Excluding the lack of financial resources, which can be filled with the governmental incentives, are three the main hindrances faced by businesses when adopting Industry 4.0 technologies: first of all, enterprises struggle in finding skilled workers able to manage the new digital environment. This situation is due to a shortage of internal and external skills that affects 22% of respondents. Another hurdle consists of the long implementation timing required by new technologies, experienced by 23% of the firms. Finally, enterprises are hindered in maximising the benefits deriving by Industry 4.0 for a lack detected at infrastructural level and that constitutes the backbone of this project's implementation: as matter of fact, Italy does not dispose of a network entirely covered by broadband and this has hampered almost 25% of the adopters.

As concerns, the core of this work, just 24,2% of adopters have implemented the Internet of Things and smart products. As one might expect, the highest adoption rate has been registered among the big-firms (~40%) to then decrease progressively with the company's size, even if surprisingly, companies generating less than one million euros turnover showed a relatively high rate of adoption (~27%), as much as the one generated by mid-sized companies. The low IoT's adoption rate compared to other technologies 4.0 can be justified by the late timing of adoption; for instance, laser cutting and robotics were embraced already in 2008, while there is clear evidence of the Internet of Things and 3D printing machines only from 2014 when its adoption rate is exploded.

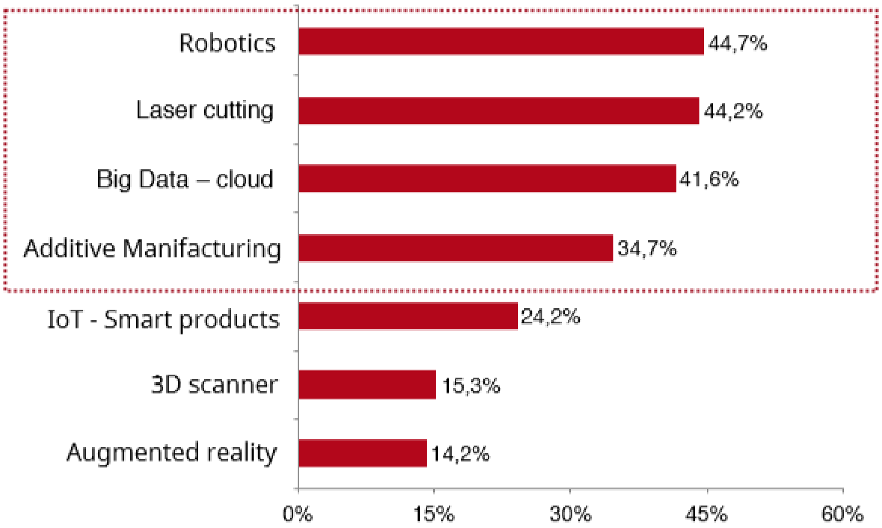

Figure 23 – Technologies adopted by Respondents (Source: DML, 2017)

As shown by the figure below (Fig. 25), companies belonging to three sectors — illumination, electronic appliances, and textile — have highlighted the IoT's adoption rates above the average, ranging from 40 to 50%. Follows the eyewear industry, with a penetration rate of around 25%. It is to be noted that in the sport industry, the reference technologies were not applied by any one of the respondents.

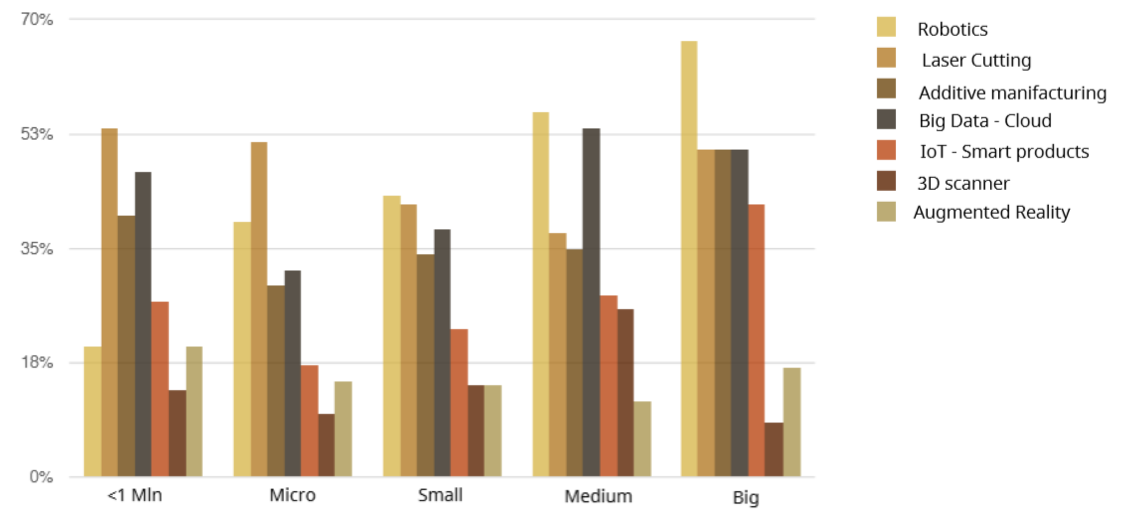

Figure 24 – Technologies adopted by Size (Source: DML, 2017)

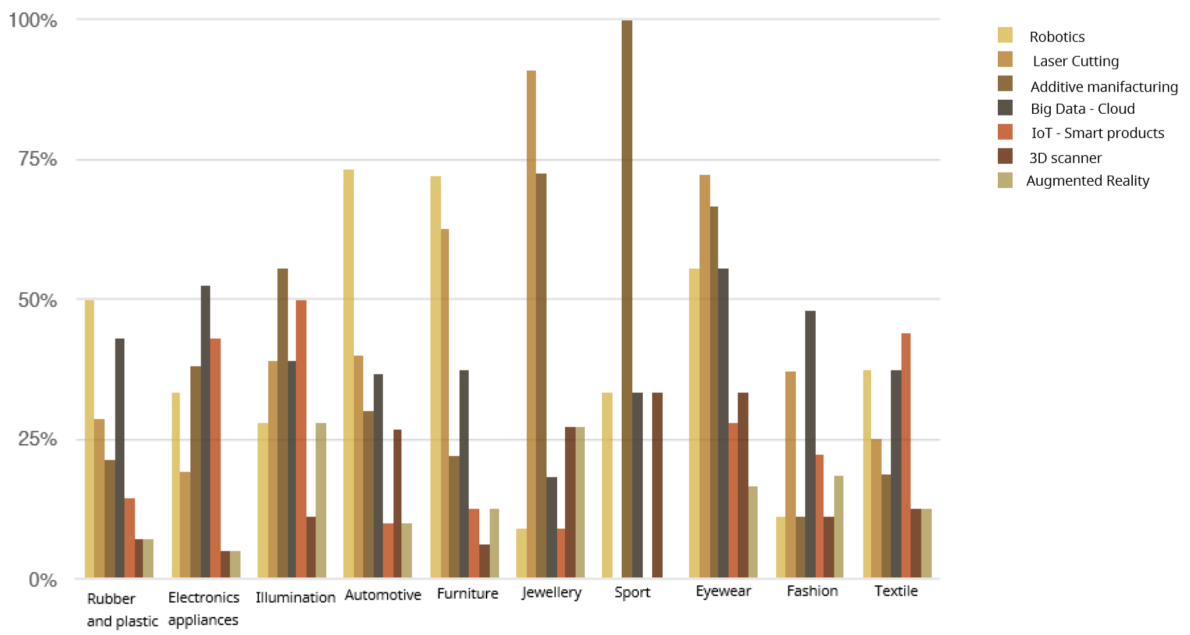

Figure 25- Technologies adopted by Sector (Source: DML, 2017)

The figure below (Fig. 26) portraits the scope of application of IoT: wide application is made in production and management processes, with respectively around 15% and 10% of respondents deploying IoT in those activities. Furthermore, collected data show an increasing deployment of IoT technologies used for the activities of prototyping and developing new products. The employment in after-sales services and marketing activities is very low, in fact, it is exploited by only 5% of adopters. Between 2017, year in which the study was carried out, and 2019 the taking of IoT technologies in Italian manufacturing companies has moved forward, due to its strategic role of digital enabler in almost all sectors: in fact, along with the Artificial Intelligence, the Internet of Things is the most promising technology of Industry 4.0 (Anitec – Assinform, 2018; Istat, 2018).

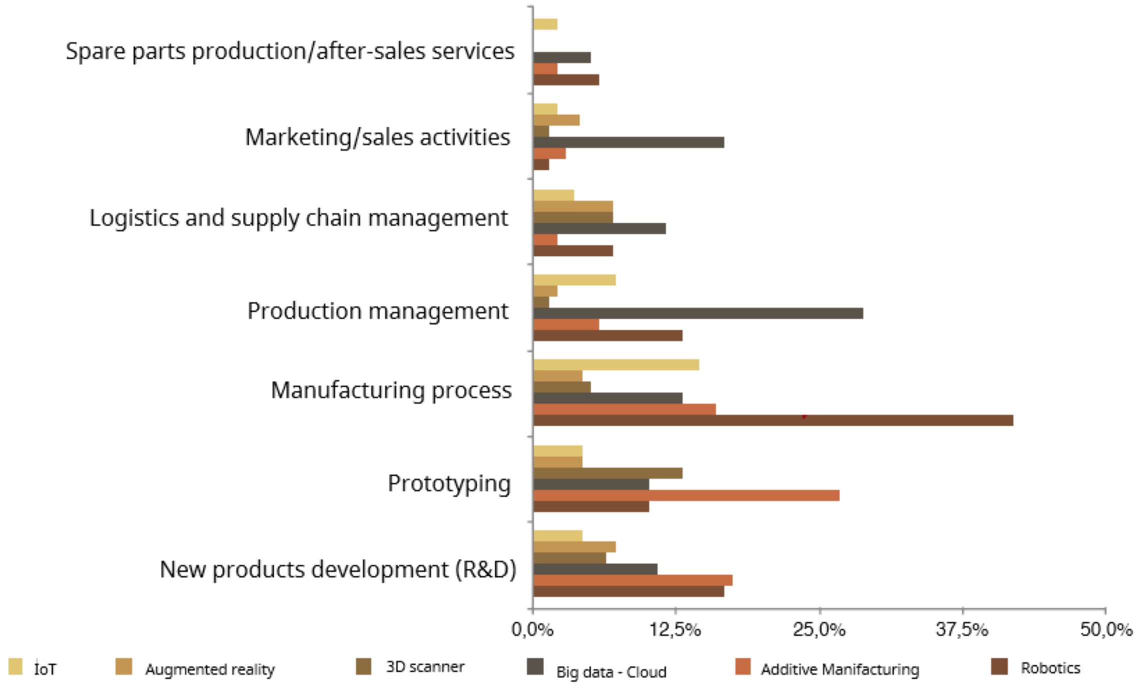

Figure 26 – Scope of application of Technologies of Industry 4.0 (Source: DML, 2017)

Specifically, the first has a strategic role in the IoT market, opening up new opportunities to enhance the data collected with the aim of anticipating the needs of companies and consumers. According to a recent study conducted by the *Internet of Things Observatory* of the School of Management of the Politecnico di Milano, compared to 2017, there is an increase in the IoT market of 35%, equal to 5 billion euros invested by Italian companies in 2018 and it is expected to keep growing, mainly in the Smart Metering[42], Smart Car, Smart Home and Industrial IoT segments (Salvadori, 2019). The study points out the growth is being driven by the services enabled by the connected objects (36% of the market), for an amount equal to 1.8 billion euros and an increase of 44% compared to the previous year, but the IoT solutions offer is very dynamic and in continuous development. Either way, the path towards the appropriation of the Internet of Things is only at the beginning and in this regard are quoted the words of Giovanni Miragliotta, Scientific Responsible of the Internet of Things Observatory in Milan, who portrays the current situation in the field of the Industrial IoT[43]:

"The Industrial Internet of Things in Italy is growing, but the path is still in its infancy. More work needs to be done on small businesses, which need to find the right key to understanding

[42] The term "Smart Metering" means the systems that allow the remote reading and remote management of electricity, gas and water meters.
Source: https://www.arera.it/it/operatori/smartmetering.htm
[43] The term Industrial IoT refers exclusively to the application of the Internet of Things in the industry system. While IoT allows company to make machines intelligent, the I-IoT allows to connect them each other and develop data for optimizing processes and the company as a whole.
Source: https://www.internet4things.it/tag/industrial-iot/

I-IoT solutions. Companies still need to understand how to best analyse the data collected and be able to build value-added services on them, even if some interesting projects are emerging".

4.4 DOES THE APPLICATION OF IOT GENERATE INNOVATIVE PRODUCTS? EVIDENCE FROM ITALIAN MANUFACTURING FIRMS

Once the manufacturing context has been clarified, the work presents five case studies of Italian Manufacturing firms that have embraced the new technological paradigm and more specifically, have invested in the Internet of Things. The research on the influence exerted by these technologies over the process of product innovation is still scarce, mainly due to the fact it is a recent event and that the studies made tend to focus on the innovation of processes rather than on the one of products, due to the trend of manufacturing firms of investing first on this kind of innovation rather than on the product's one. This part aim at delve into the two coexisting contrasts of the IoT: the first emerged from the Digital Manufacturing Lab study, namely that the Internet of Things is among the technologies least used in the manufacturing 4.0 context; the latter is that this clashes with the forecasts that make the IoT the most promising technology of Industry 4.0. Everything within the framework of the new competitive environment which calls urgently for continual innovation. For these reasons, it was of the greatest interest deepening the motivations that foster its adoption, the influence it exercises on the product innovation process and on the product itself, finally, the impacts and results of such decision for the adopting firms.

4.4.1 METHODOLOGY

The selection of the sample at the focus of this work was primarily based on the list of the respondents to the questionnaire structured by the Digital Manufacturing Lab of the Department of Economics and Management of the University of Padua. Of the 1020 reference companies that responded, 18.6% adopted at least one Industry 4.0 technology; among them only the 24,2% states to have invested in the Internet of Things, equal to 47 companies. The benchmarked sample is made up of those selected companies that declared to deploy the Internet of Things in their innovation processes. It must be recalled that the enterprises analysed by the Digital Manufacturing Lab operate in the north of Italy, more precisely in Piedmont, Lombardy, Veneto, Friuli Venezia Giulia, Trentino Alto Adige, Emilia-Romagna. This is relevant because companies located in North Italy have a major relevance on Italian Gross Domestic Product (GDP) and on the national competitiveness in the international markets (Bettiol, et al., 2019).

For the purpose of this work, twenty companies from the list have been contacted. In addition to these, the study has been expanded to six more enterprises identified based on recommendations or information found on academic papers. Among the 26 selected, to three have been proposed a physical interview, while the remaining firms have been selected for setting a telephone interview or, alternatively, to fill online the questionnaire (see Appendix for the questions), which constitutes the starting point for every type of interview. The results come from: three telephone interviews, one face to face in-depth interview and two open questions questionnaires submitted via email. Accordingly, the sample analysed is represented by seven companies, ranging from micro-sized (less than 2 million euros) to large-sized (more than 50 Million euros) manufacturing firms operating in Veneto, Piedmont, and Lombardy.

The case studies make an in-depth description of five of the seven companies that constitute the reference sample, while in the part reserved for the cross-analysis of all the cases (see "Discussion"), also the two other companies will be included. This choice is due to the scarcity of information found on the latter, but which is nevertheless relevant in a context of holistic analysis.

The approach adopted is a multiple case study based on qualitative data analysis. The choice was made because pursuing a qualitative analysis, instead of a quantitative one, allows an exhausting exploration and understanding of complex issues and can be considered a robust research method particularly when a holistic, in-depth investigation is required (Zainal, 2007). In this manner is easier to understand the motivations that pushed the selected companies to adopt the Internet of Things and the related consequences. On the other hand, a multiple case study contributes to better understand a contemporary phenomenon within its real-life context and in which multiple sources of evidence are used (Yin 1984). Further, Yin (2003) explains that when the researcher chooses to do a multiple case study he is able to analyse the data within each situation and also across different situations, in a way that is able to understand the similarities and differences between the cases. Additionally, according to Baxter & Jack (2008), the evidence that is generated from a multiple case study is strong and reliable. The qualitative data have been gathered through structured interviews made between September and November 2019 with entrepreneurs and managers in charge of manufacturing and technological processes of firms adopting the Internet of Things in their product offering. As secondary sources, in addition to the primary data gained through interviews, were consulted companies' websites or articles for triangulation purposes. Taking as reference point the firms under analysis, characterized by a range of innovative products, the aim of this work is understanding if the integration of the Internet of Things within physical products it is the catalyst of the product innovation. The overarching objective is to observe if and how the IoT impacted the way these companies perform innovation. Then, are analysed the hurdles firms had to overcome in order to embrace the new technologies and the course change that the connected product triggered within and outside the business. It must be considered that there are some limits in the analysis performed, first due to the limited size of the reference sample and second because of the limits linked to the lack of information completeness about those companies with which it was not possible to establish a direct contact. Consequently, the results obtained cannot be considered as representative of the whole universe of companies adopting IoT technologies in their path towards innovation.

4.4.2 PORTRAIT OF THE CASE STUDIES

Before proceeding with an in-depth analysis of the companies interviewed, the section introduces a portrait of their basic characteristics which help us to better identify them within the reference context. The following table outlines the company operation field, the region in which the companies are headquartered, their size (based on turnover) and age.

Table 2 – Basic Characteristics of Respondents

Firm	Present in the DML sample	Sector	Region	Size[44]				Age		
				Micro	Small	Medium	Big	Before 1990	1990-2000	After 2000
ELITE	No	Sport	Veneto			X		X		
AQAMAI (by Hydor)	Yes, but just for a qualitative part	Electronics	Veneto		X					X[45]
ENERGIA-EUROPA	Yes	Industrial Equipment	Veneto		X				X	
AP2	Yes	Industrial Equipment	Veneto		X				X	
ZAMASPORT	Yes	Textile	Piedmont				X	X		
ELESI LUCE*	Yes	Illumination	Veneto	X					X	
ARKESYS*	Yes	Illumination	Lombardy	X						X

The firms constitute a heterogeneous sample of the Italian manufacturing industry, both for age and size. Only one firm is young, founded at the end of 2016, while are being present two

[44] Micro: up to 2€ *M*, Small: 2-10€ *M*, Medium: 10-50€ *M*, Large: more than 50€ *M*..
[45] The Line Aqamai was launched at the end of 2016, but the company *Hydor* was established in 1984. [45]
* Due to the scarcity of information gathered, the results obtained from the cases of Elesi Luce and Arkesys will be covered in the paragraph "Discussion".

companies active since way before the 90s. Most of them belong to the group of SMEs, but there is also an exception in opposite directions, in fact, are represented also micro and big-sized firms. In the same way, the company operation fields widely range. Indeed, companies belong to five different sectors: electronics, illumination, industrial equipment, sport, textile and fashion.

ELITE Srl

Overview

Elite Srl is an Italian company leader in the design and production of training rollers, water bottles and bottle cages for the cycling and sport industry. It was founded in 1979 by Amerigo Sartore who since the beginning had the vision to open his company to the future, indeed, Elite tells a story of digital transformation. The step further toward this direction occurred at the beginning of the new millennium when by embodying Bluetooth and ANT+ technologies into mechanical trainers for indoor training, Elite launched in the market the first training roller for bikes that could be connected to a PC and communicate with the firm's software. This revolutionized the world of indoor cycling training, until then, a boring activity for the professional cycler. Thanks to specific algorithms the new electronic trainers allowed the user to train in an entertaining and professional way, by giving him the possibility to customize his training and obtain high performance in terms of simulation of the outdoors training conditions. By default, thereafter all the trainers were equipped with an Internet connection. However, the product range of the Paduan company does not stop at rollers, in fact, as mentioned above, it includes water bottles, bottle cages, articles for the conveyance and repairing of bikes and massage creams. Another distinguishing element of the firm's products is the high design that recalls the automotive industry, with linear and minimal shapes.

Market Positioning

Due to the professional nature of its customers, Elite has expanded massively its presence worldwide. It exports in over 70 countries: the main market is Europe with a share of 65%, while the market of North and South America counts for 15% of the sales. The remaining share of Elite's export is covered by the remaining markets, such as Australia and Asia, with a special focus on Japan. The company generates an overall annual turnover of about 37-38 million, scoring +5% compared to 2017.

Figure 27 – "Drivo II", the Most Interactive Roller Worldwide (Source: Elite website)

Nowadays the international competition for the professional cycling market is increasingly pushing the demand towards highly technological features and performance of the product. In this sector customers take for granted the presence of technology within the products, especially of the IoT; if the company is not able to offer this kind of value, or even better, anticipate customers' needs, they easily switch to the product of another competitor. Moreover, another hurdle is the occurring of numerous mergers and acquisitions the company is facing. As a matter of fact, some big groups of companies are incorporating the firm's competitors, thus growing in size and power, raising furtherly the competitive bar and destabilizing a market that is already facing a highly competitive pressure.

Product Offer: The Path of Innovation

Since the beginning of its activity, research, technological innovation, and team-working were the basis on which Elite built its modus operandi and mission as well, characterized by continuous innovative tension and a strong synergy of teamwork. As a matter of fact, the key factor of Elite's competitive advantage is its approach to research and innovation, whose components are creativity and discipline. After the above-mentioned software-embedded roller, in 2003 Elite has continued the path to digitization by introducing into the roller the possibility of watching videos of the most famous races in the world taken directly from the road. This product was connected with the company's software that was taking into account the recent usage data for offering customized training and increasing incredibly the added value of the product. In 2007 the company revolutionize again the market, launching a new indoor trainer with a slope until 20%. The innovative boost did not slow down not even with the occurring of the huge economic distress caused by the financial crisis. The company, in 2014, introduced in the market a new generation of bike trainers that get rid of the real bike wheel and increased the interactiveness of the device, by providing different software that adapts to different types of training. The launch of new products even during the ten years of crisis was possible for Elite because of its policy of always re-investing its profit within and for the company itself. Indeed, it has been always characterized for being a “healthy” reality and this allowed it to take the risk of entering the market with new products for which at that time there was no demand, exploiting advantages and returns years later. During the crisis also the fact to be international has favoured the business success; indeed, Giulio Bertolo, Ceo of Elite, sustains that *being in contact with the rest of the world, and particularly with the most creative areas from a technological point of view, helped the company to react in time and sometimes even to be a precursor.* Following the logic of continuous innovation, the last new smart indoor training bike of Elite, shown at Salone del Mobile 2019 and which will be launched soon, represents a new gamble for the company. “Fuoripista” overturns the bike notion relative to competitors, proposing a bike that matches design materials, like wood and glass, with the cutting-edge technology distinguishing Elite. It is designed for indoor trainers and not professionals and, albeit is an art piece for the house, maintains the same performance of a profile bike. The objective of Elite is that of differentiating itself from competitors by offering this kind of product for a higher price compared to the traditional offer but producing less quantity of samples.

Figure 28 – “Fuoripista” (Source: Bicitech.it)

The rollers range is divided into classic, smart and interactive that is the top of the line. The smart and interactive ones are embedded by default sensors - in this sense they have “sensorless” technology ie do not require to apply additional external sensors to the bike - while the classic ones do not have embedded sensors but the user has the possibility to buy and add them separately. The smart rollers sensors, like Misuro B+, immediately transmit the data of power, speed, and cadence of 79qamai79ri to compatible apps (Elite offers the software My E-Training), peripherals (smartphones or tablets), or computers, allowing the roller to configure itself, to build a precise and stimulating training plan and to replicate pedaling as much as possible similar to the one on the road. Data transmission is wireless and exploits ANT + communication protocol and Bluetooth Smart. The interactive rollers, like Drivo II, embed a power meter sensor, OTS (Optical Torque Sensor), that makes it the most accurate home trainer on the market (accuracy of +/- 0.5%). These rollers are more reactive to external stimuli and take advantage of virtual reality technology. So, for example, the user can project in a screen a real concrete landscape and cycling living the real physical and optical conditions. Here as well the ANT + FE-C & Bluetooth interactive bike rollers interact with apps, software, computers and peripherals of all kinds with IOS, Android, MacOS and Windows. Moreover, Elite makes its products compatible also with other software and platforms for indoor cycling, like Zwift. The company manages the data received both onsite and, on the cloud, where are aggregated and processed to get meaningful insights. They also enable Elite to perform remote assistance and warn users of possible system failures or device misuses. For instance, especially in the past, if it emerged from the data collected that users cannot use the system because of the memory card full, they received a tip message on the app with the instructions to solve the problem. Nowadays the capacity problem does not occur anymore because all the data storage is done in the Cloud, therefore also remote assistance for this kind of problem is less needed. Before this transition, with the growing heaviness of software, it has been crucial and challenging for Elite equip itself of the instruments for assisting customers, who at that time were not technology-wise, to break the digital barrier. The logic behind the creation of such services is to assist the customer in the maximisation of the product's functionalities by simplifying their use.

Industry 4.0

From the start Elite has seized the importance of embedding strong digital components into products, thus, with the technological products that are the 70% of the firm's turnover compared to the 10% of four years ago, now more than ever it believes that integrating the new technologies, independently of Industry 4.0, is the only way to keep being strongly competitive. Therefore, the adoption of Industry 4.0 has been a logical and inevitable step due to the necessity to have a complete tracking of products for satisfying the need for continuous software updates and an overall detailed knowledge of the product technical datasheet. For managing the huge amount of data generated by the devices, Elite invested in a database that allows the company to identify exactly what the end customer owns and how he is using it. The possibility to track products allows the firm to satisfy the high levels of precision and performance that are required for safeguarding the intrinsic features of each individual product, characterized by increasing complexity and technological barriers. However, customers in this sector do not look just for high technological performance but are increasingly asking for customization also outside the product: for this reason, Elite embraced the new paradigm, ie to satisfy also the demand for customized products, essential in the cycling market. Most of the customers buy the products because of the open software that allows them to use it synergistically with the apps on the market. This triggers the need for supplying products combined with services that assist customers during their use. For this reason, most of the data gathered is useful for performing real-time maintenance and on an ongoing basis. Data is also used to get suggestions for new products development and to know the user's product usage: for instance, a product has been created with some features, but from the usage, Elite realizes that just three out of five functionalitites are effectively used by the users, and so that it is necessary to review these features. In doing so, the company was also able to cut some huge costs linked to aggregate functionalities within the product that in reality were not used by customers. Data allows also to know if the roller is used by the company's program or by third party, enabling the firm to understand their lacks as well as customers' needs and desires. For all these reasons, Elite values as the main benefit of Industry 4.0 the data gathered.

Within the business the whole testing and calibration of the interactive training rollers are processed in 4.0, while for what concerns the water bottles Elite invested in a digital machine that can make few pieces and quickly, allowing to extremely customize products in a way that one differs from the other and so respecting the different needs of each cycler. The machines, both for rollers and in the near future even for water bottles, communicate directly with the management software where are saved all the data of each product, basically its identity card. In particular, the last investment of Elite is a digital machine that will dialogue not only with the management software but also with the internal network, so enabling the graphic designer to communicate directly with the machine.

Incentives

For what concerns the investment made, Elite has leveraged the Industry 4.0 incentives, like the tax credit for R&D and the patent box, but it would have invested regardless of the economic facilitations provided by the Plan. Indeed, the company's strategy was implemented independently of an economic return because the innovation process is something consolidated within it. Nonetheless, the incentives allowed Elite to save money to invest in the development of new products, in the sense that instead of creating one product they have been able to develop two and this has made them more competitive. Today the ability to launch new products timely on the market is a key factor in the actual competitive environment of the cycling industry. The customer always expects something technologically new and advanced and Elite believes that if you are able to anticipate the customer's desire by offering technological solutions first, you also have the advantage of entering the market with a different force and nowadays becomes crucial to be the first mover. The company suffered the effects of digitalization especially in terms of the product life cycle: while once a product lasted six years, today digitalization has increasingly shortened the product's life. The market asks for new products each year and even if the one launched the year before is a good product, it is necessary to change it and upgrade it on a yearly basis. Elite highlighted that the integration of the firmware updates, that improve performance based on the data gathered, pushed customers to claim for software updates even before he has bought the last version of the product. The embedding the Internet of Things enabled Elite to modify products during their life; these have increasingly assumed a chameleonic nature able to transform and innovate itself continuously on the basis of their cumulative knowledge. The firm is aware that the product launched in the market today will not be the 100% final product: the one launched is sufficiently innovative but the company knows that there will be added upgrades during life. It is an ongoing process that requires an incremental development.

R&D and Internal Organization

At the core of the innovative activity, Elite places the research: annually, it invests in research and development of innovative products from 5% to 8% of its turnover, an amount largely superior to the national average of 1,1% of the SMEs[46]. The efforts and investments made in research and development have turned into numerous achievements: in 2016 Elite has been awarded of a prestigious certification that declared its indoor digital roller as the most accurate trainer in the world; further, after three years of experimental research, Elite launched the lightest water bottle in the world, a product at the cutting edge of technology, weight and performance. The thickness of the bottle is manageable, allowing the Research and Development team to create a practical structure with variable thicknesses. The quantity of material was reduced by maintaining a higher thickness at the base of the bottle and at the height of the cap (giving rigidity to the bottle) compared to the thickness that extends along the body of the bottle, which is much thinner. FLY 550 weighs only 54g, -40% of a traditional cycling bottle of 550ml, without putting a strain on cost and granting at the same time a competitive price for the end-user.

[46] https://www.corrierecomunicazioni.it/digital-economy/ict-investimenti-al-palo-meno-di-un-impresa-su-4-va-oltre-l-1-dei-ricavi/

Figure 29 -FLY 550, the lightest water bottle in the world (Source: Elite website)

The endowment of an already strong technical apparatus made up of mechanical, electronic and IT engineers, was crucial to gradually arrive at Industria 4.0. The digitization strongly impacted the size and strategic relevance of technical offices as well as has demanded for a widening of the quality department, making necessary a deep change in the internal set-up as well as increase the need of key technical resources. The section dedicated to the assistance area has been expanded as well because vital to offer the proper service to customers. The product's complexity and digitalization, as well as customers more and more expert and demanding, have pushed Elite to train highly specialized professionals, able to deeply understand the product's technical data sheets and uses: the trade manager is therefore evolved from a seller into a marketing manager. Nowadays the company struggles not so much in selling the product but in finding the right way to exhaustively explain its features and capabilities. Thus, the marketing manager has the role to instruct other sellers about everything related to the products; the attention shifted on giving to customers the right information at the right time in all the channels rather than catching the order. In fact, the company focused on its communication, especially online, where most of the existing consumers gather the needed company's information: *"today an order can, so to speak, autogenerate itself, for example by creating the right interest online, he is the user himself who comes to ask for it to the company and the whole chain must be ready to give the right information to all channels"*, claims Nicoletta Sartore, Coo of Elite. However, in Elite there is the awareness that, if in the short period promotion and marketing win, it is innovation that allows the achievement of long-term competitive advantage.

Continuous Workforce Training

For what concerns the workforce, Elite greatly invests in people and skills. In fact, continuous training courses are made in order to update their competencies and fill existing gaps. First of all, it funds all the employees of English language courses held by mother-tongue teachers, so that everyone within the company is able to efficiently communicate and interact with the international clientele. Moreover, there has been a course of project management, one on CAD design with CATIA software, as well as quality courses. Recently the firm started a project on the lean transformation that seems to be the next step towards a new level of internal efficiency and flexibility, even if its structures are already quite lean and allows fast decision-making. The training course about lean transformation has already involved customer care, will move on to production and finally to planning.

External Network

Because Elite does not assemble anything in-house but turn to third parties which work exclusively, or almost, for them, it had to impose its high qualitative and technological standards also to its suppliers. It follows that Elite calls strongly the digital transformation also of its partners. Since they are linked by a strong network of relationships, often the company itself has trained and increased the levels of skills of these companies in order to obtain adequate levels of service; happened also it furnished some with the necessary equipment so that the supplier could produce what Elite needed and thus maintain the business relationship. Furthermore, the need to connect Elite's machines sited in the suppliers establishments with the proprietary server, claimed for an upgrade to a proper internet connection able to safely transmit the data generated and respect the characteristics of their IT structures. The search for the right supply network is an ongoing process for Elite, although it tries to maintain historical and national relationships. In fact, the nature of the components of their products and the need for specific raw materials has also led them to turn to foreign suppliers, but once found them also in Italy, and on the strength of their experience abroad, they also had the opportunity to educate the Italians to do the same. For instance, two years ago it succeeded in moving the production of carbon fiber, used for the bottle cages, from China to Italy increasing costs only slightly. Currently, 90% of the production is made in Italy, with the exception of a Croatian factory that produces the water bottles.

Universities and Research Centers

For what concerns other types of external relationships, Elite is open to entertain partnerships with universities and research centers, in particular with Roma Tre University and Centro Galileo, from whose collaboration interesting projects were born. Notably, the company has developed an important algorithm with a prestigious German university and has forged a fruitful collaboration with a German scientist for the development of an efficient power meter. According to Elite, these relationships have ambivalent nature, in the sense that sometimes they revealed themselves for being strategic, others a waste of time. Following this viewpoint Elite aligns its opinion about the Competence Center, namely that it endorses the potential benefits it may trigger but is skeptical about the result's substance of this kind of project. It underlined that in the past some partnerships with universities have proved to be unhappy because of the collusion of times and purposes of the two different realities. Indeed, Elite believes that a similar initiative could benefit the company on condition that the universities guarantee concrete performance and times aligned with the ones of a business reality.

AQAMAI by HYDOR Srl

Overview

Hydor is an Italian company operating for over 35 years in the production of aquariums components, that is all the parts that must be installed in an aquarium. The company's product offer ranges from pumps to heaters, to systems for dosing food of fish, rather than external filters, skimmers (which act as a filter) and pumps for ascents, at the exception of the production of the glass fish tanks. Launched in between the 2016 and 2017, Aqamai – whose meaning comes from a Hawaiian word that means "intelligent, up-to-date and at the forefront" – is the brand-new tip line of aquarium products from Hydor, which represents the new path taken by the firm towards new technologies and digitalization. The new product range currently is including wireless LED lighting and circulation pumps both for small and big fish tanks, however, the company has the goal to expand its offer in the future. Despite Hydor, and so Aqamai, researches, designs and produces entirely in Italy, its reference markets are the American – the main importer of fishes worldwide – and the German one, with a small share of sales in Italy, generating an annual overall turnover of about 5 million euros.

Market Positioning

Hydor has been the main player in the traditional aquarium sector for the last 10 years. However, during these years, the competition within the sector increased mainly as result of the presence of established field players but also electronics giants, like Phillips that has applied its know-how in LED lighting in the aquarium industry, launching in the market CoralCare Led Aquarium Light, an innovative LED lighting designed to achieve an optimal balance between coral growth and natural reef appearance[47]. Further, once the critical period of the crisis is over,

[47] Source: https://www.lighting.philips.co.uk/consumer/coralcare

consumers restarted to invest in this field, making grow the animals' market and the one its accessories and this has furtherly attracted new players in the competitive field. In Italy, this market is worth more than 2 billion euros and in 2018 it was up 1.5% compared to 2017[48]. However, the main threats come from foreign markets, especially the American one, where Hydor holds the highest percentage of sales and where this sector is more developed. It is precisely for this reason that the company has set up a place of business in Sacramento (USA), which is the point of commercial reference in the United States for Hydor's brands and from whose suggestions and ideas Aqamai creates its products.

Product Offer

For maintaining its leading position Hydor, already with a strong technical background, decided to embrace the emerging approach on the market, namely new advanced technologies and high design features. Aqamai focuses on the production of pumps and LED lights, labelled as *Internet of Tanks*, which are embedded with Wi-fi connectivity, that works direct point to point and allows the user to manage the smart aquarium directly from his smartphone and tablet (iOS and Android). All the products communicate through the app, that exploits the connection to the home network and whose control is based on Cloud, so it is possible for the user to use one account on multiple devices. In case of blockage of a motion pump, that is vital for the aquarium's life, the app sends the user a notification on the phone that warns him of the malfunction. The same happens with the lamps, even if their stop is less critical than the one of pumps. In the field of aquariology, these issues have a great relevance, because of the high costs associated with this kind of events; just think that a marine aquarium can range from 2000 to 3000 euros of fishes and corals and that in 3-4 hours all the life within it can die if the pump which stopped to work is not timely repaired. Consequently, it is crucial for the company offering a product highly reliable that allows the customer to always be connected and monitor the conditions on which rely his fish tank. Connected pumps and lighting optimize the maintaining of the fishtank hygiene, but also improve the way of living of the fishes, granting the right water oxygenation against attacks by parasites and bacteria. Beside cutting-edge technology, the second key factor of Aqamai is the design it proposes: as a matter of fact, the aquariology sector greatly evaluates the degree of aesthetics of the aquarium's environment. Hand in hand with the development of devices' smart capabilities, the customers have thus increased also the attention and research of aesthetic features that reflect the technological soul of the objects. After long researches, Aqamai, applying cooling technology to the LED ceiling

[48] Source: https://www.repubblica.it/economia/rapporti/osserva-italia/stili-di-vita/2019/05/06/news/cibi_e_accessori_per_animali_un_mercato_che_cresce-225604564/

lamp, both for salt and freshwater, was able to minimise the thickness of the object. The result obtained has been a minimal and linear lamp with Power LEDs of 8 different colours, that the electronic board manages through 6 control channels. The pumps as well were designed following a minimalistic approach, in fact, they are the smallest in their category. Both the products' functions are totally manageable from the app, without the need to add further external components.

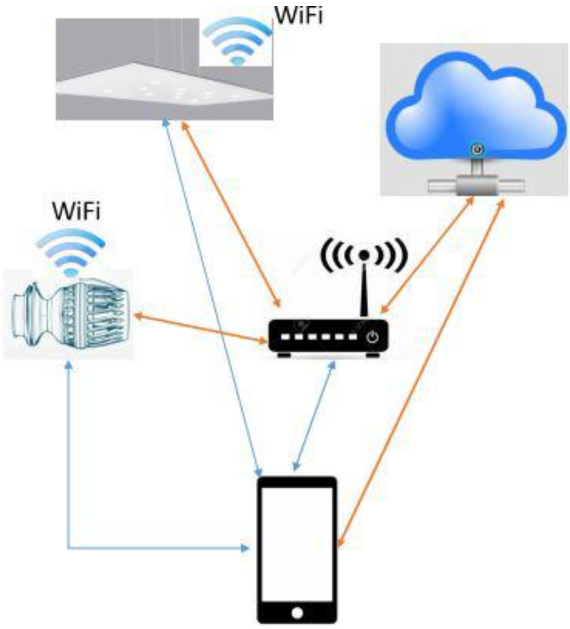

Figure 30 – Aqamai's Monitoring System (Source: acquariomania.net)

Under the product's viewpoint, Industria 4.0, and thus the application of the IoT technologies within pumps and lighting, inevitably reverted the whole nature of the traditional Hydor's offer. First of all, through the mean of the app Aqamai, the new product's functionalities opened a direct channel between Aqamai and its customers, or better, users. Indeed, once they download the app, the company obtains direct access to statistical data about the users, which directly flow in the Cloud. The company does not use proprietary servers but exploits those from Amazon, which provide security and reliability. Once they have access to data of all the users of the app, like what and how many products they have, how do they use them, etc., they can aggregate them and make statistics for example on the sex and age of people, rather than on what kind devices they have, for instance, the firm has 50% of its users who use iPhone, while the other 50% Android. Aqamai believes that deep customers' knowledge is exactly the purpose of the IoT. As confirmation of what just said, on the customer's side the IoT becomes mean for offering a better service through the smartphone, but Aqamai adds that for the companies it is more a way to deeply know its customers. From the aggregate data, Aqamai gets insights over the state-of-art of its products, technical issues and possible future improvements, rather than business information over the broadening of targets or new markets to develop. For example, with a product not-IoT was impossible knowing why customers were not buying a lamp. Indeed, the company relied on a chain of word of mouth that started from the customer, moved on to the shopkeeper, who reported his idea of why customers didn't like the lamp to the sellers, and finally to the company. In all this process the information was losing value because filtered by personal opinions. Today with the app the firm is able to have an overview of its clients and from the statistics get they do not use the red light, but the blue one, so in the next version of the lamp it will substitute the red light with a blue one and this constitutes an advantage because enables the company to capture real-time needs and preferences of its customers. Another advantage obtained from the IoT embedding is the access for the user of a wide range of personalization options that allows him to adapt the action within the tank of both, pumps and lights. Every aspect of the daily programming settings can be controlled and personalized on the base of the user's requirements, from the movement of the waves to the colours of the LEDs. Moreover, the device offers the additional service to automatically on the company's servers the sets that a person creates himself. Hydor designed Aqamai for being suitable for different customer needs. Moving away from its traditional offer, which has only one socket and therefore can only be switched on or off, Aqamai despite being a young reality, obtained results that have place Hydor a step ahead of competitors. Therefore, the Aqamai brand changed the customer target Hydor looks at. Indeed, the *Internet of Tanks* attracted a type of customer Hydor never had: entering the IoT world has challenged the firm to face customers who expect the news every year and require ongoing novelty, which may be a graphical update or adding functionality in the App. So, Hydor had to adapt also the product's life cycle itself to the new market requirements that ask for new products on a yearly basis, independently of their kind. Traditionally, the customer bought a product whose operation was established, and he kept it until the end of the product's life, while today the spare part is also dictated by the design or by a new functionality of the app that commands it. The possibility to update the software and offering new features move the customers' attention to look for the novelty regardless of the product's functionality. For instance, the new clients of Aqamai buy the new lamp that has just come out, but the following year when a new one comes out, they sell the old one and replace it even if the changes have been minimal.

Service Offer

Despite the service logic of Aqamai's offer, the company currently does not seem to move forward to monetization of these services, in other words adopting a pay-per-use business model. The services offered by the app, namely the remote notifications on pumps or lighting's fails and the option to save the sets above mentioned, are free and it is likely it will remain like this. In the development phase of the new brand, the firm thought to offer some payment services, ie it wanted to do the Aqamai environment by making pre-sets available, for example with the light as it is in Indonesia or as it is in the coral reef in Australia, or with the movement of the waves in certain areas of the world, to then sell this service. This project, however, was not carried out because priority was given to services that went to supplement the products, which are more supportive than a source of income. It must also be noticed that the average customer of Aqamai is a professional aquarist who prefers to build on his own the aquarium's environment and would not pay for a ready-to-use set. Currently, the company can enter the system but is not able to perform remote fixing of the bugs. The next months' implementation projects are indeed the update of the application by creating services also for retailers or at least for those who do maintenance. The scope is to let them have access to the customer's device and maybe do the daily sets or at least remotely perform product maintenance.

Industria 4.0

The motivations that fostered the adoption of Industria 4.0 are both external and internal. On one hand, the global trend in the use of technologies such as smartphones or automated systems has inevitably led the company to analyse and investigate what could have been an application of these technologies in its products, in other words, the development of the Aqamai line has been market-driven. On the other hand, given the willingness to start designing smart products, first Hydor had to speed-up the development and production process. Currently, in the design office, the firm has two 3D printers with two different technologies. For the development and design of the Aqamai's electronic parts are used Industry 4.0's websites for makers. The employment of these machines for designing the new products is completely different from the design method used for developing the traditional Hydor's products, that are not IoT. With the 3D printing machines the company has been able to decrease notably the development times: for instance, the creation of a new pump presupposed to build special molds, that required three months only to have the pump's mold. Today, 3D print fosters incredibly this process, by reducing this period to 15 days, in fact, the machines enable the creation of a functioning product ready to be tested in a real environment, namely in the aquarium. In such a way the business not only saves time but also gains in terms of cost advantages because it can do the prototypes in-house, without depending on external third parties, thus eliminating the costs for the realisation of external prototypes. Furthermore, Aqamai experienced a reduction of the product's development cycle, enhancing at the same time the creativity part of the process. The classic mold, once built, offers just a single solution without giving the possibility to change the features on the way; instead, realizing it internally, if changes in terms of product's geometry or dimension occur, the designer can see them in real-time and reprint the piece with the new modifications. In this way, the company speeds up the tests. The design process has increased in freedom in the sense that now if there is an idea, it is possible to print the prototype and if is necessary to make some changes, it is reprinted with the necessary modifications: as result, the creative process within the company is stimulated and encouraged. For what concerns the product development, since the company is still at the beginning of its path towards the digitization of its offer, it is difficult to foresee which impact this will have on the traditional product life cycle.

Figure 31 – LRm: Led Ceiling Lamp and KPm: Motion Pump (Source: Aqamai website)

Innovation & Internal Reorganisation

The technical office works mainly to develop new products mainly on the base of the ideas, opinions, and requests of the sales managers established in USA, so the company basically produces in base of the American target. The investments in the Industria 4.0's machines were the successful completion of a vision already consolidated in the company that has always placed technological innovation in the first place. Accordingly, there was not a revolutionary change, but mostly an evolutionary passage towards the new manufacturing system. As matter of fact, the company has implemented over the years the management system, while the design systems are updated from year to year, so when was to the time of 3D printing or numerical control Hydor has only followed up the trends and tried to understand how to exploit them. During this process, the passage to Industria 4.0 has been fostered using government incentives. Accordingly, the internal organization has undergone a redeployment of the whole departments that had to adapt to the company's new strategy and kind of products. For instance, now the quality control is done by a verification of the parameters through the app, while before the quality test was performed directly to the pump, in such way Hydor was able to implement the whole line of verification. In order to treat the new electronics appropriately, the production department was extended in favour of a separate side with electrostatic mats dedicated exclusively to the research and development of new products.

Skills & Capabilities

On one hand, the company had the advantage to start the new project guided by people with solid technical knowledge: the brand Aqamai was born from the collaboration of the current Chief Technology Officer Mocellin with two ex-employees who were makers with the appropriate digital knowledge and skills to develop the Aqamai's products. Mr Mocellin himself, who currently oversees the projects Aqamai, claims that without such know-how the project Aqamai would not have been possible, or rather would have been very difficult creating something similar. For this reason, in the fast-paced technological environment, it is crucial to provide continuous internal training of the workforce. Mr Mocellin personally trains the customer care and the production manager on how the products work and change, he also updates who is in charge of the customer care in the United States. The development of Aqamai has, in fact, demanded a more skilled workforce in charge of the customer care service who helps and supports customers in the use of the pumps or lights, in any event, thus becoming a key factor for the company. The range of new products has given rise to a series of problems that did not exist before, linked to the functioning of the application, rather than the compatibility of the App with the user's phone and that requires someone who carefully and efficiently manages them.

External Relationships

The choice of external partners was made with the desire to keep the entire development process "made in Italy", as well as a result of the need to have a whole supply network as much as possible "at km 0". Except for few foreign suppliers, on which Aqamai relies only for targeted requirements or a specific component produced only by a specific supplier, the tendency it is to maintain Italian partners, specifically to involve local companies, with gains in terms of functionality, communication, and speed. Industria 4.0 has therefore entailed an integration of the historical relationships with new ones built with suppliers of high-level electronics that makes up the basis of the Aqamai products. Such a company policy is the result of past negative experiences that the company experienced at the beginning of the development of the new brand. Aqamai started to produce lamps in China by relying on a trading company. Due to communication issues, i.e. the difficulty in communicating such a complex technical product to an operator who spoke both Chinese and Italian, Hydor decided to move the lamps production back to Italy and this turned out to be a winning decision; it indeed found an electronics partner that also supports it in the design features of the product. Instead, for what concerns the development phase, Aqamai is highly engaged with the University of Bari even if it collaborates with other research centres. In this viewpoint, Aqamai sees as beneficial a potential relationship between companies and Competence Centers, as long as this is not hindered and slowed down by state bureaucracy. The company believes that often it is faster to develop new products by itself, without seeking help outside the organization, especially if the support offered is governmental.

ENERGIA EUROPA Spa

Overview

Energia-Europa is an Italian company specialized in the development and production of innovative systems for the energy efficiency of production sites, retail stores and office units. It started its activity in 1999 focusing on the production of voltage regulators for lighting, mainly industrial and public. Because a corporate crisis combined with the ageing of the products, in 2007 there was an ownership transfer, that led to the inclusion of three new board members and the release of the old ones. Along with the change of ownership, so did the company's strategy. In fact, the new ownership structure moved away from the energy saving in the lighting industry to invest in the transformation of the product in the field of innovative energy efficiency. Thanks to the particular will and contribution of one of the new shareholders, the company sought towards the intervention of an American company in the Energia Europa's capital. Therefore, in 2014 stepped in a fourth minority shareholder who bought 10 % of the shares whose proceeds reinvested in the company's share capital, financing de facto the development of the firm. This action allowed the company to make a big leap: so, Energia Europa became highly capitalized, i.e. with the necessary resources to keep growing and this has also enabled it to activate fruitful collaborations with Universities, like the one of Firenze, but also with other partners and do further research aimed at product development. In 2010 was released the flagship of its offer: The patented E-Power system, a smart-managed passive inductive filter that improves the electrical line's energy quality and efficiency in all kinds of applications, generating savings over electrical disturbances and granting equal output.

Market Positioning

In the efficiency energy market, Energia Europa is an ESCo (Energy Savings Company), ie a business that provides a wide range of solutions for energy savings projects, with the peculiarity of sharing the risk of the investment with the customer. Thus, on the basis of the business relationship between the company and its customers, there are risk-sharing contracts. The company's target customers are mainly large-scale retailers, both in Italy and Europe, and among its clients, Energia Europa includes significant companies, like IperCoop, Sma, Auchan, Bennet, Ikea, Metro, just to name a few. However, in recent years, it also started installing the E-Power systems in the industrial field and among its customers there are international giants of the European and global distribution, like Findus, Birra Peroni, Rovagnati, Fiat and Autogrill. Offering ESCo contracts, the firm serves also single customers that, for example, do not want to sustain alone such financial commitment but want to share the energy efficiency investment's risk. In this viewpoint, there are customers like Botecco and Cisalfa Sport, with which Energia Europa has set up an ESCo contract based on risk's sharing.

The reference market of the company is growing strongly worldwide, for instance, in Italy it has grown by 6,3% (between 2017 and 2018) with over 7 billion investments in 2018 (2.3 attributable to the industrial sector), three quarters of which for innovations that integrate technologies for energy efficiency and digital solutions in the most complex management system of the factory, exploiting the exceptional driving force of the Industry Plan 4.0[49]. As a matter of fact, despite the ongoing crisis, the company is growing, with sales increased by nearly 20% yearly, thanks to the greater general awareness in favour of energy conservation and environmental sustainability[50]. Furthermore, an increasing number of companies are enrolling Energy Managers who have the responsibility for reducing energy consumption and the environmental impact of their company's operations. In this context, the company has important plans as regards internationalization, also in non-European countries[51].

Figure 32 – The E-Power System (Source: Energia Europa website)

[49] Source: http://www.greenreport.it/news/energia/efficienza-energetica-in-italia-mercato-in-forte-crescita-63-ma-non-piu-a-doppia-cifra/

[50] The EU in 2009 enacted the 2020 climate & energy package a set of binding legislation to ensure the EU meets its climate and energy targets for the year 2020. The package sets three key targets: 20% cut in greenhouse gas emissions (from 1990 levels); 20% of EU energy from renewables; 20% improvement in energy efficiency. For cutting greenhouse gas emissions from large-scale facilities in the power and industry sectors, as well as the aviation sector, the EU launched its key tool, ie the EU emissions trading system (ETS). (Source: https://ec.europa.eu/clima/policies/strategies/2020_en)

[51]Case study: Energia Europa, carried out by ABB, leader in energy and automation technologies. (Source: https://library.e.abb.com/public/a5e8a629e5594664b1cb0c6405ee06b8/2CSC500027B0201-ENERGIA%20EUROPA%20ENG-Case%20note.pdf)

The Product: The E-Power System

The E-Power system is placed inside the electric cabins that can be of different sizes, from 50 A to 4000 A. The one of 4000 A, for instance, is 2.50 m high and 3.10 m long with a depth of almost 1m. The price ranges from 8000 euros to 200.000 euros. The machines are composed by three parts: an autotransformer which is the filter which generates the savings; from a control framework that makes the various stages of the transformer intervene, therefore it is the purely actuating part of the machine; and finally a communicative and analytical part. Inside there are network analyzers, namely instruments that read the electrical quantities both at the input and at the output of the machine, that generate data. Every two seconds the machines download a series of information regarding the electric current of the companies, the consumption, rather than the waveform, briefly, all the technical information regarding the electric current. Then, these are transferred to the controllers, which are tools that gather the data from the various network analyzers, through a modem and then this information is transmitted to a Cloud, where they are stored. In other words, it is like there are testers that read the electrical quantities and then send them to a microcomputer that stores and transmits them. Currently, the transmission of data does not exploit Wi-Fi but can take place in two ways: or via LAN, if the customer gives the company the access to its network, otherwise via modem with telephone card.

Both, the company and its customer, have access to the data scanned on the Cloud. In this case, the company disposes of an active software, ie that monitors the electronic system and directly communicates to customers information about their machines, so that they do not have to personally check the data, but it is the machine itself that quickly communicate it. Furtherly, the machines can deliver preset reports with technical, economic, and maintenance value, to the subjects the customer identifies through the E-Power software, that is the customer maps autonomously which information it wants to show, to who wants to show it and when showing it, for example, it can configure the machine to send the data every week, or month, rather than on pre-established periods. The benefits in terms of energy efficiency have been substantial for many Energia Europa's customers, also thanks to the great accuracy ensured by the energy savings measurements: for instance, through the integration of the data generated by the firm's machines in its computer system, a customer can realize that production sites with similar surface area are more energy-consuming than others. Through the data analysis, it could detect the source of the problem and intervene. The result is an essential improvement in energy efficiency: for instance, an important benefit, not easily quantifiable, but always reported by the firm's customers, particularly in the industrial sector, is the reduction of micro-failures, that in specific operations can lead to great economic losses[52]. From this, it results also that, as a consequence of the better energy quality, the life cycle of the electronic system is extended. It follows then a benefit in terms of energy savings, ie cost reduction. Indeed, the reduction of electricity consumption, conditions of work being equal, turns into an economic saving variable between 3% and 7% according to the type of scientifically measurable electrical system thanks to the patented Bypass system and the data retrieval and transmission ensured by the E-Controller device. However, the advantages offered by the installation of the E-Power devices do not have only efficiency nature, but also can be measured in terms of environmental sustainability, namely, every kWh saved is equivalent to 0.5 kg of lower CO_2 emissions in the atmosphere.

Recently, Energia Europa entered also in the residential sector. The achievement of this goal has required not only a miniaturization of the existing product but has involved the research of an almost entirely new product, although it is based on the same principles of operation. EP-Mini encloses in an extremely compact and optimized device all the innovative functions of the E-Power system, but better suits for the characteristics of small industrial, commercial and executive offices. However, its optimization is still under way and new developments of this product are expected, especially regarding the software associated with it.

Figure 33 – EP-Mini (Source: Energia Europa website)

Industria 4.0

The approach with the plan Industria 4.0 has been indirect, in the sense that the firm did not directly invest as far as is concerned its production process, nonetheless, the sold machines fall within such classification. Indeed, what pushed Energia Europa to enter the market Industria 4.0 has been the willingness to indulge the needs of a clientele keen to enter this market, by helping them to navigate this landscape and thus, indirectly exploiting the advantages coming from "the 4.0". As matter of fact, the main reason that pushed the company to change strategic course towards this direction has been mainly market-driven, facilitated also by a target market

[52] Source: see note 49.

that has always been focused on the analysis of Big Data. Energia Europa, indeed, has a very simple production process: much of the assembly is done outside, while the final assembling, trial activities and testing are done internally. The company defines itself as a “very IT” company, mainly devoted to the activities of R&D, Big Data management, as well as the design work, that is all done in-house. In other words, the company is aimed at setting up the necessary software for the management of the information that is then collected by the machines. Therefore, it developed a targeted system that simplifies the analysis of such volumes of data and thus, the management of the information collected. Economically speaking, the company’s presence within the market of Industry 4.0 has positively influenced its turnover, with increase in sales one year to the next of about +20%.

Industria 4.0: Data Management

The most relevant advantage of the Internet of Things has been to allow the company to exploit data in many ways: first, data are used for enhancing product’s performance, for example by improving the software settings and fostering the way customers use it; secondly, it is essential for performing a timely maintenance of the machine. The evolution of the Big Data market is further and further pushing the company to switch from being a mere seller of machines for the energy efficiency, to be able to cover the market also as a service provider. Energia Europa is already undergoing an internal restructuring towards this direction: data storage, server management, data query programs, are already charged as paid service after two years from the installation. The firm is now evaluating to integrate its machine with other network analyzers that are on the market in order to transform it into a reference node for electrical information, ie a node that collects information and then transmits it to a Cloud server. This could be a great deal in order to shift the core business towards the sale of services, which are not just maintenance and warranty on the machine, the so-called warranty extensions on the machine, but are also services of data management and analysis.

Product Life Cycle

For what concern the life cycle of the product, Energia Europa believes that the changes are occurring at software level, rather than on product level: indeed, the product itself maintains its traditional life cycle, while what is changing is the software embedded inside it, thus the software life cycle is evolving gradually as result of increasing rise of customers information to process. Indeed, more information to manage require a more powerful software, so it is necessary that the company constant research ways to upgrade and optimize the current one, thus resulting in an ongoing renewal of the software life cycle through updates. As already mentioned, the software the company used before was passive, so the customer needed to connect and personally go to see the data, while today it is the software itself that communicates directly to the customer. By implication also the innovation of the product occurs on an ongoing basis, in parallel with the one of its software.

Incentives 4.0

For what concern the governmental incentives, on one side, Energia Europa has exploited the incentives 4.0 ("Credito d'imposta Ricerca e Sviluppo") relative to the research and development of the E-Power system. On the other side, the installation of the E-Power system allows companies themselves, thanks to the machine's embedded systems, to access the so-called "White Certificates", ie energy efficiency certificates (TEE) issued by the GSE (Energy Services Operator). These certificates represent an incentive born at European level to achieve the primary energy reduction targets set by the "20-20-20 climate-energy" package following the Kyoto Protocol (see note 48). Moreover, the E-Power system also benefits from the "hyper-depreciation 2019".

Internal Organization

The production of advanced machines incorporating complex intangible features has required some internal changes, starting from the growth of the IT department and the one dedicated to software. Due to the concept's change of data management, it has been required a passage from internal management servers to the Cloud. Despite Energia Europa could leverage an already strong informative architecture that only required to be improved, such facilitating indeed its evolution, nevertheless it had to expand the area of software's R&D. This area has a key role in the activity of the company and currently, about 1/3 of its workforce is employed in the R&D department, so a large proportion of the firm's employees has a technical background. The company strongly believes that without an already strong IT structure, especially for a company of this type, would be really challenging other than more expensive, to look at Industry 4.0, not only from a technical point of view but also managerial. In this perspective, one of the hurdles for the company has been to find personnel highly skilled not only in IT but also in the managerial field. As a matter of fact, the internal management has required managerial figures with an holistic knowledge about mechanical, as well as electronics and legal issues – just think to the privacy regulations linked to the data management –, able to in-depth understanding the product's features and communicate with all the different actor involved; in short, someone able manage such level of internal complexity.

External Partners

The impact of this transition has also changed the strength of relationships Energia Europa has beyond its internal borders. Depending on the technology supplied, some collaborations resulted strengthened, like those with the modems' and analysers' suppliers, ie the digital and electronics components of the new machine. In others, like those with the suppliers of mechanical, or simpler parts, there has not been a significant influence of Industria 4.0 but rather were maintained the previous arrangements. For what concern the research and development of the E-Power System, some external partnerships have played a crucial role. In fact, one of all led to the positive outcome of the company's project: The University of Florence. With the Department of Information Engineering, Energia Europa has open activities and also shares a joint research laboratory, the *Smart Energy Lab*, that counts two locations, one in the province of Vicenza and the other at the University of Florence. The goal is to perform jointly research to pursue continuous experimentation on increasingly effective technological solutions. However, Energia Europa has also set up joint research and analysis activities with prestigious international universities and research centers, such as the Madrid Polytechnic in Spain and two prestigious research institutes in Germany and Poland. However, it finds difficult to link up universities and, in this perspective, it evaluates extremely positively an initiative like the Competence Center, but with some reservations: in fact, the company often experienced that the objective of the universities was not of realizing projects with companies with the scope of jointly doing research and sharing results. In the company's opinion, many times the research project is seen as "company=customer and university=supplier" and accordingly, doing research and development without a beneficial involvement of companies is the big flaw of the Italian system. This distances us from other countries where the collaboration between companies and research institutes, as well as universities, is much easier to activate and manage. Consequently, Energia Europa attributes the Competence Center the role of trigger ad regulator of the resources exchange between companies and universities, ie it should have the goal of stimulating the entry of students into the companies' laboratories, for giving them the opportunity to help organizations through their knowledge, dynamism and at the same time generating a return for both, the university and the company itself. The company continues that it would also like Competence Centers becoming communicators of what in practice happened on the territory so that stimulating entrepreneurs, both as customers and as producers, to improve and replicate the successful practices through the employment of Industria 4.0.

ZAMASPORT Spa

Overview

Zamasport is an Italian family business with more than 50 years of experience in the textile and fashion industry. Born from the conversion of the Maglificio Augusto Zanetti founded at the beginning of the last century, nowadays it is a leader in the development and production of high-end clothing for luxury ready-to-wear brands. Among its clients, there are excellent brands of the Italian and international fashion system, such as Helmut Lang, Norma Kamali, Katharine Hamnett and Romeo Gigli. Furthermore, from 1993 to 2000, the firm has been worldwide licensee for the production and distribution of Gucci. Zamasport can boast of having participated in the birth of the prêt-à-porter in Italy, with the Callaghan brand, which has had among its creative directors also a young Gianni Versace, who designed the collection from 1972 to 1986. The company oversees all the phases that transform the raw material into a finished piece of clothing: from the sketch to the realization of the prototype, to the sample for sale, to the purchase of materials and to industrial production in synergy with the partner, always granting secrecy conditions on the collections, essential element for the relationship's maintenance with its customers. Today, the company develops more than twenty collections per year for premium brands, generating a turnover of over 50 million euros. Zamasport has always kept up with the evolution of the fashion industry, so true is it that it was able to combine the "doing well" rooted in the "made in Italy" craftmanship to the new technologies 4.0.

Competitive Environment

The Italian textile industry, mainly consisting on historical small and medium enterprises aggregated in clusters sited in areas of ancient textile tradition, keeps holding the role as excellence for the national industrial system but also of the global textile industry. This industry strongly depends on the fashion sector, that still distinguishes itself for being one of the most dynamic in our industrial system, generating 1,3% of GDP[53]. In 2017 in Italy the textile industry generated an aggregate turnover of 20,2 billion euros. To remain in the market and counter the threat from East, the textile companies are increasingly investing in technology, thus experiencing an evolution path towards the digitization of the whole value chain, from design to production, but at the same time maintaining internally all the steps constituting the production chain. In conformity with the Italian textile ecosystem, Zamasport since 2016 has embraced Industria 4.0 technologies as a solution to up to date its productive process and thus remain highly competitive worldwide. The company was classified by Ceccarelli as one of the most profitable Italian companies operating in intermediate sectors of the value chain, with a

[53] Source: https://www.startingfinance.com/approfondimenti/settore-moda-italiana/

turnover of 53.3 million euros (Gambarini, 2017). The sample analyzed more than 1000 enterprises among the most sustainable Italian firms, that have been able to increase their added value, with performances that make presume further improvements.

Industria 4.0

At the base of the investment in 4.0, there was the need to optimize the production process, in other words, the company needed to eliminate those manual operations that are subject to errors in the material cutting phase and which had negative effects on the finished product. For this reason, it has been strategic making investments in CAD technology cutting machines: these allowed the company to cut automatically fabrics, as well as various components that make up the garment, making them ready for the subsequent assembly and sewing phases. As a result, the company started to manage more efficiently the raw materials, with relevant cost savings. With the adoption of Industry 4.0, the choice of the fabrics transformed in an even more crucial phase, because, in addition to having very high-quality levels, they must comply with very strict deadlines for the production cycle and deliveries, so their supply requires maximum efficiency. As a matter of fact, due to its success and globalization, Zamasport finds itself facing demands for higher-volume orders to be delivered on time while maintaining high-quality standards (Lectra, 2016). For this reason, in combination with the mentioned technology, Zamasport introduced Product Lifecycle Management, pushed by the need to have immediate control over the entire production cycle. Accordingly, it has been created an online platform that allows the firm to oversee each product's life step, sharing real-time information with those customers that use the same system. The integration of such a system enabled the textile leader to automatically manage and organize an important flow of activities, as well as reliable data generated throughout the entire process. As a matter of fact, PLM is a comprehensive system that allows sharing accurate information in real-time throughout the internal digital thread, thus linking all the different divisions. As a consequence, Zamasport benefitted of a relevant reduction of the communication and executions times, so it fostered the decision-making process. Moreover, fabric waste, overlapping tasks and errors have been eliminated, dramatically reducing time to market, because such a system makes possible the collaborative management of collection life cycles with both internal and external stakeholders, allowing to reach operational levels of excellence. This factor, together with the increased flexibility achieved, has been an important milestone for Zamasport because enabled it to be part of the so-called "See now buy now". This is an innovation recently introduced by very few brands, like Valentino, Versace and Ermenegildo Zegna, that has led to an "epochal revolution" in the production cycle of the textile company. The phenomenon consists of providing immediate availability for the sale to the public of fashion items and accessories right after the fashion shows. From Zamasport viewpoint it has meant being able to present to its customers the garments of certain models of the season before the official presentation to the public. Accordingly, in industrial terms, this has meant working with anticipated timing and excellent raw materials purchase management. Since this represents a great competitive advantage for the partners of Zamasport, it had to optimize its entire value chain, maintaining at the same time the high-standards of quality demanded by clients operating in the luxury fashion system. As matter of fact, in addition to the benefits before mentioned, the adoption of the PLM allowed the company to improve the general quality of the finished products, through the upgrade, in terms of accuracy and quality, of the control phases. Finally, in synergy with the PLM, it has been integrated the RFM (radiofrequency identification) system, which allows the identification and automatic storage, via radio messages, of information regarding the elements during the process and the position of the finished garments, furtherly optimizing the logistics and thus the efficiency of the internal organization. Broadly speaking, these technologies gave the firm the possibility of locating part of the supply as close as possible to the demand (Lectra , s.d.), enabling it to comply quickly with a high degree of customization demanded by final customers. The investments made in technological evolution besides what said above, have positively affected also the side of costs, as well as, through the exploiting of data, the real-time diagnoses of any problems, that has consequently resulted in promptly intervenes throughout the production process, furtherly optimizing it. The integration of Industria 4.0 within a manufacturing process based on craftmanship capabilities and a consolidated production process has been gradual, in order to permit all the actors involved, as well as the structures, to adapt to the new company's approach and, by the way, it is still ongoing. For instance, is under construction an expansion of the plants dedicated to the production and warehouse[54]. Furthermore, Zamasport is currently planning future implementation of a CAD software for the realization of 3D models capable of responding to the need for design, in order to have an immediate feedback for the elimination of any imperfections that would occur only in the packaging phase, and that will also allow the firm to determine the wearability of the garments according to the mechanical characteristics of the different fabrics used. For realizing its projects in Industria 4.0 perspective, the company has exploited the governmental incentives.

[54] Source: https://morettispa.it/nuova-sede-produttiva-zamasport/

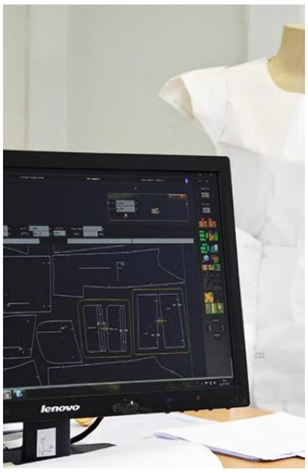

Figure 34 – Models' Design with CAD technology (Source: Zamasport website)

Internal Organization & Competences

For a perfect integration of the new technologies and the absorption of the even faster times required by the "on-Demand" diktat imposed by the evolving fashion industry, Zamasport heavily relies on the great availability of its human resources, that despite the artisanal nature of their know-how, have been able to adapt to the new skills required by the automated production process. For this purpose, the company has activated internal training courses for the upgrading of the workforce competencies by external resources, as well as for educating new professional figures to be included in the industrial chain. The courses are oriented to the acquisition of direct knowledge for learning the procedures consolidated in the business environment but using state-of-the-art technologies and specific IT systems. In some cases, it has been necessary to re-train, rather than relocate some of the employees, since the tasks now required obviously are different and more technical. CAD technology, for example, has mainly affected the modelling study and design area, which is the focal point of the company business. In this department the staff is dedicated to each brand, interpreting the client's stylistic requirements and making them realizable on the existing item. The professional figure of the model maker is the one most involved in the mastery of a 2D digitized work system, which, as mentioned before, is destined to become 3D in the near future. However, human tasks have not been totally substituted by the machine. Indeed, despite the high precision automation guaranteed by the machines, in the most delicate cases, the cutting is still done by hand by highly competent seamstresses. This artisan has a key role within the company because it is a link that combines traditional to digital manual skills and, on whose training, Zamasport has invested huge resources. On the other hand, stepping into digitization and process automation has also led the company to a reduction in personnel. For what concern the importance given to training, Zamasport, despite did not know the Competence Centers, believes that initiatives of this kind could be very profitable for companies, especially for small and medium enterprises that struggle to keep abreast of technological evolution. Further, it attributes them the essential role as promulgators of the introduction and spreading of Industry 4.0 in the SME environment.

External Resources

In addition to the internal human asset, Zamasport could not approach Industria 4.0 without a strong network of external partnerships. The introduction of new technologies, indeed, has required the company to strengthen closer relationships with them, for what concern the supply of raw materials, as well as the one of technologies 4.0 and digital machines. For instance, in 2016, after being for over twenty years its customer, Zamasport strengthened the collaboration with Lectra: indeed, the latter became its supplier for the solutions 4.0, assuming a key role in the evolution of the company. Lectra is a world leader in integrated technology solutions dedicated to industries using fabrics, leather, technical textiles and composite materials and one of the pioneers of supply of IoT solutions in this sector. For instance, since 2007, all its cutters have been equipped with sensors for allowing it to perform predictive maintenance. Lectra supplied the firm from Novara of the PLM Fashion system, de facto supporting the digitization and automation business progress.

AP2 Srl

Company Overview

The Italian company has more than twenty years of experience as System Integrator in numerous markets ranging from rubber to plastic, from coating lines to 103qamai103ring lines up to tire packaging lines. It is specialized in the design and development of hardware and software PLC and HMI and related interfacing with management systems, as well as drafting of electrical specifications. Further, it is involved in the construction of the switchboards electrical, rather than it does internal testing, commissioning, production assistance and product engineering, as well as remote assistance. The core business is in the tyre industry, where the firm covers their entire production chain. It is in this segment that has the greatest number of applications and achievements. AP2 generates an annual turnover of 5 million euros and employs about 20 workers.

Market Overview

In the field of industrial automation for semi-finished and tire packaging lines, AP2 always distinguished itself for being deliberately oriented to a purely technical aspect, with proven high levels of competence and quality standards, thanks to the exclusively internal development of all stages of production. Being an excellence in this field allowed the company, in 2015, to successfully bid the project of the first factory built in Europe by an Indian tire manufacturer, which required the automatisation of the entire plant but also complete traceability of the entire industrial cycle. This commission gave AP2 the additional possibility to aim at international clients and expand its sales scope, which indeed crosses the Italian borders. In 2018 the automation industry registered a total turnover of 5.1 billion euros and an increase of 7.3% compared to the previous year, confirming the continuous growth trend that characterized the evolution of the sector in the last five years and a more dynamic profile compared to the manufacturing average. Between 2013 and 2018, manufacturing and process automation showed an average annual increase in total turnover of 7% against just under 2% recorded by manufacturing[55].

Product Offer: The Internet of Things

It is useful in this case to remember that AP2 provides hardware and software tools for automatizing the whole customer's production lines. Given the increasing importance assumed by the Supervisory Systems (HMI) for the control not only of the operational functions of the plants but also of the production control tracking systems (Trace Management), AP2 has developed its own supervision system, especially employed in the Automotive and in the Tire sector. Moreover, the company perform the commissioning of the electrical equipment and software of its own realization, offering through ad hoc systems constant support for the resolution of any problems following the start-up and for the optimization of the production sequences. Among the solutions developed for its customers, there are the scheduled maintenance as well as tracking and trace solutions. As a matter of fact, in the automotive industry, the tracing and historicizing of production is of fundamental importance. In addition to the tools now in common use, such as recipe management and integrated track management, the AP2 Software development team has created a data exchange system with the MES of the plant able to receive production orders and synchronize the recipe database in a simple and transparent way. The system also controls the materials and tools used through the use of barcode readers and RFID receivers whose data is crossed with those provided in the production recipe in order to optimize the operation of the line. As far as IoT technologies, the company do not provide tags or sensors, but rather it deals with their management in a way that satisfies the technical specifications of the customer, which is the principal. This kind of solutions are purchased by the latter and AP2 is responsible for their set up. For instance, considering an RFID, this is leaning on a product, when the product passes on the reader is recognized as such, it is then worked with the meter traceability for meter and when it gets to the bottom all the data of the process are downloaded on the RFID. So, the final product beyond the initial data has all

[55] Source: https://anieautomazione.anie.it/settore-in-cifre/#.XcWKXdXSLIU

those for which it was processed, and that will be useful for the customer. Thereby, the main deployment of this technology is the acquisition of signals coming from the field, but it cannot be considered as a crucial element for the company's offer. It can be stated that it completed the product, rather than innovated it. In this sense, the data collected benefit the final customer because once the data is collected and archived and linked to the final product, the customer can see and know the uses of that product or how it was made, rather than all the information that constitutes it. For instance, the clients can have information not only from a qualitative point of view but also of energy used, for instance relating the temperature the product has received, they can consider the energy they have received and therefore consequently can know how much energy has been spent for that single product. Indeed, in industrial applications energy efficiency is particularly important in electric drive systems as over 70% of energy consumption is here concentrated. From the point of view of the company, the IoT enabled it to program the product remotely, while before it had to be programmed first by local. In this sense, the Internet of Things has completed the production processes.

Industry 4.0

AP2, given the nature of its business, shows an evergreen approach to technological innovation that developed over time: Industry 4.0 represents more a physiological and natural development of the products and so of the business itself, that during its activity has experienced first the 2.0, passing through the 3.0 and finally the 4.0. In this perspective, the company believes that Industry 4.0 was already something established within its DNA as due step of the technological evolution but obtained such hype thanks to the highlighting given by media. In fact, AP2 by creating electrical equipment and systems for the production of tires and working on specification, it is strictly dependent on the customers' requirements for the company's configuration. Customers, certainly, are those that influence the company's deployment of new technical discoveries because they think, obtaining high-tech products, they have a competitive advantage. It follows that, under an internal point of view, the company did not need to change its set-up, neither develop different skills for approaching new technologies. What required the adaptation to 4.0 was already part of the company's know-how, so there has not been any difficulty in moving to the new paradigm. Actually, the company employ all the technologies categorized as "4.0" and their handling by the workforce has been the result of a unceasing training process which belongs already to its daily attitude: right because it works on specification, the company does not dispose of a department dedicated to R&D, but on the other side this has implied that having to satisfy customer requests from time to time, the employees strengthened their skills and knowledge in order to meet the demands of the orders. Moreover, precisely, for this reason, that is that when the research "is drowned" in something that should be sold is not considered as research by the governmental requirements, the company could not take benefit of the incentives guaranteed by the Industry 4.0 plan. The employees, however, are dedicated to continuous updating regardless of 4.0, because the change has occurred not only in relation to technologies but also for what concerns new materials, components, rather than software. Especially within the framework of a social fabric made of small and medium enterprises, the company believes that training activities like those offered by the Competence Centers are extremely necessary especially for those companies, if still operating in the market, that make products of medium and low quality, that more than the others need to know what is necessary to know and use to adopt the 4.0. Broadly speaking, it considers positively all training activities, regardless of their point of departure and arrival. As a matter of fact, to confirm what just claimed above, the AP2's CEO believes that *only the customer leads to seeking new ways to innovate the company's service and offer*. In this perspective the company has assisted to a different behaviour of the latter towards Industria 4.0, that is over the years the end customer has moved towards digitalization and automation for two reasons, for a quality of the process, or for an economic interest, ie for the financing linked to the use of 4.0. In other words, perhaps the customer was not interested in improving the process at all, but since 4.0 presumed that companies had to dispose of at least a system for data collection, the client adequate itself and has addressed AP2 to supply it a way to collect data. This confirms the trend, detected by the company, that is happening an ongoing change and development of the products towards an increase of the informative content in- and outside the product itself.

Industry 4.0: Results

The company acknowledges both positive and negative results from the adoption of the whole chain 4.0. In the first case, they allowed a more accurate monitoring of the processes. Furthermore, there has been an evolution from the side of data collection, ie before the company's lines were autonomous, while subsequently, all these have required for the implementation of a data collection and data tracking: this has indeed brought results both in product's implementation terms but also in economic terms. However, on the other side the company did not registered a changes of the overall turnover that good or bad has remained the same, but rather has recorded a lengthening of the time to market, because the time for pitting the lines into service have become longer due to the more time scheduled for the programming and implementation, with consequently negative effects on the product's commissioning. The relationships with the external partners, instead, have not been affected by Industria 4.0, in fact, where before, for example, Siemens, presented to AP2 drive motors in a certain way, today it presents those with sensors, or in general the ones of the new generation.

4.4.3. DISCUSSION

Preamble

In this part the work it is carried out a cross-analysis of the aforementioned firms, to which it will be added the findings from other two undertakings, Elesi Luce Srl and Arkesys Srl, both active in the illumination sector.

ELESI LUCE Srl is a company headquartered in the province of Padua, that produces indoor lighting devices. Within the company take place the processes of design, prototyping, product industrialization, production, marketing, post-sales assistance. The activity of design sometimes engages external collaborations for the development of special samples. The production is divided between catalogue products and “tailored” products. The latter include lamps that can be installed in home automation systems, so through the integration of IoT technologies. This kind of offer is only on request, as there is no single home automation system and therefore the components must be changed on the basis of specific customer requests. The products in his catalogue can be defined as “technological decorations” as LED technology is used integrated in non-technical design products. Its clientele is very heterogeneous and include specialized lighting shops and architecture studios, rather than interior designers, lighting consultants, as well as installers and contractors. Elesi Luce’s characteristic is its flexibility in production, that is, being equipped with an internal mechanical workshop and assembly department, can produce both individual pieces and small and medium-sized lots (from 2 to 500 pieces).

ARKESYS Srl is an Italian company with about ten years of experience in the design and production of LED lighting fixtures. Its reference market is in the retail sector, where the required performance is very high. One of the firm’s strengths is the product customization, in fact, it relies heavily on complying with requests or ideas that are submitted for the creation of new products with features and performance that are pleasant for the customer. Currently the use of IoT technologies is under development, along with other 4.0 solutions.

Cross-Analysis

Of seven examined firms, the majority – six out of seven companies – strictly invested in product innovation in the sense that their focus has been in those internal and external activities aimed at improving the quality and variety of goods produced and offered. Zamasport constitutes an exception in the sense that because it cannot be considered as a company with a product offer with high innovative content. It is the oldest business within the sample and due to the belonging sector, ie textile, its path towards digitalization has been strongly pushed by the willingness to maintain its reputation and competitive positioning. Given these preconditions, its adoption of Industria 4.0 must be seen more as a way taken to optimize its production process, but however with the aim to obtain a better-quality finished product, which is perceived as innovative by its customers for the intrinsic added value. Further, must be noticed that Zamasport is the only one in which persist a high artisanal component.

The sample analyzed partially confutes what claimed in paragraph 4.2 by Bugamelli et al., who attaches the limits of the competitiveness of the Italian manufacturing, in terms of innovation and adoption of new technologies, to the composition of its productive fabric that counts many micro and small enterprises. These are described with limited attitude to innovation and rate of adoption of advanced technology, as well as propensity to internationalization. However, five out of seven that suits the definition of micro and small-sized firms realize a considerable proportion of their sales through exports. Elesi Luce exports 75% of its production and 25% of the product delivered in Italy is mostly destined for abroad (about 10-15%). Likewise, Energia-Europa is expanding its selling radius and currently realizes about 45% of the installations out of the Italian borders with the willingness to increase this datum. In the extreme side, there is Aqamai, that bases its offer on the requirements of another country, the USA, and stood out in foreign markets for the innovativeness of its offer in a niche market such as aquariology. Germany is a common denominator for the sample SMEs as the main target of their internationalization strategy, specifically Elite, Aqamai, Arkesys and increasingly for Energia Europa. Broadly, the firms under examine confirm what found by the Digital Manufacturing Lab, namely the adopters prove to be innovative companies, which have often already made an investment path on the ICT front. Indeed, a characteristic that all the companies share, independently of their size and even their age, is the attitude towards technological innovation, in other words, their DNA always made them oriented at investing in new technologies, upgrading product quality, so strengthening innovation; for instance, Energia Europa, with the new ownership structure, and AP2 are right born in the field of Big Data and Automatization, so they always have operated in high technological industries. Elite can be considered the one that, among those analyzed, most stood out for efficiency, performance and strategy, in terms of innovation, technology, and exports. Even when it came to cope with the financial crisis, Elite invested always in itself by adopting a qualitative upgrading strategy and an international point of view, distinguishing itself worldwide for innovativeness. For the above reasons it perfectly reflects the description of Bugamelli of medium-sized outperforming enterprises similarly to European competitors, if not better. Moreover, the business dispels what found out by the DML, ie that companies operating in the sport industry do not exploit IoT technologies. On the contrary, Elite embedded them since their early stage, when it launched the first connected roller in 2000. Consequently, it can be claimed that for these companies has been a natural development the embrace of Industria 4.0 and did not require huge efforts in terms of adaptation and investments.

Even for what concern the scope of the adoption of the Internet of Things, there is not an all-encompassing trend. Among the companies that are “innovative-born”, so Elite, Energia-Europa, AP2, the IoT technology is well implemented and connected solutions are part of the standard range of products. These have already registered positive results in terms of sales and competitive advantage. Others, like Aqamai and Elesi Luce, launched only recently, for both around 2017, the new IoT-line that is parallel to the traditional range of products. In the first case, the company highlights to be better prepared for this kind of market, because has a strong past technical knowledge. On the other side, Elesi Luce is undertaking projects of internal restructuring in order to be able to integrate commercial management software for data management. However, for the latter, as well as for Arkesys, since they could not rely on strong digital architectures, the transformation is in process and it is too early to have a clear evidence of the results achieved. At the basis of the adoption of this strategy, majority of respondents – six out of seven – highlights to have recurred to the Internet of Things, generally to all new technologies 4.0, for increasing or maintaining their competitiveness, as well as exploring new market possibilities. This confirms what claimed by the Digital Manufacturing Lab, namely that market dynamics drive the rate of adoption of these technologies. As a matter of fact, investments decisions are not made necessarily to obtain an increase in revenues, but rather is a mandatory passage mainly pushed by the willingness to offer the best customer service. The CEO of Elite argues that all those who 10 years ago did not grasp the innovative wave lost the market opportunity offered by the integration between software and hardware, lagging behind the others. As a result, there is the awareness that if are not made investments for offering customers connected products, in the long run, there is the risk that the offer range will be regarded as obsolete.

Other similarities can be figured in the two common reasons behind the systematic approach to innovation: the first is driven by the competitive pressure of the reference market which consequence of the peculiarities of the belonging sector. Such pressure affects in particular in the Illumination sector, where the rules are made by the big multinationals, like Phillips, Osram, Amazon, and Google, which dispose of available funds to technological innovation not even comparable with those of SMEs. In this sector, the integration of the Internet of Things within the offer becomes a choice dictated by the need to offer advanced services like those of the companies mentioned above. In this perspective, the tendency of companies like Elesi Luce and Arkesys, is to focus on an offer that gives ample opportunities for customization. For instance, Elesi Luce lamps can be installed in home automation systems only on request, as there is no single home automation system and therefore the components must be changed on the basis of specific customer requests. However, this kind of offer keeps having a secondary role in domestic demand since customers still do not accept this innovation, in fact in Italy the demand for lighting bodies with replaceable bulbs continues to be important, pushing the companies that want to bet on smart lighting at moving the horizon over the Italian borders. Another factor that pushed companies to specialize in high tech products is the high level of expectation in industries where products have by default high standards of technological content. Despite the sectors belonging to Elite and Aqamai are not strictly related, both products are dependent on a heavy customer's expectation in terms of technological features and product performance. In the case of Elite, the competitive battle is based on the companies' ability to raise, launch after launch, the product's technological barrier. In the case of Aqamai, the pressure is posed by the customer himself rather than by the performance of its competitors. Indeed, unlike its competitors that tend to change only the aesthetic aspect of a product, Aqamai's competitive advantage is based on ongoing "real" innovation of technological features that meet customer needs. In both cases, embodying the IoT within products has been the answer to the need of offering customers ongoing innovation. Both dispose of an App that is the direct link with their customers; simple software upgrades, elaborate in base of users' data, enabled them to guarantee ongoing innovation and empowered performance and, consequently, always "new" products, just by adding incremental features or functionalities to their offer.

Table 3 – The Influence of the IoT in the Process of Product Innovation

FIRM	IOT POSITIONING	USE OF DATA	TOWARDS PRODUCT-AS-A-SERVICE?	MOTIVATION THAT FOSTERED ADOPTION
ELITE	Within Product	• Get insights on product's usage • Remote assistance • Real-time maintenance • Data tracking of product's technical sheet	Combination Product/Service	• Maintain strong competitive position • Better service to customers
AQAMAI	Within Product	• Get insights and statistics from product ownership and usage • Use insights for product improvements, innovation, new markets and targets • Personalisation options • Notification of malfunctions	No	• Differentiate from competitors • Have a direct channel with customers • Better service to customers
ENERGIA EUROPA	Within Product	• Enhance product performance • Timely maintenance • Offer better service	Yes	• Explore new market opportunities
ZAMASPORT	In the process for the product improvement	• Information sharing among internal divisions and clients	No	• Elimination of operations subjects to errors • Reduction time-to-market

		• Fosterer decision-making process • Real-time problems diagnosis		• Optimization of internal efficiency • Quality upgrade
AP2	Within Product	• Monitoring process improvement • Remote programming	No	• Improve competitiveness • Better service to customers
ELESI LUCE	Within Product	• BIM's development • Customization	Yes	• Increase in services offered • Better service to customers • Better performance and cost management • Better data collection, tracking & management • Imitate competitors • Improve competitiveness
ARKESYS	Within Product	• Implementation in progress (expected results in 2020)	No	• Imitate competitors • Improve competitiveness

The second reason, instead, is based on the need to strengthen the range and quality of services offered to end-users whose a higher perceived added-value and satisfaction are the primary goals of all the analysed companies. The achievement of this objective requires a deep knowledge of customers, as well as of own products. The IoT has provided enterprises flows of timely, reliable, objective data that constitutes the basis of information exploited for the process of product development and innovation.

Data Management

Because data form the basis of each phase of product development, the presence of strong architectures for their collection and tracking has become a prerequisite of paramount importance to support the firm in handling the flow of data generated by the connected products. The development of suitable software and the passage to external platforms claimed all the companies for the adaptation of internal structures. The tendency is to move the data collection on the Cloud, at exception of Elite which operates both in the Cloud and in-site. Despite the meaningfulness of data is widely recognized, there are still some companies that do not dispose of a systematic system for data management, like Arkesys and Elesi Luce, but these are striving to quickly adapt since they integrated IoT technologies only recently. The Internet of Things has opened many opportunities for companies to offer customized products at low cost: in this case, the findings fully reflect what the literature states. The main use of data of getting information, or better, an in-depth knowledge of customers, allows firms to offer a better service because customized to the need of customers. Indeed, the IoT allows companies to have a direct channel with the end-users; the huge amount of data at their disposal informs cheaply and real-time of customers' statistics on sex or age, rather than product usage, or preferences, that allow the company to get insights on future markets or possible customer targets. According to the CEO of Elite "cold data" at first instance does not help, but gives you tendencies, which if you know how to interpret, they indicate where you should go. Once data are collected they are aggregated and processed to get meaningful insights that advantage both the firm and the customers. Therefore, data are also useful during the implementation phase to furnish ideas about new products specifications, improvements or possible innovation, especially for those objects that closely interact with customers, like in the case of Aqamai and Elite. Another important benefit gained by the integration of digital components into physical devices is related to real-time problem diagnosis, as well as maintenance and optimization of the device performance. Indeed, the IoT enabled businesses to assist their customers in the product's usage, sending suggestions about the best use of some functionalities or warning of malfunctions, like as with Aqamai. As a matter of fact, the data gathered enabled most of the companies – i.e. five out of seven – to exploit real-time data by activating in this way a continuous process of monitoring and verification. This factor is crucial especially for device electronically complex, such as in the case of the E-Power system of Energia Europa and the automation solutions offered by AP2. For what concern Zamasport, in addition to real-time problems diagnosis, the evolution of data collection and tracking fostered the decision-making process, allowing the company to offer a kind of "innovate" offer, namely based on a fast time to market, high levels of customization and close relationships with clients, always granting high levels of quality. Following this viewpoint, the revamp of the data management system enabled levels of internal efficiency and flexibility that made the company suitable to something like "See now, Buy now".

Ideation Phase

The collection of ideas and information for the creation of new objects or the implementation of the existing ones has been extremely facilitated by the quantity of available data. It can be even state that connected products opened a direct access to the "customer's mind", allowing companies to catch needs and desires that before could have been accessible only at the point-of-sale. Indeed, data processed and converted into meaningful information constitute one of the most objective and reliable, if not also updated resources from which gather new ideas or suggestions for future product improvements, as stated by literature. Moreover, another advantage has been the elimination of the mediation within the relationship company-customer by other figures, like shopkeepers or the salesforce itself, that tainted the purity and objectivity of the information, like explained in 4.4.2 with the case of Aqamai.

However, for what concerns the phase of ideas generation and creativity, most of the respondents tend to remain true to the traditional method of gathering ideas, ie that especially for those companies with a systematic approach to innovation, the process for the development of new product is something consolidated and did not change due to the effect of the influence of new technologies. In the case of Elite, for instance, the ideas and opinions from people, also external to the company, really matter for the creation of new projects and the creativity of everybody is appreciated and stimulated. Thus, the company considers sources both from objective data, but without ignoring the human contribution. The company disposes also of an area called "Cloud", where everyone can suggest his idea and Elite takes the responsibility to evaluate it and, if it is strategically suitable, develop it. The process of Aqamai is consolidated as well and does not show great deviation from the one used for not IoT-products; nevertheless, the ideas coming from the managers of the American place of business play the relevant role for the company strategic decisions. Elesi Luce instead, from 2018 has developed an open work environment of design that exploits the BIM (Building Information Modeling) technology which constitutes an international reference platform for architects and designers. The BIM library is a free of charge service offered by the company to design professionals and consists in the collaborative creation of the digital version of the products, that are defined as team members establish proposals and solutions for all aspects of the project. From the initiative, Elesi Luce already registered a positive increment of sales. For what concern AP2, the ideation phase is not relevant because the implementation of its products relies exclusively on commissions given by the clients, that are those that trigger the process of innovation within the firm. Despite the increasing deployment of machineries 4.0 and the consequent adaptation of the company to the new paradigm, Zamasport still gives priority to people creativity for the creation of new models, without any interference coming from data gathered through IoT, proving that the manual skills and creative flair typical of "made in Italy" are still key factors of competitiveness and, contrary to the literature, source of productivity.

Implementation Phase

The implementation of products which combine hardware and software components has strengthened the significance given to technical knowledge, as well as to research and development. Three of the companies analysed dispone of internal departments solely dedicated to R&D, for handling new technologies and creating IoT-products which often require separate areas with distinct machinery and equipment. The research has been favoured by the dedicated governmental incentives, of which most of the respondents have exploited the related benefits, or at least have requested them. Relating to the firm that works on commission, AP2, it represents an example of those Italian firms that *innovate without research*, in fact, despite its production is highly innovative and it is the result of independent research in the field of automation, it does not meet the requirements to have access to research and development tax. This case confirms that literature should not excessively focus on data about companies' investments in R&D for qualifying a business as "innovative" or not, but rather on other parameters, like the number of innovative products launched per year, so more suitable to the reality of the SMEs that they cannot rely on substantial funds for research and development of innovative offer.

In the implementation phase of a digital-physical product, it must be taken into account the nature of the company's business model. As stated above, the customer orientation of the analysed firms allowed them to extend the use of the growing volume of contextual data and to combine it in innovative ways creating on-demand, personalized solutions for customers (Antonova, 2018). Despite part of the respondents manage users data in order to offer services, only two companies showed interest in shifting their business model toward one based on data monetization; and particularly, only one business – Energia Europa – already took this path, by charging the customers the offered service after two years from the installation of the machines. For Elesi Luce, instead, it is still too soon to think about such a solution, since it is only at the early stage of the IoT adoption process. Still, it remains among the possibilities of an eventual future development evaluated by the illumination company. On the contrary, the rest of the companies, assert to have invested in the IoT for only benefit of customers and thus, the data gathered are made available to them like a service free of charge and, however, there is not any intention of monetization. Thus, the employment of the Internet of Things slightly changes the way these companies create value, but the business model is not completely revolutionized.

The internal skills become a fundamental internal source for dealing with the effort imposed by technological adaptation: the workforce had to change the way in which was get used to operate and had to adapt to a system that shifted the production from the creation of physical objects to a digital manufacturing that has more and more to do with the creation of software. Consequently, it has been necessary to hire new figures, especially in the field of informatics and engineering, who are more suitable to treat the development of the software within products and perform the continuous maintenance required, rather than the management of data analytics from which extract meaningful information. The empirical evidence confirms what literature states: Industria 4.0 imposes a high level of specialization especially in technical competences that must be continuously updated. In this respect, it has been found out a consensus among respondents about the importance of internal training of the workforce. Regardless the latter is organized internally or appointed to external resources, the employment of new technologies required the adaptation of the internal resources who had to 116qama their skills at the advanced required level. Obviously, this has also required often the widening of some departments, just like that one of R&D or software development. What the literature does not state, is that the increasing complexity within companies has resulted in the necessity of flexible figures capable to have a holistic view over the activities of the company, namely capable to manage knowledge of different nature, such informatics, mechanical rather than legal, and thus communicate with the different actors of the business ecosystem. From the analysis, it emerged that those among the analysed companies that could rely on a strong ICT architecture have been facilitated in the approach of the new production system, which has been perceived more like a natural evolution of the business, rather than a mandatory step pushed by the “innovative pressure”. Some companies, in fact, sustain that certain investments in research and new technologies would have been done independently of Industria 4.0, because part of their strategies prior to the new paradigm appearance. However, incentives in R&D have been for some companies a resource to promote the development of further innovative products, increasing this way the possibility to do research and thus increase their competitiveness by offering more products on the market. Besides, among the most high-tech firms, there is the common belief that, especially for small and medium enterprises, without a prior solid technical and digital know-how would have been very difficult, if not impossible, to fully exploit the advantages offered by Industria 4.0 and connected products. In this viewpoint are favourably seen all those external collaborations with third parties aimed at support firms in embracing new technologies, integrating the missing internal capabilities and speeding up the adoption process, like research institutes, universities and partnerships with independent scientists. Indeed, at least three out of seven examined companies are engaged in stable partnerships with the aforementioned structures with which set up projects to develop new products, software or algorithms; further, one of them, Energia Europa, has two joint laboratories with the University of Firenze with which have developed the E-Power System. However, often companies have experienced some difficulties to entertain solid collaborations with them because of a kind of conflict of interests, times, scopes, as well as for “attitude” of the universities towards research. Furthermore, companies reproach the hurdles that meet when they want to make contact with the university institutions, especially of bureaucratic nature. Energia Europa highlights the limits of the Italian research system that does not facilitate the entry of students within the companies with an overall loss for both the parties. For what concern the Competence Centers, none of the respondents knew about this initiative. The general opinion towards initiatives whose goal is to speed up innovation and integrate the lack of competences, especially in small and medium enterprises, is extremely positive because companies recognise a high value attributed to activities of open innovation. Furthermore, some firms attributed the Competence Center a role of promulgator of Industria 4.0 among SMEs, which often lack not only of financial resources but also human ones, as well as of the same possibilities of cooperation between institutions and companies. However, Aqamai and Elite, in the view of past experiences, have pointed out that, despite the good intentions of such kind of initiatives, often their long times of application collide with the ones of companies, finishing in a waste of time and resources rather than in fruitful collaborations that speed-up the implementation of new products.

Regarding the so-called feasibility phase, in other words, the process that involves the various tests to see if the development of such a product is practicable, it gets longer. This is the result of in an in-depth technical analysis, that is, if a certain product can and cannot be economically supported, and if the connected software can or not be developed, as well as if the data acquired are protected by a solid security structure and the privacy of the user is safe from cyber-attacks. To this purpose, AP2 has underlined how, precisely for the reasons mentioned above, the implementation times of a product have been lengthened as result of the incorporation of IoT technologies, because the development of the software itself and the implementation of the system require precautions more targeted and therefore longer times, a result that contrast with what experts sustain. The part of securing data and networks lines has changed the way companies operate, concentrating a large part of their investments in security and legal protection. For instance, Elite has insisted in order that its partners adopted a network that was powerful enough to guarantee the protection of data flow generated by its devices.

Broadly speaking about how to implement the new line of IoT products, most of the respondents due to the early stage of the investments, decided first to focus on complementing the traditional range of products with the one which embeds IoT technology. In this perspective, the Internet of Things represents an investment aimed at expanding the current offer with the goal of accomplishing new customers and market targets, through the offer of complimentary services. The firms that instead invested earlier in Internet of Things or had already the technical skills to cope with digital evolution, have gradually enriched their offer, and nowadays are able to provide products that are connected by default. Although the literature always refers to smart connected products, the analysis made has shown that often these adjectives do not go hand in hand. In fact, most of the objects are essentially connected, so they gather data about themselves and the surrounding environment but still are not able to elaborate them and decide independently their actions in accordance with the stimuli received from outside. At the moment, only Elite is able to offer a flagship product that is truly smart. The considered roller takes advantage of virtual reality and thus is able to react in real-time accordingly with the connected software and cycler's strain. Partly refusing the literature, there is still need of human inputs for the control of the objects and the decision about which action the objects must perform; so, it is still the manufacturer, and not the product itself, that gives meanings to the information received.

Commercialization Phase

Aside from the above-mentioned elimination of some intermediary figures along the value chain, the Internet of Things has further highlighted the need for highly trained personnel who carry out all those tasks that support customers in their usage and experience with the product, namely the so-called customer care. The integration of a digital component has, in fact, increased the complexity not only in relation to the development of an IoT product but also in its commercialization and post-sale phases. Thus, for firms, it has been necessary assisting and following more closely the customer even after the product purchase and guide him through the problems that arise consequently of the interrelation between hardware and software. The companies pointed out as connected products has triggered a range of issues before non-existent that required to be addressed, relating for example to the compatibility of the devices with users' smartphones, network connection issues, as well as the appearance of system bugs. The officer of the customer care became a key figure who acts as intermediary between intricate capabilities and functionalities of the digital devices and the concerns of the final client; he has to create a lasting engagement with the latter by enhancing at the same time the customer experience. Elite highlights that such figure needs to behave a comprehensive knowledge of every aspect of every product and how this implies that all the activities upstream and downstream of the value chain must be prepared to support this kind of activity. Two companies stated that the IoT products have required the need to appoint and train dedicated people to assist a customer in their understanding of the products and support. This has also the effect to nourish the relationships, generating increased added perceived value and so creating brand loyalty.

Product Life Cycle

For what concerns the product life cycle, the conclusions confirm once again literature: all except one respondents that embed IoT technologies within their offer agree with the fact that, by inserting the electronics within the hardware, the product turns into a real electric and electronic device, and this significantly lowers its life cycle. Furthermore, as effects of market forces, business are challenged to launch new products in increasingly tight times. However, as stated by Elite, the nature itself of the product changed assuming chameleonic features, in fact, by inserting the Internet of Things within devices allows businesses to modify them during life as effect of the increase of information gathered. Thus, companies can act accordingly over software and as result, the product becomes able to transform and innovate continuously, offering gradually improvements that better fit the needs and desires of customers, who obtain customized services. Energia Europa and Aqamai instead concurred by matching the life of the product with the one of its software, namely it is not the container and the production process that change, but rather the software that determine life and death of a product. However, when asked to quantify the extent of this reduction, most of the analysed companies cannot give an answer; indeed, as already observed, most companies are still at the beginning of the adoption process, therefore they do not dispose of the necessary information that allow them to perform such evaluations. For instance, Arkesys expects to have an overview of the results of its investments only in 2020. It follows that it will require time to estimates the extent of the IoT influence in the product life cycle, even if the firms that implemented earlier this technology are aligned with what stated above.

For what concern the company that exploited the innovation of processes, evidence suggests that the application of product life cycle management has optimized the supervision of the flow of information that allows greater efficiency in management of logistics and reduction communication times, both with internal departments as well as with external clients, but did not affect on the end product.

CHAPTER 5 – CONCLUSIONS

This work aims at examining if and at which extent the Internet of Things influences the process of product innovation of Italian manufacturing firms. Specifically, the main objective is understanding if the integration of a digital component within a product it is the catalyst of innovation. The literature suggests two ways a business can follow for implementing a digital product offer: on one hand, it can integrate the IoT into a previous generation product and revamp it through enhanced functionalities and services, thus increasing the perceived value of the customer; on the other hand, the business can launch a new market offer that, through connectivity, achieves the status of "smart".

Currently, the picture of the adoption of the Internet of Things by Italian manufacturing firms can be summed up by two main considerations well highlighted by the research carried out by the Digital Manufacturing Lab: first, this technology is adopted by a limited number of companies. Secondly, the implementation occurred only recently. For what concern the seven case studies that have been exhaustively examined in the previous chapter, all respondents are aware that innovation is the only way to remain competitive in the market. The integration for most of them is at an experimental phase, so the tendency is initially to focus on offering connected products that complement the traditional range, with the goal of creating greater value for the customer and achieve different customers, rather than new market targets. However, three out of seven adopted this technology since its early stage and today offer a complete range of connected products, even if only one of them has smart products in the full meaning of the word. The businesses that handle more successfully the IoT rely on solid technical knowledge, trustworthy internal and external network relationships, as well as on an organizational culture geared to innovation, that is suitable to deal with a highly competitive environment which is constantly put under pressure by always higher technological expectations by customers. Further, they operate in niche fields, or however, where excellent levels of technical competences are mandatory, like in the case of automation systems or energy efficiency. On the contrary, the companies belonging to traditional Made in Italy sectors are those that show a delay in the employment of the IoT and other technologies 4.0, showing an attitude towards the adoption of this technology mostly focused on firstly achieving efficiency of the internal processes. The in-depth analysis of the cases shows that in the process of product innovation, the Internet of Things is applied interdependently with the other technologies 4.0, like 3D printing or Virtual Reality. There is consensus among the adopters that the main benefit of the IoT within the process of innovation is offered by its capability to gather valuable data about customers, thus opening direct channels that has facilitated companies to offer them greater experiences and extra value that is based essentially on a variety of additional services. However, none of the respondents identify it as a exclusive catalyst of innovation, but rather as one of the key elements that will determine future strategic decisions. As a matter of fact, companies keep investing in this technology also for the given possibilities of increasing revenues through different business models, like through monetization of data, or for exploiting more opportunities in the field of customized services. Others, instead, are focusing on implementing the structures to better exploit data and identify hidden uses and potentialities not yet explored.

The study suffered strong limitations due to the reduced number of firms available for the analysis and to the scarcity of information gathered about some case studies. Furthermore, due to the recent implementation of the Internet of Things in the Italian manufacturing, it is difficult to evaluate the effects and draw conclusions in relation of the extent at which this technology makes a difference in the process of innovation. The suggestion is to keep monitoring the evolution in the coming years of the competitive strategies of companies that employ the Internet of Things in the process of innovation, in order to have a more exhaustive answer to the question to which this work wanted to answer. A possible interesting development is the investigation of the theme within sectors strictly defined as Made in Italy.

BIBLIOGRAPHY

Lectra, 2016. *Zamasport chooses Lectra Fashion PLM: Italian apparel manufacturing company strengthens partnership with Lectra by adopting its product and collection lifecycle management solution*
[Accessed October 2019].

Abdmeziem, M. R., Tandjaoui, D. & Romdhani, I., 2015. *Architecting the Internet of Things: State of the Art.*

Aerospace, Aviation & Defence (ADD) - Knowledge Transfer Network, 2012. *Autonomous Systems: Opportunities and Challenges for the UK - Preliminary Report - Volume 2.*

Albert Opher, A. C. A. O. a. K. S., 2016. *The Rise of the Data Economy: Driving Value through Internet of Things Data Monetization - A Perspective for Chief Digital Officers and Chief Technology Officers.* USA: IBM Global Services .

Andersen, N., Boersch, D. A. & Blohmke, D. J., 2019. *Innovation in Europe - A Deloitte survey on European companies and how digital technologies can strategically enhance innovation.* s.l.: Deloitte University EMEA CVBA.

Anitec - Assinform, 2018. *Digital Trends in Italy - Executive Summary.* Milano: Reggiani Arti Grafiche S.r.l.

Antonelli, G. & Marino, L., 2012. *Sistemi Produttivi Locali e Cluster di Imprese: Distretti industriali, tecnologici e proto-distretti.* s.l.:FrancoAngeli.

Antonova, A., 2018. *Smart Services as Scenario for Digital Transformation.* Sofia, Bulgaria: Center of IST, Sofia University.

Ashraf, Q. M. & Habaebi, M. H., 2015. *Introducing Autonomy in Internet of Things.*

Bettiol, M., Capestro, M., Maria, E. D. & Furlan, A., 2019. *Impacts of Industry 4.0 Investments of Firm Performance: Evidence from Italy.* Marco Fanno Working Papers - 233 : Department of Economics and Management University of Padova .

Boesso, G. & Pastega, L., 2018. *STRATEGIC & BUSINESS PLANNING - methods for effective financial forecasting.* I ed. Milano: Wolters Kluwer Italia .

Bugamelli, M. et al., 2018 . *Productivity Growth in Italy: a Tale of a Slow-motion Change,* s.l.: Banca d'Italia - Eurosistema.

Canna, F., 2019. Industria, investimenti e innovazione nel programma di Governo (e c'è anche Impresa 4.0). *Innovation Post - Politiche e Tecnologie per l'Industria*, Issue 4th of September.

Centro Studi Confindustria, 2019. *Dove Va l'Industria Italiana - Rapporto 2019.* Roma: CONFINDUSTRIA Servizi.

Charlier, M. et al., 2015. *Designing Connected Products - UX for the Consumer Internet of Things.* I ed. s.l.:O'Reilly Media.

Cline, G., 2017. *Integrated Product Lifecycle Management in the Era of IoT.* s.l.:Aberdeen Group.

Cook, A. V., Daejee, J. & Berman, J., 2019. *Deloitte - Intelligent interfaces: Reimagining the way humans, machines, and data interact.*

Cotteleer, M. & Sniderman, B., 2017. *Forces of change: Industry 4.0.*

Daecher, A. & Sniderman , B., 2018. The Innovation Paradox: A Balance between Optimization and Uncharted Waters . In: *The Industry 4.0 Paradox: Overcoming Disconnects on the Path to Digital Transformation.* s.l.: Deloitte Development LLC, pp. 18-27.

Daecher, A. et al., 2018. *The Industry 4.0 paradox: Overcoming disconnects on the path to digital transformation.* s.l.:Deloitte Insights.

De Mauro, A., 2019. *Big Data Analytics: Analizzare e interpretare dati con il machine learning.* I ed. s.l.:Apogeo.

Deloitte, 2018. *The Future of Connectivity in IoT Deployments.*

Di Maria, E. & Bettiol, M., 2014. L'innovazione. In: *Economia e Management delle imprese.* Milano: Ulrico Hoepli Editore, pp. 434-460.

EPSC Strategic Notes, 2017. *Enter the Data Economy: EU Policies for a Thriving Data Ecosystem.* s.l.:s.n.

European Commission, 2017. Italy: "Industria 4.0". *Digital Transformation Monitor*.

Frank, A. G., Dalenogare, L. S. & Ayala, N. F., 2019. Industry 4.0 technologies: implementation patterns in manufacturing companies. *International Journal of Production Economics*.

Gambarini, F., 2017. Beni di Consumo: Lusso Pigliatutto. *Corriere della Sera*, 24 July.

Gates, D. & Bremicker , M., 2017. *Beyond the hype: Separating ambition from reality in i4.0.* s.l.:KPMG International.

Goldenberg, J. & Mazursky, D., 2002. *Creativity in Product Innovation.* I ed. New York, USA: Cambridge University Press.

Harris, P., Hendricks, M., Logan, A. E. & Juras, P., 2018. *A reality check for today's C-suite on Industry 4.0 - The time for experimentation is ending.* s.l.:KPMG International Cooperative.

Hung, M., 2017. *Leading the IoT - Gartner Insights on How to Lead in a Connected World.*

IBM Corporation, 2015. *The impact of the Internet of Things on product development - Discover how to transform your engineering processes and tools to gain a competitive advantage from the Internet of Things.* s.l.:s.n.

IEEE Internet Initiative, 2015. *Towards a definition of the Internet of Things (IoT).*

Istat , 2018. *Rapporto sulla conoscenza 2018 - Economia e Società.* Roma: s.n.

Istat, 2018. Il Piano Nazionale "Impresa 4.0": Prime Valutazioni. In: *Rapporto sulla Competitività dei Settori Produttivi.* 2018 ed. Roma: s.n., pp. 103-123.

Kotler, P. & Keller, K. L., 2016. *Marketing Management.* XV ed. Usa: Pearson .

Kotsemir, M., Abroskin, A. & Dirk, M., 2013. *Innovation Concepts and Tipology - An Evolutionary Discussion,* s.l.: Basic Research program - National Research University Higher School of Economics (HSE).

KPMG, 2017. *The Factory of the Future: Industry 4.0 – The challenges of tomorrow.* s.l.:s.n.

Laudante, E., 2017. *Industry 4.0, Innovation and Design. A new approach for ergonomic analysis in manufacturing system*

Lectra , n.d. *4.0: Empowering customers through industrial intelligence.* s.l.:s.n.

MacDougall, W., 2014. *INDUSTRIE 4.0 - Smart Manufacturing for the Future.* Available at: www.gtai.com

Marr, B., 2016. *Forbes. What is the difference between Artificial Intelligence and Machine Learning.* Available at: https://www.forbes.com/sites/bernardmarr/2016/12/06/what-is-the-difference-between-artificial-intelligence-and-machine-learning/#781142642742

Marr, B., 2018. *What is Industry 4.0? Here's A Super Easy Explanation For Anyone.*

Martins, T. W. & Anderl, R., 2019. *Digital Twins for Space Factory 4.0.* Anaheim, CA, USA, Proceedings of Proceedings of the ASME 2019 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference.

Mazuryk, T. & Gervautz, M., 1999. *Virtual Reality: History, Applications, Technology and Future.* s.l.:s.n.

McEven, A. & Cassimally, H., 2014. *Designing the Internet of Things.* United Kingdom: John Wiley and Sons, Ltd..

McKinsey & Company , 2015. *The Internet of Things: Mapping the Value Beyond the Hype.*

McKinsey & Company, 2015. *Industry 4.0: How to navigate digitization of the manufacturing sector.*

MiSE, 2018. *Italy's National Plan "Impresa 4.0" - Results from 2017 – Actions for 2018.* Rome: s.n.

Moon, Y., 2005. *Break Free from the Product Life Cycle.* s.l.: Harvard Business Review.

Nish-Lapidus, M., 2014. Design for the Networked World: A Practice for the Twenty-First Century. In: *Designing for Emerging Technologies: UX for Genomics, Robotics, and the Internet of Things.* s.l.:Johnatan Follet, pp. 313-328.

OECD & Eurostat, 2005. *Oslo Manual - Guidelines for Collecting and Interpreting Innovation Data.* France: s.n.

Patel, K. K. & Patel, S. M., 2016. Internet of Things-IOT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges. *International Journal of Engineering Science and Computing*, May.

Patel, M., Shangkuan, J. & Thomas, C., 2017. *What's new with the Internet of Things?.*

Porter, M. E. & Heppelmann, J. E., 2014. *How Smart, Connected Products Are Transforming Competition.*

Porter, M. E. & Heppelmann, J. E., 2015. *How Smart, Connected Products Are Transforming Companies.*

Porter, M., Ignatius , A. & Chandrasekaran , N., 2015. *How Smart Connected Products are Trasforming Competition - Annual Meeting of the World Economic Forum.*

Ramakrishnan, R. & Gaur, L., 2017. Innovation in Product Design: IoT Objects Driven New Product Innovation and Prototyping Using 3D Printers. In: *The Internet of Things in the Modern Business Environment.* United States of America: IGI Global, pp. 189-209.

Reguia, C., June 2014. Product Innovation and the Competitive Advantage. *European Scientific Journal,* Volume I.

Romero, D., Larsson , L., Öhrwall Rönnbäck, A. & Stahr, J., 2017. *Strategizing for Production Innovation.* s.l.:s.n.

Romero, I. & Martínez-Román, J. A., 2011. Self-employment and innovation. Exploring the determinants of innovative behavior in small business. *Elsevier B.V.*, 04 August , p. Research Policy 41 (2012) 178– 189.

Rorato, G., 2019. *"Is IoT Changing The Business Model Of Italian Manufacturing Firms?,* Padova: Università degli Studi di Padova - Dipartimento di Scienze Economiche ed Aziendali "Marco Fanno".

Roxana, A. & Cornescu, V., 2019. Product Innovation: A Theoretical Framework of the Concept. In: C. Cojocaru, ed. *International Conference on Economics and Administration.* Bucharest (Romania): Filodiritto Editore – Proceedings.

Salvadori, G., 2019. *Internet of Things in Italia: mercato da 5 miliardi.* Available at: https://www.osservatori.net/it_it/osservatori/comunicati-stampa/internet-of-things-italia-mercato

Shanmuganathan, A., 2018. Product Innovation: Impact of Organizational Culture in Product Innovation. *International Journal of Advancements in Research & Technology,* July, p. Vol 7.

Sharma, A.-M. & Troillet , H., 2019. *Industrie 4.0.*

Sniderman, B., Mahto, M. & Cotteleer, M. J., 2016. *Industry 4.0 and Manufacturing Ecosystem - Exploring the World of Connected Enterprises.*

Techopedia, n.d. *Data-Driven Decision Making (DDDM).*
Available at: https://www.techopedia.com/definition/32877/data-driven-decision-making-dddm [Accessed 4 September 2019].

The Economist, 2012. *The third industrial revolution: The digitisation of manufacturing will transform the way goods are made and change the politics of jobs too.* [Online] Available at: https://www.economist.com/leaders/2012/04/21/the-third-industrial-revolution

Turber, S., vom Brocke, J., Gassmann, O. & Fl, E., 2014. *Designing Business Models in the Era of Internet of Things: Towards a Reference Framework.* Switzerland: Springer International Publishing Switzerland.

V.K.Bairagi, Joshi, S. & Barshikar, S., 2018. *A Survey on Internet of Things.*

Verganti, R., 2009. *Design Driven Innovation: Changing the Rules of Competition by Radically Innovating What Things Mean.* s.l.:Harvard Business School Publishing Corporations.

Vijayakumar, K., Dhanasekaran, C., Pugazhenthi, R. & Sivaganesan, S., 2019. Digital Twin for Factory System Simulation. *International Journal of Recent Technology and Engineering (IJRTE)*, May, pp. Vol. 8, Issue 1S2.

World Economic Forum, n.d. *Our Mission.* Available at: https://www.weforum.org

Zainal, Z., 2007. Case Study as a Research Method. *Jurnal Kemanusiaan* , June, pp. Faculty of Management and Human Resource Development, Universiti Teknologi Malaysia.

Zanardini, M. & Bacchetti, A., 2017. *Industria 4.0 e Manifattura Digitale: Guida pratica per gli artigiani e le micro e piccole imprese.* s.l.:Confartigianato Imprese.

SITOGRAPHY

AP2: www.ap2.it

Aqamai: https://www.aqamai.com/

Arkesys: https://www.arkesys.it/

Big Data: Cosa sono, come utilizzarli, soluzioni ed esempi applicativi: https://www.bigdata4innovation.it/big-data/big-data-analytics-data-science-e-data-scientist-soluzioni-e-skill-della-data-driven-economy/

Definition of RFID: https://internetofthingsagenda.techtarget.com/definition/RFID-radio-frequency-identification, s.d. *RFID (radio frequency identification).*

Elesi Luce: https://www.elesiluce.it/

Elite: https://www.elite-it.com/it

Energia Europa: https://www.energia-europa.com/it/

Hydor: https://www.hydor.com/

Industry 4.0, come il modello "Digital Twin" migliora sviluppo e prodotti: https://www.agendadigitale.eu/industry-4-0/industry-4-0-modello-digital-twin-migliora-sviluppo-prodotti/

Industry 4.0, come il modello "digital twin" migliora sviluppo e prodotti: https://www.agendadigitale.eu/industry-4-0/industry-4-0-modello-digital-twin-migliora-sviluppo-prodotti/

Ipv6 for IoT: https://iot6.eu/ipv6_for_iot.
Monetize you IoT product: https://danielelizalde.com/monetize-your-iot-product/

Philips Lighting cambia Smart Home e Smart City grazie all'IoT: https://www.internet4things.it/smart-building/philips-lighting-cambia-smart-home-e-smart-city-grazie-alliot/

Telemar: https://www.telemar.it/it/

The Evolution of Digital Twin – and How Emerging Tech Is Driving Adoption: https://www.ptc.com/en/product-lifecycle-report/digital-twin-technologies-driving-adoption?utm_source=twitter_free&utm_medium=social_corp&utm_campaign=blog_Dtadoption

Where Moore's Law Is Headed with Big Data: https://datafloq.com/read/where-moores-law-is-headed-with-big-data/4536

Zamasport: https://www.zamasport.it/home

APPENDIX

The list of questions that has been posed during the qualitative interviews.

1) Could you please briefly explain the company's main activity, products and target market?

2) Could you please name the technologies of Industry 4.0 that have been adopted by the firm?

3) Which are the motivations behind the investment in technologies of Industry 4.0?

4) Which results have you obtained with the employment of technologies of Industry 4.0?

5) Has the introduction of technologies of Industry 4.0 led to internal organization changes?

6) How important do you consider internal competences for the adoption of technologies of Industry 4.0?

7) How is innovation managed internally?

8) Have the introduction of technologies of Industry 4.0 led to any change in the relationship with suppliers and the supply chain in general?

9) Do you think that previous investments in ICT (e.g. ERP, website, social media, e-commerce, digital infrastructure, etc) have been important to exploit the potential of technologies of Industry 4.0?

10) Have technologies of Industry 4.0 impacted your business model?

11) Have the firm taken advantage, or at least applied for, Government's incentives (and/or other Regional incentives) or will it apply for them?

12) How do you manage data generated by the Internet of Things? How is it exploited? How is IoT changing your business model?

13) What are the determining factors that have allowed you to innovate the company's products? Do you think the consumer community played an important role in the process?

14) In the context of the IoT, what do you think was the impact that these technologies have had on the product life cycle? If they changed it, how?

15) Which are your expectations from the Competence Center?

Alla mia Mamma & al mio Babbo,

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Grazie.