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“PRODUCT CUSTOMIZATION AND DEVELOPMENT THROUGH IoT TECHNOLOGIES: AN EMPIRICAL STUDY”

RELATORE:

CH.MO PROF. DI MARIA ELEONORA

LAUREANDO: TOALDO TOMMASO

MATRICOLA N. 1179606

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INDEX

INTRODUCTION

In the era of all things digital, new trends are shaping the behaviours of the consumers.

A new relevantly increasing trend is the demand for more personalized services and for the possibility to customize the goods basing on the different tastes and needs that each one may have.

According to different researches, a significant amount of consumers is today expressing interest in purchasing customized products or services for which they are willing to pay more and also be involved in the process of personalization.

However, companies that are willing to pursue a strategy of this kind, giving the possibility to their clients to shape products according to their specific requirements, need some instruments to be able to realize this.

These instruments are today provided by the innovations and the tools of the **Industry 4.0**, among which there is what is defined the "**Internet of Things**".

The purpose of this experimental Master Thesis is to define the concepts of Mass Customization and Internet of Things and then to investigate through an empirical research how they are related and how it is possible to implement a strategy of personalization of the offer using this digital tool.

This work is structured in four chapters. The first chapter analyses from a theoretical point of view the peculiarities and the features that are characteristic of the concept of the Mass Customization. The most relevant theories elaborated by the researchers that studied this topic will be reviewed, listing down all the aspects, the trade offs and different approaches related to Mass Customization.

The second chapter carries out an analysis on the concept of Internet of Things, starting from its development and meanings, reviewing subsequently all the main fields of application that this digital innovation has.

The third chapter investigates how the Internet of Things can be used as an instrument to improve the Customer Experience and how companies can increase the level of their Customer Service and consequently the engagement and the loyalty of their clients through the IoT.

In the fourth chapter an empirical analysis is executed. This analysis is structured in two parts. The first part consists on a quantitative study on a sample of 75 companies, chosen among a list of 500 champions companies, that answered to a questionnaire elaborated by "**Laboratorio manifattura digitale**", a survey done by the DSEA of the University of Padua, from October 2018 to March 2019.

The aim of this analysis is to investigate on the advantages, the objectives, the results and the improvements that these companies obtained after investing in the implementation of the technologies belonging to the concept of Industry 4.0.
In particular, this study focuses specifically on the aspects that distinguish the companies that invested in IoT from those that did not adopt it and, moreover, the research aims at understanding how and why the IoT could be an important tool for the implementation of a strategy of Personalization and Customization of the offer.
The second part of the empirical analysis consists on a qualitative study based on some interviews to three companies operating in different industries that adopted the Internet of Things as an integrative tool for their products but also for their processes.
This second section focuses on the description of these three cases in order to understand how the concept of Internet of Things has been developed in these innovative companies and how it is adopted for the objective of the personalization of the products and of the customer experience. Moreover, the advantages and the future opportunities and challenges that the IoT is opening will be object of the analysis.

CHAPTER 1

The Mass Customization

One of the most significant trends in consumer behaviour, nowadays, is the research for a product that is in line with the needs and preferences of the clients. Customers are increasing their demand for customized products, rather than standardized ones, because they are more conscious of all the alternatives that the market can offer and hence of what they can get.
For this reason, there are some companies that are trying to meet these consumers' needs, implementing some systems that can enable the company to start what can be defined a proper process of Mass Personalization. New ways of conducting their business and manufacturing processes are put in place, thanks to new technologies that have made possible this process of customization of the offer.
In addition to this, it could also happen that a company and its clients collaborate in order to realize a final product that corresponds to some specific requirements of the consumer.
However, this less standardized offer does not come without a cost. Obviously, for a company, trying to make products that fit different tastes of different customers is an expensive feature to put in place. This is why the concept of "**Mass Customization**" has been developed.
The purpose of this approach is to realize some economies in the production of some modules that will then compose the final product, in order to contain the costs that come with the process of matching the offer with the requests of the consumers.
This chapter will analyse the history, the development and the main features of this concept, reviewing all the main theories elaborated by researchers on this topic.

1.1 History of Mass customization

In the period following the era of Mass Production, the complexity of the environment in which companies are competing has significantly increased due to multiple factors. In fact, in all sectors, competition has become more intense and dynamic. Moreover, an increase in variety and variability in the final demand has taken place, which influences also the demand of intermediate goods. For this reason, the market is not as simple and stable as it was during the age of Mass Production.

Referring to the final demand, Calvi (1987) stated that the differentiation and the transformation of the consumer were the phenomena that progressively determined the changing in the relationship between the user and the consuming good. As a consequence, the trend of consumers asking for more personalized solutions has grown, in order to solve in an appropriate way specific needs or maybe just to be different from the others. At the same time, consumers have acquired a position of increased independence from the production process, passing by the position of passive subordination typical of the Mass Production.

More than that, the evolution of production and design technologies has offered the companies new possibilities to respond to the enhanced variety and variability in the demand. Nowadays, there are automatic machines that are capable to execute a wide variety of operations, following the principles of what is defined "**flexible automation**". These machines are controlled by computers and it is possible to connect them inside the organization and also with machines of different organizations that are in different parts of the value chain. According to Di Bernardo and Rullani (1990), this is a paradigmatic phase in the way of producing, characterized by the development and the application of scientific knowledge to the production processes and to the flow and use of the information.

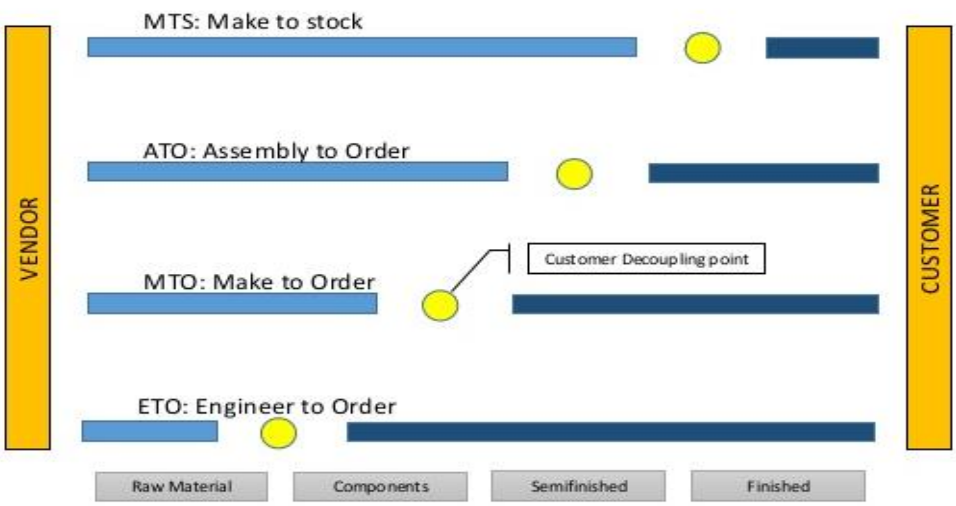
This extension of science to the management of information, through automatic machines, computers and telematic network, has made the production more flexible, creating the possibility to generate a "**low cost variability**".

Flexible automation allows to eliminate the trade off between efficiency and flexibility, characteristic of rigid production technologies. Moreover, to the extent that the flexible automation is implemented, the importance of economies of scale connected to the production of big volumes of standardized goods decreases. As a consequence, it is promoted in this way the division of the work among companies linked in the network.

Ultimately, a production system based on automation, is composed by machines capable to realize a wide spectrum of specific operations, passing from one to the other in short times and at a moderate cost. In this way, it becomes possible to obtain a wide variety of products in **small batches** at low cost. This is the most radical way to implement the "**Mass Customization**", which is a concept attributed to Stan Davis in his work "Future perfect".

1.2 The Wortmann Matrix

Inside a company, there could be different production systems that could differ also from an organizational point of view. For this reason, knowing the characteristics of the production model and being able to govern it in the best strategic way, is one of the most fundamental prerequisites to improve processes and achieve a stable and lasting competitive advantage over time. There are many classifications of the different types of production. Among the most used, there is Wortmann's 5 possible categories (1983): Make To Stock (MTS); Assembly To Order (ATO); Make To Order (MTO); Purchase To Order (PTO); Engineering To Order (ETO). Graphically, we can represent this classification as follows:



[1]

The yellow circle represents, along the entire process of realization of a product, from its design to its final assembly, the point where the customer provides the company with a specific request. For what concerns the behaviour of the customer, the sooner it intervenes, the greater is the possibility that he may have a specific customized product. At the two opposites of this type of request there are, on one hand, the products on the shelf ready for purchase and use and, on the other hand, those for which the customer asks for customization in the phase of design.

Looking instead along the horizontal axis, there is the point of view of the manufacturing company. Here, the possibilities from top to bottom are: mass production when the company offers a catalogue of finished standard products, in a number of variants, ready for purchase and use. Repeated-order production if the company offers a catalogue with the information on

[1] Image source: https://www.slideshare.net/LorenzoLeonelli/wortmann-classification-sap-mapping

the components of the finished products that are then selected by the customer and assembled according to its needs. Single-order production if the company satisfies all requests for customization by the customer.
The “production to order” system can present different characteristics, according to the specific context. Even within the same company, it is possible to find product families that respond to the needs of the different situations. When the complexity of a product increases, some components could be characterized by a repeated job, while others by a single, simple job.
The correct management of these mechanisms allows to realize products with high degrees of customization, keeping constant the overall complexity of the process. Clearly, in order to achieve this result, it is necessary to define specific structures in terms of organisation, skills and processes. Understand where to place the company's products, or their components, in the Wortmann's model, is the first step to improve the quality of the logistical-productive model and thus obtain a stable and lasting over time competitive advantage. Product customization becomes the key to differentiate you from your competitors.

1.3 Characteristics and features of Mass Customization

1.3.1 Methods to implement Mass Customization

Under the evolutionary impulses of the **Information and Communication Technology**, new modalities to respond to the variety of the demand have been developed. These new methods are:

1) Modular design
2) Product incorporated flexibility
3) Personalization through services

The concept of **Modularity** identifies a specific design of the structure and functions of the product. A modular product is composed by **components** relatively **independent** (modules) connected through **standard interfaces**. According to Sanchez and Mahoney (1996), the independence of the components and the standardization of interfaces represent the distinctive features of a modular design.
Modularity of the product allows to make “**Form Postponement**", with all its benefits and costs. Another advantage of product modularity is the ease with which product changes can be made. Modular products, in fact, allow you to change each function of the product by changing only the corresponding component. Modularity allows to meet different needs, in relation to a

single product functionality, using the minimum variety of individual components. The same component is therefore useful for multiple applications.

Information and communication technologies offer an important support to companies that adopt a modular approach to the design of the products. Moreover, this modular approach allows to implement Mass Customization, which means creating a "**low cost personalization**".

First, through modularity, it is possible to broaden the variety of the offer of the products, in order to meet the requests of the consumers with personalized solutions. In fact, because of the existence of standard interfaces, the modules can be combined in many different ways, creating a big variety of final versions of the product, that will increase additionally if one or more attributes of one module are offered in many versions. Hence, the product becomes a virtual entity, that "contains" a **plurality of possible solutions**, each one of them gets material after the consumer has selected it.

Second, modularity allows to reach **economies of scale**, not on the production of the final products, but on the production of **modules.** Standardization is still an efficiency factor, but it is translated backward, without compromising the final variety. Feitzinger and Lee (1997) stated that the key of the Mass Customization consists on the **postponement**, which means moving the phase of the creation of variety to the final part of the production process.

For what concerns the **incorporated flexibility** in the products, these ones can contain a potential of variety related to one or more functional attributes. In this case, the correspondent attribute is not specified in a determined modality, but it offers a range of solutions that allow the **personalization** of the product through the use. Companies try to design products that contain mechanisms of automatic adaptation or adjustability by the user. Depending on different users or different situations, the selected modality of the product can change.

For what concerns the personalization through services, the development of the ICTs have opened new horizons for this modality of personalization, as they are applied to the level of final products and not only to the level of design and production processes. Many companies are now working on projects related with the **robotics for the consumption**. The new frontier of product-incorporated flexibility is represented by "smart products", which allow the user and the product to have a cognitive interaction.

An other approach for personalization consists on using services that integrates the tangible product. This means to offer a variety of possible solutions of service and to personalize a determined service in the interaction with the client. This modality of mass customization is often used in the shops and, for this reason, the collaboration of the retailer is required. Moreover, personalized services that integrates a tangible product are an example of postponement like the modularity.

1.3.2 Features of Mass Customization

In order to take advantage of economies of scale while trying to serve customers as individuals, product modularity and the system of product family architecture are effective approaches to achieve mass customization**. Product family design** offers a systematic instrument to define product platform, the product architecture, and product families. Product platform is "a set of subsystems and interfaces developed to form a common structure from which a stream of derivative products can be efficiently developed and produced" (Meyer and Lehnerd 1997). Product architecting is mainly concerned with how a product is arranged into physical units and how these units interact (Ulrich and Eppinger 1995). Applying **Group Technology** in design means systematically searching, every time when designing a new part or production cycle, for an existing design of a part already made in the past or a production cycle already used in the past, that can be used as a basis for, or even instead of, a new part or a new cycle. This is made possible by classification and coding systems, which organize similar entities into groups (classification) and assign a symbolic code (coding) to these entities to facilitate the recall of information.

The development of a new **platform-based product** is based on the idea of simultaneously developing a whole family of products that address a set of related market needs and have the ability to share components, interfaces between components and production processes. As a result, instead of having multiple development teams each working on a single product, you create a single team to develop a common platform from which you can efficiently and effectively derive multiple products over time. Product platforms are those components of design variables, interfaces between components and production processes, which are common to all derived products generated over time from the platform.

Tseng and Jiao (2001) have elaborated an efficient method to tailor different products according to different customers' requirements based on common product family platform.

There are two types of prevailing product family design: **scalable** product family design and **configurational** product family design (Jiao et al. 1999). Simpson first proposed the scalable approach by using scaling variables at different dimensions to satisfy a variety of customer needs (Simpson 2004). There are two major tasks in scalable product family design. The first one is to determine the appropriate platform. The second step consists on optimizing common and distinctive variables' values to better satisfy performance and economics requirements.

"The scalable product configuration consists on employing scaling variables to shrink or stretch the platform in various dimensions to satisfy diverse customer needs whilst other variables are kept constant. Thus, the important issues are to first decide which variables should take common

value in the product family and then determine the optimal value of the common and distinctive variables in terms of customer needs and design requirements. In modular product configuration, the product is designed from adding, substituting and/or removing functional modules" (CIRP Encyclopedia of Production Engineering).
The other type of product family design is configurational product family design based on modular product architectures. It is also called **module-based product family design** (Ulrich, 1995). The modular product configuration makes use of modular components. Various modules can be introduced independently or combined in different ways to satisfy customer's heterogeneous needs.
Standardisation of a component is another feature that characterizes Mass Customization. It means increasing the level of commonality of that component within the company's product range, which means increasing the number of occurrences of that component in the BOMs of all finished articles produced by the company. In other words, component standardisation is the result of including a part, currently used for existing products, in a new product, instead of developing a new part specifically for the new product. A standardised part is purchased or produced in higher volumes, thus allowing for greater economies of scale and learning

1.3.3 Product Configuration system

Product configuration is an instrument that aims at the satisfaction of customer requirements as it attempts to elicit customer needs and map the needs to design parameters (Piller and Tseng 2010; Wang and Tseng 2014c). A product configurator consists on a set of predefined components or attributes that regulate their combination. It takes customer needs as input and the output is the desired product variant.
The product configuration implies the generation of a valid, complete and consistent description, including delivery terms and price, of the product variant that the customer is willing to buy and that the company agrees to provide (**commercial configuration**) and, subsequently, the translation of this description in the operating instructions necessary to build that product variant (**technical configuration**). Product configuration requires the exchange of information between customers, sales and technical personnel. Implementing a software-supported configuration process accelerates order acquisition, eliminating the need for sales staff to contact customers again due to configuration errors, minimizing the need for technical support to sales staff and reducing the time spent by sales staff formalizing product specifications. At the same time, the productivity of the technical department increases.

User innovation, data mining and Web learning are the main techniques of customer requirement acquisition and reasoning about user experience (Zhou et al., 2011a). New cyber-physical platforms, such as Web 2.0, cloud computing, P2P and SecondLife, offer great potential for implementing value chain platforms into online personalization engines.

1.3.4 Flexible manufacturing for mass customization

Another critical feature for mass customisation is a flexible manufacturing process, as the exponentially increased number of process varieties significantly challenges production planning and control of conventional manufacturing process (Tian et al. 2008; Terkaj et al. 2009a). From mass customization perspective, two approaches have been employed to improve the flexibility of a manufacturing process.

Manufacturing process family is one important approach. This concept consists on incorporating a set of similar production processes for various products to achieve economy of scale by utilizing the common components and standardized product platform designed within a product family. Thus, the manufacturer is able to configure the production process with quick response to product design change, by exploiting the similarity among the product variety and production process (Colledani et al. 2008).

Manufacturing for mass customization also relies on the availability of flexible manufacturing system. In addition, the system should be integrated with modern Information and Computer Technology (ICT) as well as the flexible or reconfigurable manufacturing tools, to reduce the response time from designing a new product to the production phase (Terkaj et al. 2009b).

The flexibility in workforce and production management systems are also key aspects to achieve the goals of mass customization. With more educated human resource it will be possible to meet diverse requirements without increasing cost. In addition, robust production control is essential to achieve on time delivery despite the complexity of materials management and logistics to realize mass customization.

In order to realise Mass Customization, a **Three-dimensional concurrent engineering** must be achieved. This means coordinating product design with production process design and supply chain design. Product design includes preliminary design decisions and detailed design decisions. The design of the production process includes decisions on the production system and detailed design decisions. Supply chain design includes architectural decisions and logistical and coordination decisions. Product design decisions, production process design and supply chain design are interdependent, and these interdependencies are closer when a company offers product variety and customization. Failure to recognize and manage these interdependencies can lead to costly and time-consuming re-designs, as well as lower-than-expected or even negative profits.

Evidently, since Three-dimensional Concurrent Engineering requires the contribution of different skills and functional areas, its feasibility depends on the interaction and collaboration between different people and areas of the company.

Finally, it is also important to **reduce Set-up times**. Set-up is an inevitable consequence of the product variety. Set-up operations consume resources but do not add value to products, thus reducing efficiency. Improving set-up is one of the main ways a company can increase efficiency when offering a wide variety of catalogue or custom products in small batches. According to the traditional method, the only way to reduce the total time spent on set-ups in a given period of time, is to reduce the number of set-ups in that period of time. This is achieved by increasing the size of the production batch.

Organisational changes include changing set up procedures so that most of the set-up work can be done while the machine continues to produce (external set-up). Obviously, with the same number of set-ups, if the time required for a single set-up is reduced, more time is made available for production activities.

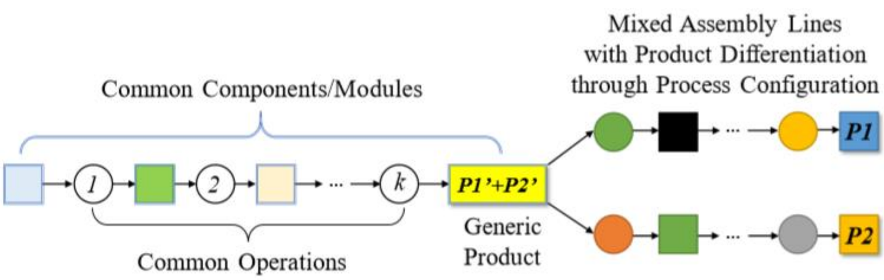
1.3.5 Reconfigurable manufacturing system

Product variety can be very high under mass customization regime in order to cope with the changing product mix and demands. Reconfigurable manufacturing systems (RMS) were proposed by Koren et al. (1998). An RMS is a system that is aimed at executing rapid changes in its structure and control in order to adjust its production capacity and functionality in response to sudden market changes. It should be noted that RMS is different from flexible manufacturing system in the sense that RMS attempts to increase the manufacturing's responsiveness to markets and customers and flexible manufacturing system aims at increasing the variety of part produced. The flexibility of a RMS is confined within the product family.

1.3.6 Delaying differentiation

To manage the high uncertainty and variety in manufacturing systems, delayed product differentiation or postponement strategy is widely used in industry. It consists on a manufacturing process that makes a generic or family product at the beginning and differentiate into a specific end-product in the later stage, when more information about the demand is obtained. Thus, the phase in which the products take their unique customized characteristics is postponed. The processes and assemblies are common up to the point of differentiation. Such postponement reduces cost and improves responsiveness of the assembly systems (Lee and Tang, 1997; Ko and Hu, 2008).

Figure 2 illustrates how delayed product differentiation is achieved though process configuration, with postponement of variety fulfilment. Multiple end-products can share those common components/modules and the corresponding fulfilment processes at initial stages, leading to a generic product that is the same before the differentiation. At a certain point, custom components/modules or specialized processes are enacted to customize the generic product into a different end-product. Therefore, mass customization is empowered by designing product platforms and reengineering the manufacturing processes to delay decisions about specific products as late as possible.



[2]

1.3.7 On-demand manufacturing system

To increase the responsiveness to customer demands, it is critical for manufacturing system to fabricating personalized product features and modules and assembling these modules with other manufacturer supplied modules flexibly. Additive manufacturing has been considered as an enabling technology towards personalization (Srinivasan and Bassan 2012). It can create 3D

[2] Image source: M. Tseng, Y. Wang (2017), Mass customization

solid objects directly from a CAD model cost-effectively. In addition, a cost effective on-demand assembly system should be able to configure and reconfigure product in response to customers' personalized designs.

1.3.8 Cyber-physical systems

Cyber-Physical Systems consist on engineered systems that are built from and depend upon the synergy of computational and physical components (NSF report - Cyber-physical systems 2012). To support the personalization collaboration and the on-demand manufacturing, it is necessary to integrate computational tools with the physical design and manufacturing systems. The development of new user interface methods and tools for personalized production will be critical to support the user experience and collaborative, distributed design approaches.

1.4 Trade-offs and success factors of Mass Customization

Mass customization is a concept that was first introduced by Davis (1987) and then developed by Pine (1993), who defined it as ''developing, producing, marketing and delivering affordable goods and services with enough variety and customization that nearly everyone finds exactly what they want.'' A more pragmatic view of this theory has been proposed more recently by Salvador et al. (2009), who defined mass customization as ''a process for aligning an organization with its customer's needs.''

In order to implement Mass Customization, there are some trade-offs to take in consideration, trade-offs between customization and cost, lead time, productivity, and quality. A company that aims at realizing Mass Customization must identify which are the best practices that can balance this factors and moderate this trade off.

According to Agrawal et al. , Zipkin (2001), by reducing these trade-offs, companies also decrease the sacrifices made by consumers in order to obtain a mass-customized product, such as those related to the price premium and delivery time. However, it is not enough to provide an efficient customization, in fact, a key component of the success of this approach is the perceived benefits that consumers derive from a specific mass customization offer.

Concentrating on production technologies, while overlooking consumer value, is a reason for the failures of some programs, as this leads to an inadequate market offering (Ahlstro ̈m and Westbrook 1999). For this reason, according to Squire (2006), in addition to understanding how to deliver efficient customization, manufacturers that adopt mass customization need to take into consideration which is the process through which this strategy creates value for the consumer and to measure the components of this specific value.

Pine (1993) described Mass Customization as mitigating and ideally eliminating the trade-offs between customization and other dimensions of operational performance. Based on this approach, several authors have defined the concept as the capacity to quickly produce a relatively high volume of customized products without substantial trade-offs, as compared with those existing in mass production (e.g., Huang et al. 2008, Liu et al. 2006, MacCarthy 2004, Squire et al. 2006, Tu et al. 2001).

Squire et al. (2006) examined the impact of customization on four competitive priorities: quality, cost, delivery lead times and reliability, and volume flexibility. They showed that customization can have a negative effect on manufacturing costs and delivery lead times

1.5 Disadvantages of the increase of variety

The increase in the product variety offered by a company has an impact:

- On the costs incurred by the company itself;
- On the times required by the company's activities;
- On the quality of products.

The following is a ranking of the negative consequences of greater customization, and therefore variety, of the product:

1) Higher material costs
2) Higher manufacturing and assembly costs
3) Less punctuality in product deliveries
4) Worse delivery performance of suppliers
5) Greater order fulfilment times
6) Lower quality of products

On average, therefore, the negative consequences of a greater variety of products mainly concern costs, secondly time and, lastly, quality.

1.6 Creation and delivery of value for the consumers

The creation and the delivery of value is one of the key points in marketing. Woodruff (1997) states that finding how to create and deliver superior consumer value is an everyday concern of marketing managers. Zeithaml (1988) defined global value as ‘‘the consumer’s overall assessment of the utility of a product based on perceptions of what is received and what he is given.’’

Researchers have identified two global sources of value in mass customization: the **product** and the **mass customization experience** or co-design process (Fiore et al. 2004, Franke and Piller 2004, Schreier 2006). During the customization process, the value that consumers will derive from the consumption of the product is anticipated before and during the process of ‘‘elicitation’’ (Kahn 1998) of a mass customization system.

Researchers of this topic have also identified three perceived benefits of mass-customized products: utilitarian, uniqueness, and self-expressiveness values (Franke, Schreier, Kaiser 2010)

Utilitarian value, which is related to the extent to which a mass-customized product fits individual preferences, integrates both aesthetic and functional fit, depending on the product category (Schreier 2006). Franke and Schreier (2008) found a positive link between this perceived benefit and the willingness to pay a premium for mass customization.

A second value component is the **Uniqueness value** (Schreier 2006). The mass-customized product enable consumers to express their individuality by exhibiting ‘‘uniqueness attributes’’ (Snyder 1992). Fiore et al. (2004) confirmed that the desire to obtain a unique product is one of the motivations behind participation in mass customization programs. Franke and Schreier (2008) identified a positive impact of the perceived uniqueness of a mass-customized product on the utility consumers derive from mass customization.

Self-expressiveness value comes from self-concept theory (Sirgy 1982) and corresponds to the benefit of owning a product that reflects one’s own image, regardless of whether the consumer wants to assert his/her identity.

A mass customized product is a possibility for the consumers to express their personalities, since they can choose from among several options.

When implementing Mass Customization, it is also important to ‘‘support customers in identifying their own solutions’’ (Salvador et al. 2009). In fact, marketing scholars have shown that the co-design process can have intrinsic value for the consumer (Franke and Piller 2003).

Two perceived benefits of this process have been identified: hedonic value and creative achievement value.

Hedonic value denotes the joy and entertainment derived from the experience. In their empirical study, Fiore et al. (2004) supported the link between the desire for an exciting experience and the willingness to use a mass customization program. In addition, Franke and Schreier (2006b) showed that hedonic value significantly influences the willingness to pay a premium for mass customization.

Creative achievement value refers to the ‘‘pride of authorship’’ identified by Schreier (2006). When consumers have the autonomy to personalize their products, they feel like they have created something.

Five benefits have been identified. The first three benefits related to the product are applicable to any mass customization strategy, whereas the benefits related to the co-design process value are appropriate only for mass customization strategies that include co-design.

Table 1 provides detailed definitions of these five perceived benefits considering two groups: the mass-customized product and the co-design process.

Table 1

PERCEIVED VALUE	**DEFINITION**
Mass-customized product value	
Utilitarian value	Value acquired from the closeness of fit between product characteristics and individual preferences
Uniqueness value	Value acquired from the opportunity to assert personal uniqueness using the customized product
Self-expressiveness value	Value derived from the opportunity to possess a product that is a reflection of personality
Co-design process value	
Hedonic value	Value acquired from the experience's capacity to meet needs related to enjoyment, fun or pleasure
Creative achievement value	Value acquired from the feeling of accomplishment related to the creative task of co-design

[3]

[3] Table source: Personal reworking

1.7 The 5 steps of Pine

Joseph Pine in his book provides five steps that a company can follow to move from a Mass Production, and thus a Cost Leadership strategy, to a Mass Customization.

1. Customize services around standardized goods/services.
2. Create customizable goods/services.
3. Provide customization at the point of distribution.
4. Provide a fast response in every part of the value chain.
5. Modularize components to customize finished products/end services.

Following the given order allows to start from the easiest methodology and to make a gradual change that transforms the mentality of human resources, which is one of the most difficult challenges to face when you decide to undertake a change. In fact, Pine talks about increasingly pervasive and fundamental techniques that require more drastic changes and the improvement of the entire business organization, including development and production. None of these methods is mutually exclusive and in practice are often overlapping; many companies use a combination of some and occasionally all of them.

1 Customize services around standardized goods/services.

Standardized goods and services can be customized before being delivered to customers in the Marketing and Distribution phases. These two functions can change the product, add features, combine it with other products (also from other companies) and provide many services that allow each consumer to receive the individual attention they want. The strong point consists on the possibility provided to the customer to customize their purchase by choosing from a very wide range of components, but produced in a standardized manner.

2. Create customizable goods/services.

In this case, during the design phase, products and services, that are essentially mass-produced but that are customizable by each customer, are created. The primary activities of the value chain which are involved are Design and Marketing.

3. Provide customization at the point of distribution.

The only way to know exactly what the consumer wants, is to be at the point of sale heard it or understand it from him. Moreover, the only way to instantly give him exactly what he wants, is to produce it right at the point of sale.

4. Provide a fast response in every part of the value chain.

Providing a quick, almost instantaneous, response to customer needs is one of the best ways to push the entire organization towards mass customization. Entrusting the distribution function with the task of quickly meeting consumer demands, triggers a chain reaction that starts at the point of distribution and goes back through marketing and sales, production and finally process development.

The absolute key to success, with this method, is the electronic and staff integration of the value chain through instantaneous information passages, common databases, multifunctional teams. Through multiple companies or through multiple functions of the same company, each link in the value chain must know not only what wants who is in the phase but what is the real demand, the real desires and needs of the real consumer, who is at the bottom of the value chain.

Reducing the time taken to travel the value chain goes hand in hand with market fragmentation, the proliferation of variety and customisation. This is the Time-Based Competition, which is the acquisition of a competitive advantage through a reduction in delivery times to the customer or, otherwise, through a faster responsiveness to external stimulations than the competition.

Fast response to the market is a technique that is made possible through continuous collection of data, fast replanning and very fast production/distribution processes.

5. Modularize components to customize finished products/end services.

The best way to achieve mass customization, minimizing costs and maximizing customization, is to create modular and interchangeable components that can be configured into a huge variety of finished products and services. The Economies of scale are obtained through components and not through products, while customization is obtained by the myriad of possible product combinations.

1.8 Pine model: 4 approaches to Mass Customization

The researchers Joseph Pine and James Gilmore have elaborated a model to analyse some potential approaches to Mass Customization. They made this study in order to help those who want to implement Mass Customization, as this strategy could represent a double-edged sword. In fact, it could be very profitable if well executed, but, at the same time, it could also be a source of unnecessary cost and complexity.

Pine and Gilmore have identified four distinct approaches to customization, which they call collaborative, adaptive, cosmetic, and transparent. They assess that, when designing or redesigning a product, process, or business unit, managers should examine each of the approaches for possible insights into how to best serve their customers. In some cases, a single approach will dominate the design. More often, however, managers will discover that they need a mix of some or all of the four approaches to serve their own particular set of customers.

Collaborative approach

The collaborative approach consists on conducting a dialogue with individual customers to help them articulate their needs, to identify the precise offering that fulfils those needs, and to make customized products for them.

This approach is the one which is most often associated with the term mass customization, and it is appropriate for businesses whose customers cannot easily articulate what they want and have some difficulties to select from a lot of options.

"Customers in these industries have to make onetime decisions based on difficult and multidimensional trade-offs—trade-offs such as length for width, comfort for fit, or complexity for functionality. This either/or sacrifice gap built into the onetime decision points toward the need to work directly with individual customers in order to determine together the customized goods or services they require. Customizing the representation permits customers to participate in the design stage and play with the possibilities available to them" (Harvard Business Review).

Pine and Gilmore state that most collaborative customizers focus on design and that design stage, however, is not the only place in the value chain where companies can apply this approach. In the case of collaborative delivery services, customers specify exactly where, when, and how to place goods, which then drives the entire flow of work processes.

Adaptive approach

Adaptive approach consists on an offer of one standard, but customizable, product that is designed so that users can alter it themselves.

The adaptive approach is appropriate for businesses whose customers want the product to perform in different ways on different occasions, and available technology makes it possible for them to customize the product easily on their own.

“Rather than provide customized offerings, adaptive customizers create standard goods or services that can easily be tailored, modified, or reconfigured to suit each customer’s needs without any direct interaction with the company. Each customer independently derives his or her own value from the product because the company has designed multiple permutations into a standard, but customizable, offering. It is the product itself, rather than the provider, that interacts with customers.

Adaptive customization is the approach of choice also when users want to reduce or eliminate the number of times they have to experiment with all the possible configurations to get the product to perform as they desire” (Harvard Business Review).

Pine and Gilmore assess that collaboration is the right approach when each customer has to choose from a vast number of elements or components to get the desired functionality or design. But, when the possible combinations can be built into the product, adaptive customization becomes a promising alternative for efficiently making many different options available to each customer.

In most cases, adaptive customizers transfer to customers the power to design, produce, and deliver the final goods or services.

Cosmetic Approach

The cosmetic approach presents a standard product differently to different customers. The cosmetic approach is appropriate when customers use a product the same way and differ only in how they want it presented. Rather than being customized or customizable, the standard offering is packaged specially for each customer. For example, the product is displayed differently, its attributes and benefits are advertised in different ways, the customer’s name is placed on each item, or promotional programs are designed and communicated differently. Although personalizing a product in this way is, frankly, cosmetic, it is still of real value to many customers.

“A company should adopt the cosmetic approach when its standard product satisfies almost every customer and only the product’s form needs to be customized. In doing so, the company visibly demonstrates that it understands the unique ways in which each customer likes the standard product to be presented. In some cases, companies can easily tailor their processes to include simple information about the customer—as simple, in fact, as his or her name—without the dialogue associated with collaborative customization.

When performed well, cosmetic customization replaces piecemeal and inefficient responses to customers’ requests with a cost-effective capability to offer every customer the exact form of the standard product he or she wants” (Harvard Business Review).

Transparent approach

The Transparent approach provides individual customers with unique goods or services without letting them know explicitly that those products and services have been customized for them.

“The transparent approach to customization is appropriate when customers’ specific needs are predictable or can easily be deduced, and especially when customers do not want to state their needs repeatedly. Transparent customizers observe customers’ behaviour without direct interaction and then inconspicuously customize their offerings within a standard package.

Transparent customizers fulfil the needs of individual customers in an indiscernible way—changing the product for them but in such a way that they may not even know that the product has been customized. Instead of requiring customers to take the time to describe their needs, transparent customizers observe behaviours over time, looking for predictable preferences. Of course, this attribute requires a business to have the luxury of time to deepen its knowledge of customers and to move progressively closer to meeting individual preferences. To become a transparent customizer, a business also must have a standard package into which its product’s customized features or components can be placed. Transparent customization is the precise opposite of cosmetic customization, with its standard content and customized package. Businesses ripe for transparent customization are those whose customers do not want to be bothered with direct collaboration” (Harvard Business Review).

Pine and Gilmore state that, instead of focusing on homogeneous markets and average offerings, mass customizers have identified the dimensions along which their customers differ in their needs. These points of common uniqueness reveal where every customer is not the same. It is at these points that traditional offerings, designed for average requirements, create customer sacrifice gaps: the difference between a company’s offering and what each customer truly desires.

“Altering the product itself for individual customers provides the most clear-cut means of customization. But adept mass customizers realize that customizing the actual product is only one way to create customer-unique value. Customizing the representation of the product, or how it is presented or portrayed to the customer, can be effective as well. In fact, separating the product from its representation can provide a useful framework for considering which forms of customization are most appropriate for a given business.

Each of the four customization approaches used alone challenges the mass production paradigm of offering standard goods or services to all customers. Many companies, however, combine two or more approaches

The key is to draw on whatever means of customization prove necessary to create customer-unique value” (Harvard Business Review).

The four approaches to customization provide a framework for companies to design customized products and supporting business processes. They demonstrate the need to mix the direct interaction of collaborative customization, the embedded capabilities of adaptive customization, the forthright acknowledgment of cosmetic customization, and the careful observation of transparent customization into one’s economic offerings. Customers do not value merchants who recite monolithic mantras on customer service; they value, and buy, goods and services that meet their particular set of needs. There is a time to conduct a dialogue with customers and a time to observe silently, a time to display uniqueness and a time to embed it. Businesses must design and build a peerless set of customization capabilities that meet the singular needs of individual customers.

In the following graph, the four approaches to Mass Customization are represented, according to the level of change in the Product and the Representation.

PRODUCT		
Change	**Transparent**	**Collaborative**
No Change	**Adaptive**	**Cosmetic**
	No Change	Change
	REPRESENTATION	

[4]

[4] Table source: personal reworking

Chapter 2
The internet of things

One of the new most relevant trends of the “Industry 4.0” is what has been defined by Kevin Ashton in 1999 as “Internet of things”.

This concept can be considered as an evolutionary step of the use of the web, where “Things” become smart, which means that they are able to communicate data about themselves and access to information about objects, creating in this way an interconnected network of smart objects. The most important characteristics of these objects are identification, connection, localization, capability to elaborate data and to interact with external environment.

The objective of Internet of things is that the electronic world creates a map of the real world, giving an electronic identity to the things and places of the physic world.

Internet of things can have many applications and, among these, there is the Mass Customization.

In fact, it is through the instruments of the internet of things that is possible to initiate a relationship and a collaboration with the customers, in order to put in place the customization of the products.

This chapter will execute an overview on the concept of Internet of Things, describing its development and its main features and functionalities. Subsequently, the main fields of applications of this technology will illustrated and analysed.

2.1 History and implications of Internet of things

Over the last several years, technologies like Radio Frequency Identification (RFID), that allow to embed physical objects with sensors and actuators, and to connect them using wireless networks and the protocol that connects the Internet, make possible the merger of information networks and physical network to form what has become known as the “Internet of Things” (IOT).

Sap, the developer of enterprise resource systems, describes the Internet of Things as follows: “A world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes. Services are available to interact with these "smart objects" over the Internet, query and change their state and any information associated with them, taking into account security and privacy issues".

2.1.1 The development of the Internet of Things

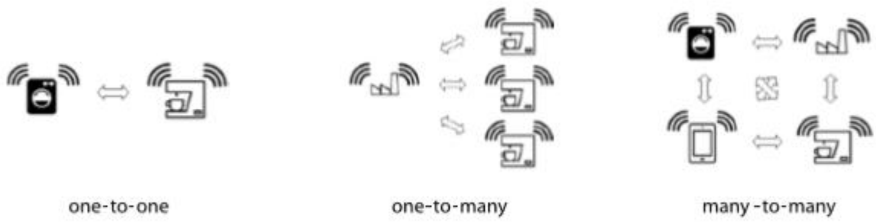
In 1991, Weiser has used the term "ubiquitous computerization" for the first time, anticipating common computerization, which then manifested in the exploitation of IT technologies in a large number of devices applied in various areas of a professional and private life. The term IOT was invented shortly after, in 1999, by Ashton (2009), who used this term in a presentation prepared for the Procter & Gamble company. He described the IOT as an ecosystem of devices equipped with sensors, communicating and exchanging data with each other. Ashton anticipated that these devices will be able to collect information on their own and that sensor technology will enable them to observe, identify and understand the world without restrictions due to the necessity of data input by humans.

Kortuem, Kawsar, Sundramoorthy, & Fitton, (2010) referred to the devices described by him as smart objects. Thus, IoT is defined as a set of devices that are capable of network communication and of processing data transmitted and identified by the network itself.

Among the essential areas of the IoT applications Vermesan and Friess (2014) list the fields like "smart cities," energy, transport, home, industry, health, logistics, industry, security and co-participation. Atzori, Iera, and Morabito (2014) group the IoT applications in five general domains: transport and logistics, health care, intelligent environment, personal and social applications and futuristic applications.

Atzori, Iera, and Morabito (2010) pointed out the followings as the characteristics of the IOT: autonomy and proactive behaviour, awareness of the environment, cooperation in the field of communication and data exchange.

Porter and Heppelmann (2014) defined three basic dimensions of the Internet of Things: one-to-one communication, one-to-many communication, and many-to-many communication



[5]

Smart objects communicating with each other can achieve such functionalities as monitoring, control, process optimization and autonomy. It is claimed that smart devices would be able to communicate anytime, anywhere and by any media (Atzori, et al., 2010). In addition, a jump in the technological development from ‘smart’ to ‘socially aware’ level is expected.

According to the predictions, the next generation of smart devices, called social objects, will be characterized by such functionalities as interaction with other objects in an autonomous way, the ability to search the Internet of Things (i.e. the network of billions of objects) in order to obtain relevant information and the ability to manifest its existence in order to provide services to the network (Atzori, et al., 2010). Atzori et al. (2014) stated that devices would become blog-jets, that is they will actively communicate with the environment. It means that their users will become an element of the ecosystem in which mutual interactions with intelligent devices will take place.

2.1.2 IoT functionalities and emerging applications

Internet of things is a tool that can open new ways of doing business, give the potential to improve processes, and more possibilities to reduce costs and risks. In fact, it is possible to generate an incredible amount of **data** from the information network by putting sensors on “things” and, in this way, it is possible to both **sense the environment** and **communicate among the things.**

“Operation managers can **track and analyse the data** to understand what is happening, even in complex systems, and respond quickly if necessary. This helps operations save significant amount of money in lost, stolen or wasted products by helping manufacturers, distribution companies and retailers to pinpoint exactly the **position and state of every item** in the supply chain. So, for example, if a product had to be recalled because of a health-risk scare, the exact location of every potentially dangerous product could be immediately identified. Shoppers could easily scan a product to learn more about its characteristics and features while they are in the store, waiting at checkout counters could be eliminated because items will be scanned automatically by readers, the bill could even be automatically debited from your personal account as you leave the store. Data on how customers use products can be collected automatically and accurate recycling of waste materials could be made considerably easier” (Slack et al. 2016).

[5] Image source: L. Marek , J.Woźniczka, The Internet of Things as a customer experience tool

According to Michael Chui, Markus Löffler, and Roger Roberts, who made a research on this topic for Mckinsey, there are six distinct types of emerging applications that fall into two broad categories: first, **information and analysis** and, second, **automation and control**.

Information and analysis

Because IOT networks link data from products, equipment, processes and the operating environment, they will produce enhanced information and more sophisticated analysis, which can augment operations management decisions. In particular three aspects of information and analysis could be affected:

1) **Tracking behaviour** :

Tracking will be easier because the movement of products and their interactions with processes will be monitored in real time. "When products are embedded with sensors, companies can track the movements of these products and even monitor interactions with them. Business models can be fine-tuned to take advantage of this behavioural data. In the business-to-business marketplace, one well-known application of the Internet of Things involves using sensors to track RFID (radio-frequency identification) tags placed on products moving through supply chains, thus improving inventory management while reducing working capital and logistics costs. The range of possible uses for tracking is expanding " (Chui, Loffler, Roberts, 2017)

2) **Enhanced situational awareness**:

The data from a large number of sensors, located in such infrastructural resources as roads and buildings, can report on conditions so that managers have an instantaneous awareness of events, particularly when the sensors are used with advanced display or visualization technologies. "Some advanced security systems already use elements of these technologies, but more far-reaching applications are in the works as sensors become smaller and more powerful, and software systems more adept at analysing and displaying captured information. In this way, managers are increasing their ability to make constant routing adjustments that reduce congestion costs and increase a network's effective capacity" (Chui, Loffler, Roberts, 2017).

3) **Sensor-driven decision analytics**

"The Internet of Things also can support longer-range, more complex human planning and decision making. The technology requirements—tremendous storage and computing resources linked with advanced software systems that generate a variety of graphical displays for analysing data—rise accordingly

Automation and control

Controlling any operation or process involves monitoring what is actually happening within the operation or process, comparing what is actually happening with what should be happening, then making any necessary interventions to correct any deviations from what should be happening. So monitoring and data collection are at the heart of the control activity, and monitoring and data are what the IOT is particularly good at. When information is fed back through a network to some kind of automation that can intervene and modify process behaviour, control can be exercised (theoretically at least) without human intervention.

For this reason, closing the loop from data to automated applications can raise productivity, as systems that adjust automatically to complex situations make many human interventions unnecessary. Again, three aspects could be affected:

1) **Process optimization**:

"Process that can be controlled can be more easily optimized. sensors feed data to computers, which in turn analyse them and then send signals to actuators that adjust processes. Sensors and actuators can also be used to change the position of a physical object as it moves down an assembly line, ensuring that it arrives at machine tools in an optimum position (small deviations in the position of work in process can jam or even damage machine tools). This improved instrumentation, multiplied hundreds of times during an entire process, allows for major reductions in waste, energy costs, and human intervention" (Chui, Loffler, Roberts, 2017).

2) **Optimized resource consumption**:

"Knowing exactly how much resource is being used can help in reducing costs. Networked sensors and automated feedback mechanisms can change usage patterns for scarce resources, including energy and water, often by enabling more dynamic pricing. Data centers, which are among the fastest-growing segments of global energy demand, are starting to adopt power-management techniques tied to information feedback. Power consumption is often half of a typical facility's total lifetime cost, but most managers lack a detailed view of energy consumption patterns. Getting such a view isn't easy, since the energy usage of servers spikes at various times, depending on workloads. Furthermore, many servers draw some power 24/7 but are used mostly at minimal capacity, since they are tied to specific operations.

Manufacturers have developed sensors that monitor each server's power use, employing software that balances computing loads and eliminates the need for underused servers and storage devices. Greenfield data centres already are adopting such technologies, which could become standard features of data centres infrastructure within a few years" (Chui, Loffler, Roberts, 2017).

3) Complex autonomous systems:

"The most demanding use of the Internet of Things involves the rapid, real-time sensing of unpredictable conditions and instantaneous responses guided by automated systems. This kind of machine decision making mimics human reactions, though at vastly enhanced performance levels.

Here below the six distinct types of emerging applications are summed up with some examples reported (Chui, Loffler, Roberts, 2017)

Information and analysis			Automation and control		
1 Tracking behavior	**2 Enhanced situational awareness**	**3 Sensor-driven decision analytics**	**1 Process optimization**	**2 Optimized resource consumption**	**3 Complex autonomous systems**
Monitoring the behavior of persons, things, or data through space and time.	Achieving real-time awareness of physical environment.	Assisting human decision making through deep analysis and data visualization	Automated control of closed (self-contained) systems	Control of consumption to optimize resource use across network	Automated control in open environments with great uncertainty
Examples: Presence-based advertising and payments based on locations of consumers Inventory and supply chain monitoring and management	*Example:* Sniper detection using direction of sound to locate shooters	*Examples:* Oil field site planning with 3D visualization and simulation Continuous monitoring of chronic diseases to help doctors determine best treatments	*Examples:* Maximization of lime kiln throughput via wireless sensors Continuous, precise adjustments in manufacturing lines	*Examples:* Smart meters and energy grids that match loads and generation capacity in order to lower costs Data-center management to optimize energy, storage, and processor utilization	*Examples:* Collision avoidance systems to sense objects and automatically apply brake Clean up of hazardous materials through the use of swarms of robots

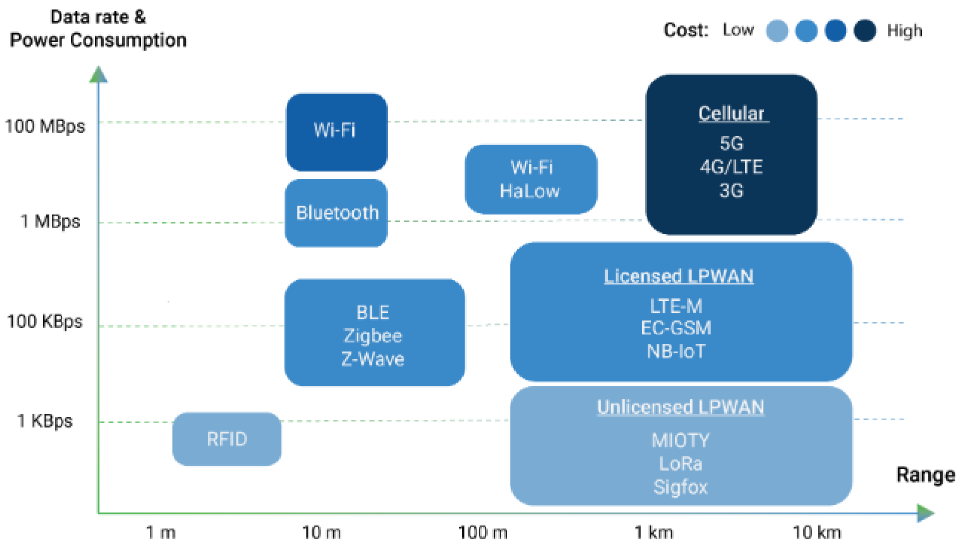
[6]

[6] Image source: Chui, Loffler, Roberts, 2017, The internet of Things

2.2 IoT Technology tools for Mass customization

The Internet of Things is a concept based on connectivity but, since IoT has a widely diverse and multifaceted spectrum of applications, there is not a unique communication solution that can fit in all situations.

There are different types of solutions that it is possible to find more commonly. Each solution has its strengths and weaknesses in various network criteria and is therefore best-suited for different IoT use cases.



Positioning of different IoT wireless tech (Adapted from: IoT for all)

[7]

Here in this graph are represented the main technologies that belongs to the IoT. These technologies are **LPWAN** (Low Power Wide Area Network), which aims at creating large scale IoT networks spreading over vast industrial and commercial campuses.

Then there is **RFID** (Radio Frequency Identification) which uses radio waves to transmit small amounts of data from an RFID tag to a reader within a very short distance.

There are also technologies like the **Cellular 3G, 4G, 5G**, which are well-established in the consumer mobile market and offer reliable broadband communication supporting various voice calls and video streaming applications.

[7] Image source: https://behrtech.com/lpwan-technology/

Subsequently, there is the well known **Bluetooth**, which is a short-range communication well-positioned in the consumer marketplace.

Then **Wi-Fi**, which is ubiquitous in every environment today, but a bit less significant than other technologies for IoT.

All this group of technologies can serve companies in order to install profitable relationships with customers, but, more in general, with all the people that have access to these tools, that, nowadays, is the most part of the population in the world. Hence, companies have the possibility to get the data they need to develop their products and then to realize economies applying mass customization, basing their production schedule on the preferences of their customers.

According to Mckinsey researchers Gandi, Magard, Roberts, implementing Mass Customization for big global companies is a key step: “The benefits for successful companies are compelling, not least for global brands struggling with a decrease in loyalty after the recession and eager to avoid a painful race to the bottom of the cost curve in globalized and standardized product arenas. Mass customization has the potential to help companies increase revenue and gain competitive advantage, improve cash flow, and reduce waste through on-demand production. Mass customization can also generate valuable data that may be used in the development of standard products and in online marketing and public-relations campaigns”.

The researchers have identified seven different technologies that will enable the realization of mass customization. They have divided these technologies in two groups, differentiating those that make it easier to create customization value for the consumer and those that control costs for the producer.

2.2.1 Creating customization value

The first group of new Iot technologies regards those tools that allow companies to be more effective in the process of creating value for the customers.

“Before launching customized products, executives must understand what customers want to individualize and what components they want to configure, consequently, which options should be offered and how they should be priced. What used to entail a costly conjoint analysis to define the solution space can now be done much more easily with the help of new technologies, many of which also make the transactions required for creating customization value smoother, swifter, and less expensive”.

2.2.2 Social technologies

Social medias are one of the main points of touch that companies nowadays can count on. In the last years they became more and more popular for the companies as an effective and cheap way to get in contact with consumers. Moreover, these platforms are a good tool for initiating collaborative relationships with customers.

"Social media and crowdsourcing are by no means new, but they pave the way for better customization options by allowing companies to analyse the value that consumers attach to existing or proposed components of current or hypothetical "virtual" products. By allowing customers to create real and virtual products, companies can in effect use customers as marketers and cocreators. Social technologies empower customers to broadcast their creations to a large network, which is essentially free marketing for the company whose products they are promoting. This is uniquely suited to customized products, as many consumers are proud of their creations".

2.2.3 Online interactive product configurators

Internet sites nowadays can offer amazing customization experiences to the customers, given them not only the opportunity to create their own version of the product, but also to have fun while doing it. Moreover, these are factors that contribute to the creation of brand loyalty.

"Online configurators are at the heart of the mass customization trend because they provide a user-friendly and speedy way to gather a consumer's customization preferences. While online configurators have been around for years, user interaction in the past was limited to selecting a few configuration options in a form. Any advanced configuration was cumbersome and expensive, often requiring a salesperson to discuss options and selections with the customer. Today, advances in product visualization and the increased speed and adaptiveness of configuration software have made product configuration engaging and what many consumers describe as a fun experience".

2.2.4 3-D scanning and modelling

A technology that will help the rise of the mass customization is 3 D scanning and modelling. This particular tool will allow to get precise models of different objects like, for example, the costumer's body. In this way it will enable people and companies to reach a maximum level of customization, as it will be possible to adapt what you are buying to the exact shapes of your body

“The shape of real world objects can be analysed by 3-D scanners, which collect data that can then be used to construct 3-D digital models. Traditionally, these technologies have been expensive, hard to install, and difficult to roll out at scale”.

2.2.5 Recommendation engines

This tool nowadays is very common, especially in combination with social networks, where, in the ad section, it is possible to find advertisement of something that the consumer has researched online. Now these tools are evolving, allowing also the consumers to start the personalization process.

“E-commerce software has for years been able to recommend product choices based on previous selections. Recommendation engines are now moving into the customization space by helping customers configure products”.

2.2.6 Smart algorithms for dynamic pricing

According to different timing, tastes and total demand, customers could find different prices. In this way, companies are implementing a customization of the price that will be charged to different customers.

“On-demand custom orders can often challenge companies with unpredictable spikes in demand, resulting in long wait times, which in turn are a potential deal breaker for consumers. Some companies are managing on-demand capacity by using smart algorithms and better data-processing capacity to enable dynamic pricing, thereby reducing the time consumers have to wait”,

2.2.7 Controlling manufacturing costs

The second group of IoT technologies regards those that allow to control manufacturing costs. Controlling costs, while implementing customization and hence increasing variety, is a key aspect to consider for a company that aims at efficiency and effectiveness at the same time.

“Technology has driven and will continue to drive dramatic productivity and flexibility improvements in manufacturing. Modularization of product designs, advanced back-office software, and flexible production technology already have the power to reduce the costs of mass customization.”

2.2.8 Enterprise and production software

Software like ERP and MRP are now enabling companies to manage complex schedules of production, integrating them with their suppliers. In this way, a company will be able to respect the timing of their production program, knowing exactly how long the process of production will take.

Moreover, these systems will allow companies to plan efficiently the production of diversified products, allowing them to increase the variety of their offer.

"Traditional technology for enterprise resource planning and supply-chain management (SCM) was designed to enable sales and manage production of a limited variety of products with clearly defined input components. Translating an individualized order from a single customer into a custom picking list and assembly instructions for warehouse and production workers was a big challenge. Now companies have developed packaged software that enables tracking of individualized design features in customer orders and their translation into sourcing and production instructions. These tools connect the configurators at the front end with the production and SCM systems. This doesn't only mean that the production staff knows what to assemble; it also means that customers are promised realistic lead times and progress updates and that they are not served up any options for which the components are not in stock. These back-office software changes can thus effectively enable smooth production of vast variety".

2.2.9 Flexible production systems

Flexible production systems are techniques and modern tools that allow companies to contain costs even when producing variety. 3-D printers and Robotics that can be dynamically programmed with interchangeable tooling that can switch agilely between models and variants with no loss of efficiency are some examples.

"Flexible manufacturing systems are essential to making small-batch production for mass customization profitable. Furthermore, the advent of 3-D printing is truly changing the way we think of manufacturing. These flexible devices can print objects with materials such as ceramics, metals, and even chocolate. While primarily used in prototyping, 3-D printers are making inroads into the mass production of customized objects, such as jewellery, home decoration, and clothing. The advances of this technology mean that the primary constraint in adoption will be the creativity of entrepreneurs and leaders in how it is applied".

2.3 Applications domains of IoT

The Internet of Things has some different domains where it could be applicable. The variables that characterise its applications can be network availability, coverage, scale, heterogeneity, repeatability, user involvement and impact (A. Gluhak, S. Krco, M. Nati, D. Pfisterer, N. Mitton, T. Razafindralambo). According to Gubbi, Buyya, Marusic, Palaniswami, in their paper "Internet of Things (IoT): "A Vision, Architectural Elements, and Future Directions", the applications of IoT can be differentiated in four domains: (1) Personal and Home; (2) Enterprise; (3) Utilities; and (4) Mobile.

"There is a huge crossover in applications and the use of data between the domains. For instance, the Personal and Home IoT produces electricity usage data in the house and makes it available to the electricity (utility) company which can in turn optimizes the supply and demand in the Utility IoT. Internet enables sharing of data between different service providers in a seamless manner creating multiple business opportunities" (Gubbi, Buyya, Marusic, Palaniswami).

In this paragraph, four applications domains of IoT technologies are analysed, considering mostly to which kind of users a particular type of technology is referred.

In the next paragraph there will be a more in deep analysis of the particular type of applications of smart IoT technologies.

Personal and Home

The first field of application is the one related with personal and home use, where information of individual users, related to their everyday life habits, are collected.

"The sensor information collected is used only by the individuals who directly own the network. Usually **WiFi** is used as the backbone enabling higher bandwidth data (video) transfer as well as higher sampling rates (Sound)". (Gubbi, Buyya, Marusic, Palaniswami)

Sensors that monitor our body and health are becoming really popular in the field of IoT, as they could be integrated with apps that can give us some useful information on our health conditions, without the need to consult a doctor. "Ubiquitous **healthcare** has been envisioned for the past two decades. IoT gives a perfect platform to realize this vision using body area sensors and IoT backend to upload the data to servers. For instance, a Smartphone can be used for communication along with several interfaces like Bluetooth for interfacing sensors measuring physiological parameters. So far, there are several applications available for Apple iOS, Google Android and Windows Phone operating system that measure various parameters. An extension of the personal body area network is creating a home monitoring system for agedcare, which allows the doctor to monitor patients and elderly in their homes thereby reducing hospitalization costs through early intervention and treatment”.

Another field of personal and home applications regards the **home equipment**, which can now be integrated with new sensors and software that allow the owner to monitor their usage and also to improve their performance. “Control of home equipment such as air conditioners, refrigerators, washing machines etc., will allow better home and energy management. This will see consumers become involved in IoT revolution in the same manner as the Internet revolution itself. Social networking is set to undergo another transformation with billions of interconnected objects. An interesting development will be using a Twitter like concept where individual “Things” in the house can periodically tweet the readings which can be easily followed from anywhere creating a TweetOT. Although this provides a common framework using cloud for information access, a new security paradigm will be required for this to be fully realized” (Gubbi, Buyya, Marusic, Palaniswami).

Enterprise

The second field of application is the work environment, where it can have many uses, like environmental monitoring and maintenance of the equipment.

“We refer to the “Network of Things” within a work environment as an enterprise based application. Information collected from such networks are used only by the owners and the data may be released selectively. **Environmental monitoring** is the first common application which is implemented to keep a track of the number of occupants and manage the utilities within the building (e.g., HVAC, lighting).

Sensors have always been an integral part of factory setup for security, automation, climate control, etc. This will eventually be replaced by wireless system giving the flexibility to make changes to the setup whenever required. This is nothing but an IoT subnet dedicated to **factory maintenance**”. (Gubbi, Buyya, Marusic, Palaniswami).

Subsequently, another application concerns the **smart environment**.

“One of the major IoT application areas which is already drawing attention is Smart Environment IoT. The applications or use cases within the urban environment that can benefit from the realisation of a smart city WSN capability are shown in the Table. These applications are grouped according to their impact areas. This includes the effect on citizens considering health and well being issues; transport in light of its impact on mobility, productivity, pollution;

and services in terms of critical community services managed and provided by local government to city inhabitants" (Gubbi, Buyya, Marusic, Palaniswami).

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Citizens	
Healthcare	triage, patient monitoring, personnel monitoring, disease spread modelling and containment - real-time health status and predictive information to assist practitioners in the field, or policy decisions in pandemic scenarios
Emergency services, defence	remote personnel monitoring (health, location); resource management and distribution, response planning; sensors built into building infrastructure to guide first responders in emergencies or disaster scenarios
Crowd monitoring	crowd flow monitoring for emergency management; efficient use of public and retail spaces; workflow in commercial environments
Transport	
Traffic management	Intelligent transportation through real-time traffic information and path optimisation
Infrastructure monitoring	sensors built into infrastructure to monitor structural fatigue and other maintenance; accident monitoring for incident management and emergency response coordination
Services	
Water	water quality, leakage, usage, distribution, waste management
Building management	temperature, humidity control, activity monitoring for energy usage management Ð Heating, Ventilation and Air Conditioning (HVAC)
Environment	Air pollution, noise monitoring, waterways, industry monitoring

[8]

Utilities

Another field of applications is related to services, where IoT systems are used to achieve an efficient energy consumption. Subsequently, they can also be used for video-based technologies that can scan and detect people and objects just by its image. Another use can be the monitoring of the public water, in order to avoid contamination or to control the level and the use of the water.

"The information from the networks in this application domain are usually for service optimisation rather than consumer consumption. It is already being used by utility companies for **resource management** in order to optimise cost vs. profit. These are made up of very extensive networks for monitoring critical utilities and efficient resource management. The backbone network used can vary between cellular, WiFi and satellite communication. Smart

[8] Image source: O. Vermesan P. Friess. Internet of Things – From Research and Innovation to Market Deployment

grid and smart metering is another potential IoT application which is being implemented around the world. Efficient energy consumption can be achieved by continuously monitoring every electricity point within a house and using this information to modify the way electricity is consumed. This information at the city scale is used for maintaining the load balance within the grid ensuring high quality of service. **Video based IoT** which integrates image processing, computer vision and networking frameworks will help develop a new challenging scientific research area at the intersection of video, infrared, microphone and network technologies. **Surveillance**, the most widely used camera network applications, helps track targets, identify suspicious activities, detect left luggage and monitor unauthorized access. Automatic behaviour analysis and event detection (as part of sophisticated video analytics) is in its infancy and breakthroughs are expected in the next decade**. Water network monitoring** and quality assurance of drinking water is another critical application that is being addressed using IoT. Sensors measuring critical water parameters are installed at important locations in order to ensure high supply quality. This avoids accidental contamination among storm water drains, drinking water and sewage disposal. The same network can be extended to monitor irrigation in agricultural land. The network is also extended for monitoring soil parameters which allows informed decision making about agriculture" (Gubbi, Buyya, Marusic, Palaniswami).

Mobile

The mobile domain of application allows to get dynamic information related, for example, to the conditions of the traffic congestion in the cities. This is made possible by the monitoring of the signals sent from mobiles or other devices that the drivers own.

Moreover, the mobile domain is also related with the management of logistic processes, which is fundamental in order to keep track of the transportations of all the products in an efficient way.

"**Dynamic traffic information** will affect freight movement, allow better planning and improved scheduling. The transport IoT will enable the use of large scale WSNs for online monitoring of travel times, origin-destination (OD) route choice behaviour, queue lengths and air pollutant and noise emissions. Combined with information gathered from the urban traffic control system, valid and relevant information on traffic conditions can be presented to travellers. The prevalence of Bluetooth technology (BT) devices reflects the current IoT penetration in a number of digital products such as mobile phones, car hands-free sets, navigation systems, etc. BT devices emit signals with a unique Media Access Identification (MAC-ID) number that can be read by BT sensors within the coverage area. Readers placed at different locations can be used to identify the movement of the devices.

Another important application in mobile IoT domain is **efficient logistics management**. This includes monitoring the items being transported as well as efficient transportation planning. The monitoring of items is carried out more locally, say, within a truck replicating enterprise domain but transport planning is carried out using a large scale IoT network" (Gubbi, Buyya, Marusic, Palaniswami).

2.4 Main applications of IoT systems

Nowadays, new societal trends are determining the evolution of markets and applications, creating new economic potential that can be obtained from the exploitation of these new opportunities. These new trends are grouped as: health and wellness, transport and mobility, security and safety, energy and environment, communication and e-society.

Thanks to the innovations of the Internet of Things, there is a huge number of new applications that fit into the different areas of every-day life of individuals, enterprises, and society as a whole.

The IERC, European Research Cluster on the Internet of Things, "Internet of Things-Pan European Research and Innovation Vision", has identified and described the main Internet of Things applications, which span numerous applications domains: smart energy, smart health, smart buildings, smart transport, smart industry and smart city. The IoT application domains identified by IERC covers "smart" environments/spaces in domains such as: Transportation, Building, City, Lifestyle, Retail, Agriculture, Factory, Supply chain, Emergency, Health care, User interaction, Culture and tourism, Environment and Energy.

In the next section, the main applications, as identified by the IERC, will be analysed more in depth.

Smart Cities

The field of **urbanization** will be a very relevant one in the application of Internet of Things, as by 2025 more than the 60% of the entire population is expected to live in urban cities.

The increase of the population and the development of the infrastructures will influence the expansion of the borders of the cities, which will incorporate the surrounding cities forming what are called **megacities**, which could count a population of more than 10 million.

This future type of urban context will impact and influence the lives and the mobility of people and will lead to the evolution of **smart cities** with eight smart features, including Smart

Economy, Smart Buildings, Smart Mobility, Smart Energy, Smart Information Communication and Technology, Smart Planning, Smart Citizen and Smart Governance.

“A smart city is defined as a city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rail/subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens. Emergency response management to both natural as well as manmade challenges to the system can be focused. With advanced monitoring systems and built-in smart sensors, data can be collected and evaluated in real time, enhancing city management’s decision-making. In the long term Smart Cities vision, systems and structures will monitor their own conditions and carry out self-repair, as needed.

The physical environment, air, water, and surrounding green spaces will be monitored in non-obtrusive ways for optimal quality, thus creating an enhanced living and working environment that is clean, efficient, and secure and that offers these advantages within the framework of the most effective use of all resources.

A smart city is a developed urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas: economy, mobility, environment, people, living, and government” (Internet of Things – From Research and Innovation to Market Deployment).

Smart Energy and the Smart Grid

A change in the energy consumption behaviour is taking place nowadays. Due to the necessity to put more attention on which resources we are using and which impact they have on the environment and on the costs for producing the energy we need, a new concept of energy consumption is emerging.

“Because of its volatile nature such supply of electrical energy demands an **intelligent and flexible electrical grid** which is able to react to power fluctuations by controlling electrical energy sources (generation, storage) and sinks (load, storage) and by suitable reconfiguration. Such functions will be based on networked intelligent devices (appliances, micro-generation equipment, infrastructure, consumer products) and grid infrastructure elements, largely based on IoT concepts.

Future energy grids are characterized by a high number of distributed small and medium sized energy sources and power plants which may be combined virtually ad hoc to virtual power plants; moreover in the case of energy outages or disasters certain areas may be isolated from the grid and supplied from within by internal energy sources such as photovoltaics on the roofs, block heat and power plants or energy storages of a residential area ("islanding")". (Internet of Things – From Research and Innovation to Market Deployment).

A new concept of consumption of energy in which the energy packet is managed similarly to the data packet is evolving - across routers and gateways which autonomously can decide the best pathway for the packet to reach its destination with the best integrity levels. Therefore, energy consumption can be managed like data in IoT, creating what is defined "Internet of Energy".

"The Internet of Energy (IoE) provides an innovative concept for power distribution, energy storage, grid monitoring and communication. It will allow units of energy to be transferred when and where it is needed. Power consumption monitoring will be performed on all levels, from local individual devices up to national and international level.

Saving energy based on an improved user awareness of momentary energy consumption is another pillar of future energy management concepts. Smart meters can give information about the instantaneous energy consumption to the user, thus allowing for identification and elimination of energy wasting devices and for providing hints for optimizing individual energy consumption.

Depending on connectivity, cloud-based IoT concepts might be advantageous when considering energy dissipation and hardware effort. Many IoT applications will go beyond one industrial sector. Energy, mobility and home/buildings sectors will share data through energy gateways that will control the transfer of energy and information. Sophisticated and flexible data filtering, data mining and processing procedures and systems will become necessary in order to handle the high amount of raw data provided by billions of data sources. System and data models need to support the design of flexible systems which guarantee a reliable and secure real-time operation" (Internet of Things – From Research and Innovation to Market Deployment).

Smart Home, Smart Buildings and Infrastructure

In this context, many companies are working to build platforms that integrate the building automation with entertainment, healthcare monitoring, energy monitoring and wireless sensor monitoring in the home and building.

"Several organizations are working to equip homes with technology that enables the occupants to use a single device to control all electronic devices and appliances. The solutions focus primarily on environmental monitoring, energy management, assisted living, comfort, and convenience. The solutions are based on open platforms that employ a network of intelligent sensors to provide information about the state of the home. These sensors monitor systems such as energy generation and metering; heating, ventilation, and air conditioning (HVAC); lighting; security; and environmental key performance indicators. The information is processed and made available through a number of access methods such as touch screens, mobile phones, and 3–D browsers.

In this way, mobile devices ensure that consumers have access to a portable ’controller’ for the electronics connected to the network. these devices can be used as gateways for IoT applications.” (Internet of Things – From Research and Innovation to Market Deployment).

The aim of Smart Building is to use technologies like wireless sensor networks (WSNs) to facilitate **intelligent energy management** and control in buildings. In this way, buildings’ energy information and control systems can be monitored from a laptop or a Smartphone placed anywhere in the world.

Smart Factory and Smart Manufacturing

IoT will enable to introduce new applications to the systems of the factories.

Some examples could be the connection of the factory to the smart grid, sharing the production facility as a service or allowing more agility and flexibility within the production systems themselves.

“The first evolutionary step towards a shared smart factory could be demonstrated by enabling access to today’s external stakeholders in order to interact with an IoT - enabled manufacturing system. These stakeholders could include the suppliers of the productions tools, as well as the production logistics and maintenance and re-tooling actors.

The convergence of microelectronics and micromechanical parts within a sensing device, the ubiquity of communications, the rise of micro-robotics, the customization made possible by software will significantly change the world of manufacturing. In addition, broader pervasiveness of telecommunications in many environments is one of the reasons why these environments take the shape of ecosystems” (Internet of Things – From Research and Innovation to Market Deployment).

Some of the main challenges associated with the implementation of cyber-physical systems in include **affordability**, **network integration, and the interoperability of engineering systems**.

Smart Health

For those patients whose physiological status requires close attention, using IoT-driven, non invasive monitoring it is possible to do so. This requires sensors to collect comprehensive physiological information and uses gateways and the cloud to analyse and store the information and then send the analysed data wirelessly to caregivers for further analysis and review.

These techniques improve the quality of care through constant attention and lower the cost of care by eliminating the need for a caregiver to actively engage in data collection and analysis. In addition, the technology can be used for remote monitoring using small, wireless solutions connected through the IoT.

"IoT applications are pushing the development of platforms for implementing **ambient assisted living (AAL)** systems that will offer services in the areas of assistance to carry out daily activities, health and activity monitoring, enhancing safety and security, getting access to medical and emergency systems, and facilitating rapid health support. The main objective is to enhance life quality for people who need permanent support or monitoring, to decrease barriers for monitoring important health parameters, to avoid unnecessary healthcare costs and efforts, and to provide the right medical support at the right time" (Internet of Things – From Research and Innovation to Market Deployment).

Food and Water Tracking and Security

Food and fresh water are the most important natural resources in the world. This will inevitably lead to attempts to control the origin or the production process.

"Using IoT in such scenarios to secure **tracking of food or water** from the production place to the consumer is one of the important topics. After the "mad cow disease" outbreak in the late 20th century, some beef manufacturers together with large supermarket chains in Ireland are offering "from pasture to plate" traceability of each package of beef meat in an attempt to assure consumers that the meat is safe for consumption. However, this is limited to certain types of food and enables tracing back to the origin of the food only, without information on the production process" (Internet of Things – From Research and Innovation to Market Deployment) .

Participatory Sensing

The "community wisdom" today is based on conscious input from people, based on opinions of individuals about experiences of the everyday life like , for example, recommendations for a good restaurant, car mechanic, movie, phone plan, etc.

“With the development of IoT technology and ICT in general, it is becoming interesting to expand the concept of community knowledge to automated observation of events in the real world.
These systems can be used as tools for **sustainability**. Individuals and communities can explore their transportation and consumption habits, and corporations can promote more sustainable practices among employees.
Participatory sensing applications aim at utilizing each person, mobile phone, and car and associated sensors as automatic sensory stations taking a multi-sensor snapshot of the immediate environment” (Internet of Things – From Research and Innovation to Market Deployment). By combining these individual snapshots in an intelligent manner it is possible to create a clear picture of the physical world that can be shared.

Smart Logistic and Retail

The Internet of Things creates opportunities to achieve efficient solutions in the retail sector by addressing the right person, right content at the right time and right place. Connectivity is key to be connected anytime, anywhere with any devices..
“To keep up with all these changes, retailers must deploy smart, connected devices throughout their operations. By tying together everything from inventory tracking to advertising, retailers can gain visibility into their operations and nimbly respond to shifts in consumer behaviour. Retailers are also using sensors, beacons, scanning devices, and other IoT technologies to optimize internally: inventory, fleet, resource, and partner management through real-time analytics, automatic replenishment, notifications, store layout, and more. The Big data generated now affords retailers a factual understanding of how their products, customers, affiliates, employees, and external factors come together” (Internet of Things – From Research and Innovation to Market Deployment).

2.5 IT outsorcing: partnering with an Application Solution Provider

Implementing a complex IT system inside a company, in today’s rapid changing markets, is becoming more and more difficult to do. For this reason, partnering in the computer-solutions industry is now becoming really important in order to implement efficiently diverse Internet solutions.

One possible way to implement outsourcing is to collaborate with an **ASP, Application Solution Provider**, which is a company that offers the disposal and management of applications via the Internet or a private network based on monthly or per-user fees.

"Its core concept, based on providing software as a service driven by the Internet, enables software and IT infrastructure markets to converge. Typical services provided by ASPs are packaged software applications developed by independent software vendors; systems implementation and integration offered by systems integrators; data centres and connectivity from hosting companies, hardware vendors, and telecommunication providers; application monitoring and ongoing support from consulting firms; and ongoing support from systems integrators or independent software vendors" (Lee, Huynh, Kwok, Pi).

What makes ASPs attractive is that they can allow to get faster time to market, IT expertise, ease of use, and lower cost.

Anyway, there could be also potential drawbacks. In fact, ASP system failure can cause the stop of critical operations and result in a big loss of client productivity. Moreover, system incompatibility can complicate the integration between the client and its ASP, system security and trust issues can complicate the sharing of important data between the client and its ASP.

The ASP model is the synthesis of several products and services, such as software, connectivity, Web hosting, hardware, systems integration, network and application monitoring, and extended support and help desk. A strong alliance with a capable ASP allows a firm to leverage a key part of the value chain to create new business opportunities. Maximizing such a tightly coupled partnership requires the integration of the strategic, economic, and social perspectives.

For this reason, from the social perspective, since partnering with an ASP involves exchanging valuable resources, this relationship requires mutual trust rather than the sole pursuit of self-interest.

Another goal that this relationship must achieve is to maximize flexibility and control in the management of the information resource, in order to pursue different options as soon as the context changes.

As the scope and complexity of IT expand, many organizations are less inclined to implement in-house development, since outsourcing allows them to better leverage their resources and focus on core applications to increase IT's value to corporate missions.

The process of structuring an IT collaboration starts from understanding the service provider's focus, core competency, and organizational structure, as well as establishing relationships with key personnel. It is also important to evaluate the service provider's corporate values.

According to Lee, Huynh, Kwok, Pi, after that one IT partner has been selected, the following eight steps should be followed in order to structure an effective relationship:

• Understand each other’s business. Strive toward a shared understanding of important goals and policies.
• Set short- and long-term goals. Prioritize to accomplish intermediate goals without losing the long term focus.
• Define realistic expectations clearly. Set reasonable expectations and anticipate a learning curve. No partnership is perfect on the first day.
• Share benefits and risks. Establish explicit articulation and agreement upon the benefits and risks. Good performance should be rewarded, while a bad situation should be addressed together.
• Develop performance standards. Define, agree, and communicate clear and measurable standards of performance.
• Expect changes and revisions. Improvement and growth come from revision and refinement.
• Prepare for the unexpected. Try to identify potential problems by playing out what-if scenarios and discussing options.
• Nurture the relationship. Like any relationship, a successful partnership requires continual maintenance to increase its value.

2.6 Cybersecurity in the IoT age

With the advent of IoT innovations, companies are connecting more and more their devices, products and production systems. For this reason, it is estimated that the number of connected objects in 2020 will count 20 to 30 billion up from 10 to 15 billion devices in 2015.
The reason behind this grow in number of IoT devices, is the enormous potential that this technology can represent, making a company’s products and services better or improving production efficiency.
Anyway, these opportunities don’t come without any risk. In fact, it is becoming more relevant also the topic of **cybersecurity**, as this huge amount of data needs to stay private and to be protected. The risks coming with confidentiality and integrity of data is now a bigger concern than risks that come with the availability of information. In fact, now with all the smart products incorporated with sensors present in the market, it is quite easy to obtain an incredible amount of data.
Security challenges are an issue that go along with all the product life cycle, even after the product has been sold. Security now is becoming an issue also for what concerns the production phase. In fact, critical equipment, such as pacemakers and entire manufacturing plants, are now

vulnerable, meaning that customer health and a company's total production capability are at risk.

As the number of Smart connected objects increases, also the number of cybersecurity increases. "While in the past, the number of end points in a large corporate network would be somewhere between 50,000 and 500,000, with the IoT, we are talking about millions or tens of millions of end points. Unfortunately, many of these consist of legacy devices with either no or very insufficient security.

All in all, this added complexity makes the IoT a significantly more challenging security environment for companies to manage. If they are successful though, strong cybersecurity can become a differentiating factor in many industries, moving from a cost factor to an asset" (Bauer, Scherf, von der Tann, Klinkhammer).

According to a research conducted by Mckinsey on this topic, the results indicate that there is a shocking gap between perceived priority and the level of preparedness. "Of the IoT involved experts surveyed, 75 percent say that IoT security is either important or very important—and that its relevance will increase—but only 16 percent say their company is well prepared for the challenge. Typically, low preparedness is also linked to insufficient budget allocated to cybersecurity in the IoT. Along the IoT security action chain (predict, prevent, detect, react), companies are ill-prepared at each step of the way. Especially weak are prediction capabilities (16 percent feel well prepared compared to 24 to 28 percent on prevent, detect and react). More than one-third of companies do not even have a cybersecurity strategy in place that also covers the IoT. The rest seem to have some sort of strategy but struggle with implementation."

The reasons identified by Mckinsey' research behind this lack of implementation of cybersecurity policies are: lack of prioritization, as often there is a tendency to postpone actions concerning cyber security, unclear responsibility, as within organizations it is not clear which unit should take the lead, and lack of standards and technical skill.

Chapter 3
Big data and IoT as a tool for Customer Relationship Management

Customer Relationship Management is a marketing approach that is becoming more and more fundamental for the effectiveness of a business process of a company. This system allows to better manage the relationships with the customers, as it keeps track of all the interactions that the company has. More than this, CRM systems, by the use of new IoT integrated tools, can collect a huge amount of data regarding customers, storing them into the client database.
In this way, it is possible now to know what each single customer considers more valuable and, focusing on that, companies can aim at establishing long lasting relationships with their customers.
This process is called **Fidelization,** and its main goal is to create loyal customers that could become also ambassadors of the brand, that will spread their passion for the company, giving the possibility to get new customers.
With the advent of new technological trends, CRM is becoming even a more powerful tool, as now it can be integrated with the innovations brought by the Internet of Things. IoT with its smart and connected tools are highly increasing the accessible amount of data and information about the consumers, giving the possibility to improve the customer service and hence the customer satisfaction.
The goal that can now be achieved with the help of this tools, is the **personalization of the customer experience,** according to the data about the interactions that the company has. Moreover, IoT can also be used to implement the **customization of the products**, increasing the possibilities to get more value from the relationships with the customers.
This chapter will analyse the relationship between the concepts of Customer experience and engagement with the applications of the tools of the Internet of Things.
It will be then illustrated how the IoT can affect the attachment to one brand and also how the adoption of these innovative tools is characterised.

3.1 The Relational Marketing

Nowadays, Relational Marketing is considered as the new paradigm of marketing, that deeply revises the concept of marketing management developed during the mass production era.
Some contexts have shown earlier this interactive evolution inside marketing. For example, industrial marketing and service marketing. Subsequently, through the progressive extension of the relational approach for consumer goods, marketing tends to have a relational identity that goes through all the different specialised sectors.
The Relational Marketing represents the necessary completion of mass customization. The focus on Relations signals the pass from "mass" to single individuals as the scope of marketing. According to Pepper and Rogers (2001), Relational marketing necessarily corresponds to a "one to one" approach with customers.
Relational Marketing is oriented to the construction of lasting relations with the client. With this approach, the value of the customer is projected in the future and this is what is called "**lifetime customer value**", which could be calculated at the actual state or at a potential level, that means keeping in consideration the one-to-one initiatives of the company with the client that aim at increasing the value. The best way to maximise the value in the time is the **interaction**.
A company must adopt technologies, define processes and organizational structures, devolop services that together allow to activate and maintain interactive relations with the clients. The system of technologies, of the organization and of services oriented to the interaction defines the competences of the **Customer Relationship Management (CRM),** that represents the operative projection of Relational Marketing.
Relational marketing aims at constructing an interactive relation that ensures the effective matching of supply of variety from the company and demand of variety expressed by consumers. This aim has a positive effect on the **customer satisfaction**, that must be monitored individually. The satisfaction related to the product purchased creates the base for the customer **fidelization** and hence for the repetition of the interaction in more purchase occasions of the same or of other products. Moreover, the interaction favours the learning from the side of consumer and of the company (**learning relationship**). From this the company can acquire ideas, hints and critics they can exploit in the development of new products, in modifications for improvement of existing products and for the improvement of the CRM itself.
In a company using a Relational Marketing approach, the marketing informatics system assumes a different configuration from the traditional one. In fact, the importance of the relations with the clients puts at the centre of the system the **customer database,** that

memorizes for every client the history of his relationship with the company. From one side, the database is continuously updated with the information generated from the relationships. From the other side, the staff working in the front-line with the customers disposes of a high informatics support, which enables him to get each time it gets in contact with a client, the entire course of the relationship until that moment. In this way, it could be possible to improve the management of the relationship.

What is new and different in this new concept of marketing, is the "interactivity". Relational Marketing is based on a logic of exchange, where the relationship assumes a bidirectional, interactive and collaborative trend. More than that, the final result of the Relational Marketing is a specific asset for the company, that is called "**marketing network**", which is composed by the company and its stakeholders: clients, employees, suppliers, retailers and other actors involved in commercial relationships of mutual benefit.

Moreover, ICTs have made possible the development of this approach, improving what is called the "**marketing knowledge management**".

3.2 Internet of Things tools and customer experience

Modern technologies nowadays allow to access to a huge amount of information about the consumers and their tastes and habits. Revolutionary concepts as Internet of Things are now giving the possibility to install a connection between different kind of "smart objects" that are now able to share data, making possible to understand how a customer is related to a determined product during his life. Indeed, the number of devices that can now be connected to the internet is highly increasing, which is the cause of the growing number of data that are generated and distributed.

For this reason, it is also possible for the company, using this amount of data collected with IOT systems, to create new innovative products that are more in line with consumer tastes and that allow to gain a competitive advantage. Moreover, IOT also supports companies in the process of managing customer experience in the course of their relationship with a company, brand or a product, leading to the increase of a customer satisfaction and the companies' results. According to Patel (2015); Porter & Heppelmann (2014) these smart devices are also able to provide information about observed consumer experiences during the use or other contacts with a product. Thanks to the IoT technology, the marketers gain access to a broad and uninterrupted stream of data, which in turn gives them insight into users behaviours, their interactions with products and a knowledge of how to communicate with them effectively.

Consequently, as Hoffman & Novak sustained (2018), it is claimed that IOT has a potential to revolutionize the customer experience. As customers can interact with smart objects and objects can work together as assemblages through a process of ongoing interaction, new qualities and capacities are going to emerge, expanding the range of mutual interactions beyond the human-centric paradigm.

3.2.1 Definition of Customer experience

According to Pine and Gilmore (1998), many goods and services were losing their distinction and become more and more common to customers and so, for this reason, companies are now forced to compete through the provision of special user experiences.

Meyer and Schwager (2007) developed this concept which was based on the definition of customer experience as the internal and subjective response customers have to any direct or indirect contact with a company. According to them, the data about customer experiences are collected at so-called touch points, meaning all customer's direct contacts with the organization, brand or product.

Customer experience is also defined as a "result of multiple interactions between a customer and a product or a company, always personal and of rational, emotional, sensorial, physical and even spiritual nature" (Gentile, Spiller, & Noci, 2007); or as a "multidimensional construct involving the customer's cognitive, affective, behavioural, physical and social responses to a company's offerings during the customer's purchase journey" (Verhoef, et al., 2009; Lemon & Verhoef, 2016).

Moreover, the Customer experience can be defined as the total number of impressions created as a result of all customer interactions with a company through contacts with products, employees, service and self-service technologies, along with the accompanying information message. Sirapracha & Tocquer (2012) stated that the final result of customer experience is what customers think and feel about a company or a brand and how strong is the bond between them.

The process of developing the customer experience includes such phases like awareness, discovery, attraction, interaction, purchase, use, cultivation and advocacy (Atkinson, 2016).

The measurement of the customer experience requires a comparison between the individual's experience resulted from all touch points with a product, brand or company and his expectations towards them. Customer experience management is based on knowing customers as completely as possible. This knowledge enables an organization to provide customized experiences to customers, making them not only loyals, but also the advocates. A comprehensive knowledge about customers is essential for creating relationships with them and the analysis of data collected in companies databases can serve as the basis for anticipation of future customer behaviours and needs. Customer experience management involves also the processing of collected information in a fast and effective way.

Porter and Heppelmann (2014) accentuate the importance of in-depth insights into the value provided to customers by products, which is possible to achieve from data recorded at all touch points between a customer and the organization

The results of the research conducted by McKinsey & Company stress the importance of a customer decision journey, which consists on the chronological sequence of interactions created at touch points in the customer experience management process (Court, Elzinga, Mulder, & Vetvik, 2009; Duncan, Fanderi, Maechler, & Neher, 2016).

The concept of mapping interactions with the help of the tool known as Customer Journey Map was introduced by the IDEO company and used for the first time in 1999 – in the project of designing services for high-speed railways Acela (Brown, 2009). Other tools developed for the purpose of identification and analysis of customer experience include Service Experience Clues (Berry, Wall, & Carbone, 2006), Servicescapes (Bitner, 1992) and Service Transaction Analysis (Johnston, 1999).

Brand loyalty is not only a result of the quality of products or its features, but it is a resultant of the sum of experiences gathered in course of customer interactions with the company or brand that can strengthen or weaken the relationship between them. Successful companies develop a strong emotional bond with customers, which translates into an increase in their loyalty and their propensity to recommend the brand. According to the results of the research conducted by IBM (2015), an effective Customer Experience Management must not be a unitary project, but a comprehensive business philosophy.

3.2.2 The Internet of Things as a tool for improving the customer experience

The IoT can be perceived as developed deliberately for designing and managing the customer experience. Smart devices can automatically, with their sensors, collect and transfer data obtained at numerous touch points. Their later analysis can be used to increase the number of positive interactions between customers and a product, a brand or a company, and to eliminate interactions negatively evaluated by customers. They can also provide an interface supporting the satisfaction survey, that is the evaluation of the service in the store. IoT can also be used to build relationships and emotional ties with customers, deliver products that meet their expectations at a utilitarian level, improve product service and reinvent marketing communications.

“In 2009 the number of devices connected to the Internet was for the first time higher than the number of inhabitants of the globe (6.5 billion). In 2017 this number exceeded 12.5 billion, and it is estimated that the number of smart devices connected to the Internet will reach 30 billion by 2020, and by 2025 – 75 billion” (Evans, 2014; Statista, 2018).

This trend creates an unprecedented opportunity to build competitive advantage by supporting customer experience management and enriching organization’s knowledge about customers through the precise identification of touch points and mapping a customer journey from the first contact with a brand, through product purchase, up to its use throughout the entire life cycle. Smart devices enable registration of every single interaction with a customer and an automatic transfer of these data between them. Tracking subsequent interactions and their analysis allows for a thorough analysis of how products are used by customers during their life cycle, as well as an accurate recognition of the needs and values that guide consumers. Data obtained from sensors of various devices, their analysis and finally insights into customer behaviour ensure the ability to adapt products to customer needs, thus enabling the design of interactions maximizing delivery of positive experiences.

According to Das (2016), the IoT allows to obtain immediate and instant feedback, which further improves business decision-making processes and a product design. Many researchers agree that the use of Internet of Things increases capabilities of delivering a superior customer experience and that IoT has the potential to create new and innovative ways to understand and influence customer behaviour (Kocher, 2017; Martin, 2017; Raftery, 2017; Rossi, 2017).

“Digitalization of interaction paths as such can be a method for building positive customer experience. The activities of this kind include providing customers with applications for tracking orders in real time or delivering information on the status of devices, planned technical inspections or a machine wear” (Maechler, Sahni, & Oostrum, 2016).

The Internet of Things is also changing traditional marketing communications. Mittal (2012) notes that shopping centres, sales networks, public utilities and outdoor advertising providers have adapted the IoT technology to deliver personalized information, customized advertising messages and sales promotions offers to their customers. The consumers will soon receive only the filtered message content adjusted to their needs and interests, delivered both by traditional communication channels and smart devices themselves. Unwanted advertising messages, which may have a negative impact on the customer experience, are going to be eliminated. Therefore the IoT enables companies to limit potentially negative experiences resulting from receiving standardized marketing messages.

The possibility to improve the communication with the users given by the interactions among smart devices, is enabling companies to increase their ability to monitor and analyse consumers' behaviour. Now companies are more able to listen and to understand the customers' needs, which enables them to provide to their clients right answers, at the right time, with the right channel.

In this way, Internet of Things is increasing the customer satisfaction through the customer experience. However, there are issues about security threats and privacy protection that are emerging.

Many authors are dealing with the issue of risk emerging from smart objects, which collect enormous amount of private data, often of vulnerable nature, and they also underline the need for their effective protection. The trade-off between customer benefits resulting from the IoT and the privacy protection has to be reached. The inevitable process of gathering and processing personal data with help of marketing analytics, business intelligence and machine learning systems is already to some extent regulated but there's still much work to be done. Like in case of any big data processing all individual data should be protected by effective technical solutions and the scope of data collected by IoT systems, the accessibility to data and the purposes for which the data is used should be limited by strict legal and ethical regulations. The challenges for data security in IoT systems and conventional networks are considered to be similar, but the ways of handling security issues in IoT differ and require applying advanced technology (Alaba, et al., 2017).

3.3 IoT implications on Customer acceptance

The Internet of Things has been proclaimed as essential for organisational innovation, adaptation and success, especially for firms with high amounts of connectivity, network and data (Jones, Suoranta, & Rowley, 2013; Yu, Nguyen, & Chen, 2016). For this reason, it is important to understand how to design the best fit for IoT and marketing.

Many of the rules of marketing are changing and many new approaches will be introduced in this new IoT era.

According to Balaji and kumar, in their paper "Value co-creation with Internet of Things technology in the retail industry", customer interaction with IoT retail technology results in value co-creation, revealing that ease of use, superior functionality, aesthetic appeal and presence are key determinants of value co-creation for IoT retail technology. The authors show that value co-creation influences the loyalty of customers to a brand and the word of mouth process they will initiate.

3.3.1 Factors that support adoption and sustained use

Canhoto and Arp, in their work "Exploring the factors that support adoption and sustained use of health and fitness wearables", focus on wearable technology for general health and fitness purposes. They noticed that only if users adopt and continue to use these products, they will become more responsible for their own health. Differently, this will not happen in the case customers will stop using these products shortly after the purchase.

For this reason, their study investigates how the characteristics of the device, the context and the user can support the **adoption** and the **sustained use** of health and fitness wearables, finding that the factors that support the former differ from those that support the latter.

The authors started from an analysis of some theoretical models about the acceptance of innovations.

The **Technology Acceptance Model (TAM)** considers why and how people accept and use a particular technological innovation (Bagozzi, 2007; Davis, Bagozzi & Warshaw, 1989), the **Innovation Diffusion Theory** examines the factors that support the popularisation and subsequent diffusion of a given innovation across a social system (Rogers, 2003). In turn, the **Unified Theory of Technology Acceptance and Use of Technology (UTAUT)** focuses on individual users (Venkatesh, Morris, Davis & Davis, 2003), whereas the Social Shaping of Technology (SST) model explores the mutual influence of technology and society on each other (Mackenzie & Wajcman, 1998; Williams & Edge, 1996).

However, this literature tends to agree that, to fully understand technology acceptance, we need to consider the **features** and **utility** of the technology, the **context** of usage, and the **user** of the technology (Miltgen, Popovic & Oliveira, 2013).

The key driver of consumer technology adoption is its expected ability to **satisfy a need** (Kim, Kim & Wachter 2013), and to "**provide benefits** to consumers in performing certain activities" (Venkatesh et al, 2012, p.159). Early technology adoption work such as TAM and UTAUT conceptualised this attribute as the ability to enhance job performance (see Venkatesh et al., 2003), though later work, which focused specifically on consumer technology, define this more broadly as the ability to **perform a certain task**.

While these utilitarian benefits may be the key driver of technology adoption, researchers should not underestimate the importance of **hedonic needs**, such as fun, excitement or pleasure (Hew, Lee, Ooi & Wei, 2015; Holbrook & Batra, 1987; Turel, Serenko & Bontis, 2010), or the extent to which the technology affords a feeling of independence and being in control (e.g., Meuter, Ostrom, Bitner & Roundtree, 2003).

Not only do technological products need to be perceived to deliver utilitarian and hedonic value, but these benefits need to exceed the costs and the effort of acquiring and using them (Sedon, 1997; Venkatesh et al., 2003; Venkatesh et al., 2012). They also need to be perceived to do so better than their alternatives (Rogers, 2003).

Subsequently, according to the authors, another factor that must be considered to understand the degree of acceptance of an innovation, is the context.

How a technological product is used, is largely influenced by the **technical and the social contexts** within which the technology is deployed. The technical context constrains what the technology can do, whereas the social context determines what is acceptable in a particular social system (Liebenau & Harindranath, 2002).

In terms of technical factors, it is important to consider the **existing infrastructure**, and whether it supports the use of the technology.

Privacy and security concerns are also deemed to be very important, particularly the lack of transparency about how personal information will be used, and the uncertainty about which other third parties data might be transferred to (Lupton, 2014).

Social factors refer to the extent to which consumer behaviour is influenced by others, and can be so strong that it even overrides dissatisfaction with the technology’s performance (Oliver 1999). On the one hand, technology adoption may occur as a result of role modelling, or peer observation, whereby the adoption of innovation is visible to others (Rogers, 2003). Innovation is an uncertain process (Williams & Edge, 1996) with uncertain outcomes. Being able to observe others adopting the new technology decreases perceived risk (Chen, Wang & Xie, 2011).

This effect is particularly relevant for technology which supports interaction between peers or where there are network externalities (Dickinger, Arami & Meyer, 2008), as is the case of mobile phones. On the other hand, technology adoption may occur because buyers perceive that relevant others believe that they should use a particular technology (Venkatesh et al., 2012); or that relevant others will view these consumers favourably as a result of using the technology (Venkatesh et al., 2003).

After this analysis of the context, the authors studied which are the characteristics of the users that affects the acceptance and usage rates.

Personal factors influence consumer behaviour in general, and the use of technology in particular (Miltgen et al., 2013; Rogers, 2003; Venkatesh et al., 2003). This includes both the consumers' personal characteristics, as well as their experiences with technology.

In terms of personal characteristics, the literature has considered factors such as age, gender, or the presence of certain psychological traits. For instance, the literature posits that young users are willing to embrace innovation in general (Yi, Jackson, Part & Probst, 2006).

Furthermore, they tend to be more task oriented than older ones and, thus, more willing to adopt technology that facilitates the accomplishment of tasks (Venkatesh et al 2003). Younger users are also susceptible to peer influence (Dickinger et al, 2008).

In terms of gender, men are usually deemed to be more willing than women to embrace new technology (Hasan, 2010). However, the effect may vary with the type of salient product features, with men deemed to favour utilitarian features, and women deemed to favour hedonic ones (Venkatesh et al 2013; Venkatesh et al 2012). Yet, other studies suggest that the effect of gender is negligible (e.g., Pascual-Miguel et al, 2015). It should also be noted that any gender effects on the adoption and use of technology arise by virtue of societal roles and expectations (Sorensen, 1992), rather than biological mechanisms. Hence, any differences that may be identified in one context, may not be transferable to another.

Finally, as far as psychological traits are concerned, research suggests that tolerance of ambiguity, intellectual ability, motivation, values, and learning style are all likely to support adoption of new technology (Greenhalgh, Robert, Macfarlane, Bate & Kyriakidou, 2004).

Experience with technology is a strong predictor of future technology use (Kim & Malhotra, 2005; Ma et al, 2014). Past experiences with technology in general shape beliefs about its value, and, thus, the decision to adopt a new technology or not (Ajzen and Fishbein, 2015). Experience also provides relevant, transferable knowledge and skills, which can reduce adoption barriers (Notani, 1998; Venkatesh et al 2012). In turn, experience with the specific technological innovation is a key factor in sustained use. This is particularly significant where using the technology has become habitual and part of the consumer's daily routine (Cotte & LaTour, 2009; Ortiz de Guinea & Markus, 2009).

Factors that influence Technology acceptance	
Features and utility	satisfy a need, provide benefits, perform a certain task, hedonic needs
Technical and social contexts	existing infrastructure, influence by others
Privacy and security concerns	personal information
Personal factors	age, gender, psychological traits, experiences with technology, tolerance of ambiguity, intellectual ability, motivation, values, learning style

[9]

3.3.2 Drivers of consumers' resistance to smart products

The paper "Drivers of consumers' resistance to smart products", by Mani and Chouk, analyses the reasons behind consumer resistance to smart and connected products. The authors note that the continued growth of the IoT raises significant challenges and ethical issues, like security, privacy and trust. For this reason, information privacy (Hsu & Lin, 2016) and identified potential problems related to data protection, lack of human control, and enslavement to devices', as well as increasing numbers of gadgets being added to the IoT ecosystem, question the utility and added value of these innovations. The study thus contributes to a better understanding of the factors that explain consumer resistance to smart products by examining some variables.

The first variable analysed is the **perceived usefulness**. According to their research, the increase in the expectation of the usefulness that the customer will get from a smart product will negatively affect the Resistance to change.

Another variable is the **perceived novelty**, which is the level of uniqueness and difference that the customer perceives in a product. This variable affects negatively the Resistance to change

[9] Table source: Unified Theory of Technology Acceptance and Use of Technology (UTAUT), personal reworking

as well. In fact, when consumers perceive smart products as different and unique, they are less reluctant to adopt these innovations.

Subsequently, another variable is the **perceived price**, which seems to be one of the core reasons why consumers resist these products. In fact, technological innovations are generally expensive and some consumers are reluctant to spend substantial amounts of money. For this reason the research highlighted a positive correlation between the increase in price and the Resistance to change.

The authors analysed then the variable of **self efficacy,** that, according to the literature, is defined as “an individual’s perception of his or her ability to use a technological innovative product (Compeau & Higgins, 1995, p. 193)”. From their research, it emerged that, when consumers feel confident about their ability to understand the use of a smart product, they tend to show less oppositional reactions.

Then, another variable analysed is the **dependence,** meaning the extent to which individuals are reliant upon technology. From their research, it resulted that dependence in negatively correlated with the Resistance to change.

Lastly, they analysed the issues related with **privacy concerns**, which is a problem that needs to be considered when talking about the IoT. In fact, many people use technologies like smart phones and internet to communicate and share private information. Users experience difficulty knowing where and how their information is stored and who is authorised to access and use it. Thus, protecting users’ data and data privacy has become a real challenge.

These products and services interact daily with the user and are characterised by ubiquity, invisibility, pervasiveness, and invasiveness (Slettemeås, 2009). They collect and manage private data or sensitive information (Sicari et al., 2015) such as activities (geographical location), business operations (financial information), and personal information.

Under these conditions, the research shows that privacy concerns have a negative effect on attitudes to the use of smart products and the continued intention to use IoT services.

The two authors concluded that, to reduce the perception of intrusiveness and privacy concerns, companies can ‘rethink’ the design of smart products. Cavoukian (2012) introduced the concept of “privacy by design”, defined as “an engineering and strategic management approach that commits to selectively and sustainably minimize information systems’ privacy risks through technical and governance controls”. They also assert that firms can conduct awareness campaigns and in this way demonstrate their benevolence towards the consumer. In addition, companies can provide technical support to consumers to help them when they face difficulties in understanding security and privacy issues.

Drivers of consumers' resistance to smart products	
Perceived usefulness	**Negative correlation**
Perceived novelty	**Negative correlation**
Perceived price	**Positive correlation**
Self efficacy	**Negative correlation**
Dependence	**Negative correlation**
Privacy concerns	**Positive correlation**

[10]

3.4 Connected products for Quality Management and Customer Service

To take advantage of the IoT, products are now designed for **interconnection and interoperability**. These products combine real-time analysis with machine-to-machine, machine-to-infrastructure and user-to-machine communication, in order to continuously adapt to ever-changing conditions. This complex interconnection with back-end systems and other intelligent products effectively transforms today's products into a **system of systems**, greatly increasing the overall complexity.

The complexity of intelligent products increases even more as many new features are based on the **interaction of software** running on both the device and the cloud, making difficult to understand where the product actually begins and ends. Today, consumers can access many product features through a wide range of devices. Meanwhile, IoT devices can also communicate with each other. As a result, the product experience can be focused, in fact, on **multi-device access**. In addition, many products are now closely related to **services**.

The power of this software-defined functionality lies in the fact that products can "**learn**" from their operating environment and can be **improved** through transparent software updates. Products can send manufacturers an early warning of imminent component failures, enabling **proactive maintenance** services to reduce unplanned downtime. Sometimes, repairs can also be performed remotely via software. Product usage and performance data can also provide

[10] Table source: personal reworking

useful information for product design, enabling companies to offer new services or features that are completely outside the scope of the originally released product.

Finally, the products are increasingly **customized** for specific markets, in order to respond to even the smallest cultural preferences or legal constraints.

The technology that in recent years has spread throughout the manufacturing world makes it possible to access a **large amount of data** and information directly from the machines, such as start and end production times of each batch or downtime, allowing to monitor in real time the key indicators of the plant, analysing the causes of the problems and even removing existing bottlenecks.

It is clear that the correct application of such a strategy has a further effect than that of improving the quality of products.

In the current context of increased global competitiveness, the issue of **quality** plays a key role, given the increased expectations of end users. It is therefore almost superfluous to remember how poor quality of the industrial production process can negatively affect the entire business: failures and recalls of products, in fact, damage the **customer experience**, which today is one of the key elements to compete successfully in any type of market.

It is no coincidence that attention to the quality of the final product has now become a priority for any corporate department, starting with marketing.

One of the keys to improve the quality of the production process lies in the exploitation of the large amount of data made available by the Internet of Things: in addition to **monitoring and predicting** the reliability of machinery, the adoption of Industrial IoT allows the detection of production advances, defects and quality problems of products, through the identification of possible anomalies and malfunctions already in the production phase.

In particular, the application of new technologies can play an important role in optimising quality. **Artificial Intelligence (AI)** can in fact help to control the quality of products by allowing to quickly consult the "**libraries of defects**" already known. In addition, modern cameras and hearing systems, often already installed in manufacturing machines, can identify problems that are too small to be detected by the human eye or ear. Solutions of this type are able to classify the severity of any defects in a short time, identifying the main cause of quality problems in terms of milliseconds. Not only: **machine learning**, with its ability to self-learn, allows these solutions to improve their degree of reliability and precision over time, thanks to the increased exposure to defects and problems.

It is clear that, in this way, manual inspections can be eliminated, which, although highly qualified, always hide the risk of being slow, ineffective, expensive and potentially dangerous.

Further support for the quality of the final product comes from other data, probably even more

valuable, which are released in their operation by the so-called **connected products**. These products can send, hour after hour, accurate and precise information on parameters such as quality, reliability, operation and safety, thus allowing to detect possible errors of unforeseen quality.
With the introduction of this connected products, it is possible to set **up customer service systems** aimed at solving the real needs of consumers. This was a far greater step forward than traditional manual and telephone complaints from consumers, which in the pre-IoT era remained the only way to provide feedback on the quality of the product in use. Thanks to this double influx of data, which covers the entire life cycle of the product, it becomes possible to meet the need for timeliness on quality, necessary for industrial companies to compete successfully in this particular historical phase.

3.5 Connecting CRM and IoT to increase Customer Engagement

Internet of things has many possible applications. One of this could be Preventive Maintenance, in fact, manufacturing firms are among the early adopters of the IoT, with low-cost sensors routinely being used to provide real-time information about equipment status, location, and performance.
Another application could be the integration of IoT and products, in order to make the "smart" and connected. Edelman Berland, in his recent survey, stated that: "Business leaders surveyed estimate 42% of the products their respective companies produce contain IoT embedded technology. In just two years, these leaders predict that half (50%) of all their products will contain IoT technology. And, in five years, they expect even larger growth—with an average estimate of 66% of their company's products containing IoT technology." (Flextronics, "The Opportunity in the Internet of Things," 2015, pg. 2.)
A crucial application that is becoming more and more key for companies is the connection of IoT with **modern CRM solutions** to further engage with customers and obtain valuable customer insights.
In the past, the extended supply chain was the main source for manufacturers to get information about customers and end users. With the innovation of connected products, integrated with IoT capabilities, it is now possible for manufacturers to get valuable data streams about product performance, customer reaction, and product lifecycle trends. This information can help guide future product development, as well as sales and marketing strategies.

Moreover, the IoT allows manufacturers to connect and communicate directly with customers, providing upsell, cross sell, and add-on sales opportunities. The final result that a company can obtain by the adoption of this instruments is the enhancement of the **customer engagement**.
In order to improve the customer experience and hence increase the customer engagement, manufacturers need a **centralized CRM solution** that can track customer history, as well as identify new opportunities and analyse trends.
A CRM solution can help manufacturers to get data that could be useful to get better insight about the use of the product, the customer and the sales. The information available for CRM solutions can be used to drive a better **customer experience** and design more effective sales and marketing campaigns.
"Manufacturers can use data collected from the units in the marketplace to predict future buying cycles. Data can show the typical lifespan of a product and warning signs of performance deterioration. Customers can be notified when their product is showing signs of wear and service or replacement is recommended. Data collected around performance characteristics can be used to provide customers with facts about benefits of upgrading to a new model or a larger capacity model, influencing the repair/replace decision. This type of fact-based selling is highly effective, especially when the data comes straight from the unit.
Use-case data can also contribute to highly targeted customer messages and campaigns, allowing manufacturers to make offers based on data trends and predictions for future preferences. Manufacturers are starting to adopt real-time offer and campaign management, a common strategy to help create a consistent customer experience across all platforms, ensuring greater customer and brand loyalty. Perhaps most importantly, customer data can be used by manufacturers to refine product design, improve performance features, and predict future inventory needs. Understanding the product's lifespan helps manufacturers plan for new releases and target replacement campaigns to customers" (Manufacturers turn to Internet of Things to boost customer engagement).
The CRM system can also be used to **manage interactions** with partners, suppliers, and distributors, keeping the extended supply chain updated about these important relationships. According to Lopez Research, "Building Smarter Manufacturing with the Internet of Things (IoT)", "IoT in manufacturing will improve business by connecting people to the right information, over the right device at the point of need and cross company boundaries to include suppliers, maintenance partners, and distribution chains."

3.5.1 The effect of IoT on communication and brand attachment

The work "The internet of things and interaction style: the effect of smart interaction and brand attachment", by Wu, Chen, and Dou, develops and examines the effect of two different interaction styles, friend-like and engineer-like communication, on consumers' brand perception.

They noticed that many companies prefer the engineer-like style of interaction when integrating IoT technologies with their products. The logic behind this practice is that the companies believe they will benefit because the approach enables them to establish a professional, competent, and innovative brand image. However, some pioneering companies have been experimenting with the friend-like style of smart interaction to embrace the friendly, well-intentioned, and trustworthy elements of their brands.

Norton (1983) viewed communication as existing on two levels: the information itself (i.e. the content) and the manner in which the information is communicated to others (i.e. style). The interaction style often determines the way in which the audience understands and responds to the conveyed information.

The social interaction model argues that, when consumers engage in service interaction when they have little knowledge of the service issues, they will largely rely on the interaction style in forming their evaluation. In addition, the interaction style has been shown to have a profound influence on customers' **purchase probability** (Dion & Notarantonio, 1992; Williams & Spiro, 1985), **trust and satisfaction** (Celli, Ghosh, Alam, & Riccardi, 2016; Webster & Sundaram, 2009), and **perceived service quality** (Notarantonio & Cohen, 1990; Sparks, Bradley, & Callan, 1997). Specifically, an affiliative, friendly, and accommodative style has been shown to be superior to a dominant, precise, and unaccommodating style.

Moreover, in these new information based and virtually interconnected markets, the customer is increasingly becoming a co-producer. This implies that product value is defined by and co-created with the customer rather than embedded in the output. Based on this rationale, some companies aim to make their smart objects speak the "customer's language", as characterised by emotion-and-feeling, and respond to their customers in a friendly and interactive way.

The results of their study suggest that a smart interaction style in the Internet of Things (IoT) context can improve consumers' perceptions of **brand warmth** and **brand competence**, and that these perceptions enhance the consumers' **emotional attachment** to the brand. Specifically, the results indicate that a friend-like interaction style produces more positive brand warmth than the engineer-like style, enhances brand competence as much as the engineer-like style does, and has a positive effect on users' brand attachment, which is mediated by brand warmth and brand competence. Furthermore, the style of smart interaction and brand positioning has interaction effects on brand warmth, brand competence and ultimately brand attachment.

3.5.2 Technological drivers for the integration of CRM and IoT

There are different technological drivers that allow the integration of the CRM with the innovations brought by the IoT.
According to the white paper "Manufacturers turn to Internet of Things to boost customer engagement", these drivers are:

1. The first one is the **Mobile CRM**, that is the IoT based on mobile connectivity. This solutions should be specifically designed for smartphones and tablets as an intelligent design has a big influence on user adoption of mobile CRM.

2. The second technological driver is the **CRM in the cloud**, which is a solution that can offer manufacturers scalability, a rapid time to value and it also offers secure CRM from any computer with Internet access . Moreover, the cloud allows to reduce a company's investment on hardware.

3. The third driver is the **CRM inside the inbox,** which consists on how a CRM solution interacts with popular email tools such as Microsoft® Outlook and Gmail. This interaction will have a big impact on the user experience and it will allow to bring CRM functionality inside the email inbox. Moreover, it will allow to avoid time-consuming double data entry or manual updates.

4. The fourth technological driver is based on **social media capabilities**. In fact, in a mobile device-driven world, it is important to engage with existing and prospective customers through social media during the sales and marketing cycle, and also for customer service and support. For this reason, a well-designed CRM solution that brings social information into the customer record is fundamental

5. The fifth driver is based on **Analitics**. A CRM solution contains essential information about customers and buying trends, as well as the performance of sales, marketing, and

customer support. It is essential that this information can be used to make informed business decisions and shape strategic priorities. Good analytics and reporting capabilities can fully exploit CRM data, delivering a deeper understanding of business performance and customer preferences.

6. The sixth technological driver is the **Integration with key business systems.** In fact, it is really important that the CRM solutions are well integrated with business systems like the ERP, in order to obtain seamless data sharing between departments and employees to help ensure a consistent customer experience. It is also important that the CRM system is integrated with desktop productivity tools, marketing automation software, and business intelligence tools.

7. The seventh driver is the **ease of customization**. As in the overall IoT infrastructure, technology evolves quickly, the CRM solution needs to be able to scale up without complication and adapt to changing business processes. Customer-facing departments must be able to tailor CRM to reflect business workflows and unique user, team, company, and industry requirements.

Chapter 4
A study on Internet of Things: characteristics and applications

In this chapter, two types of empirical analysis on Internet of Things will be executed.
In the first section, a **quantitative study** will be done. This study is based on the sample of the champions companies that answered to a questionnaire elaborated by "**Laboratorio manifattura digitale**", a study done by the DSEA of the University of Padua.
The study will focus on the characteristics and the differences that there are between the companies that have declared to adopt the Internet of Things and those that do not adopt it.
In particular, the study aims at analysing if and how the IoT is a technology that is compatible with a strategy of customization and personalisation.
Moreover, the study will highlight the propensity of the IoT adopters toward Innovation, it will show in which processes they adopt IoT more and how this technology has an impact on improving the relationship with customers through the increase of the performance of the service and the installation of a collaboration between the consumer and the company.
In the second section of the chapter, a qualitative analysis will be executed. This qualitative research is based on three interviews to companies that have adopted the IoT as an integrative tool for their products. The three companies are: Electrolux, Xylem Lowara and Carel.
These companies operate in different industries and have very different products. However, they have been able to integrate the IoT in order to give an added value to their costumers and to exploit it with different applications.
What will result from this second part of the analysis, is that despite the different sectors and different products, the three interviewed companies showed very similar characteristics in the way they manage the IoT and in the advantages and challenges that they faced with the application of this technology.

4.1.1 Quantitative analysis

In this section, a statistical and empirical analysis will be executed, which aims at investigating all the factors that contribute to the implementation of personalization and customization of products and services.
This analysis has been done on a sample composed by the top performer SMEs in Italy, which are called "Champions".

This study will focus on all the Industry 4.0 technologies that these companies have adopted, focusing on which one is the most suitable in order to perform a better service for the customers and, subsequently, on which technology allows to implement a better strategy of personalization and customization of the products and of the customer experience.

As an anticipation, the **Internet of Things** will result as the best technology for the implementation of a strategy of personalization and customization of the offer.

Indeed, it will emerge that this innovative tool is the most suitable in order to install a better service and, hence, a better collaboration with clients and with other companies involved in the value chain of the production.

As a consequence of this, it will result that the Internet of Things is an essential tool in order to realize a strategy of customization of a product, as, for this particular strategy, collaboration and connection with all the other actors is fundamental.

4.1.2 Research objectives and methodologies

In order to accomplish this research on “Champions" companies, a study has been conducted on Italian companies with the following characteristics, according to the numerical criteria of extraction reported in the analysis conducted by the ItalyPost Study Centre:

Table 1: description of the sample

REVENUES 2016	between 20 and 120 million of euro
CAGR 2010-2016	higher than 7%
EBITDA (average on the last three years)	greater than or equal to 10%
DEBT RATIO	lower or equal to 80%
NET DEBT/EBITDA (average on the last three years)	lower or equal to 1,85
NUMBER OF EMPLOYEES	greater than 20
NET INCOME 2016	Positive

The aggregate turnover of these companies is almost 22 billion, a profitability of over 4.3 billion and a total of 77,000 employees.

The universe was composed of 500 Italian companies, which meet the above requirements, as reported in ItalyPost’s research, after a detailed mapping from 14,632 companies between 20 and 120 million euros in turnover.

To accomplish my analysis on the industry 4.0 and the implementation of a strategy of customization and personalization, I took in consideration the answers that the companies have given to different questions of the questionnaire elaborated by "**Laboratorio manifattura digitale**", a survey done by the DSEA of the University of Padua, from October 2018 to March 2019.

From the universe was obtained a sample of **75 enterprises** defined **Champions** (15% response rate).

Through a telephone survey (CAWI), it has been given to entrepreneurs and managers a questionnaire to collect information about:

• sector and production specialization;

• reasons, results and difficulties related to the adoption of technologies 4.0;

• investment in industry 4.0 technology;

• investment areas and organizational impact.

The research has several objectives, the main ones are:

• investigate the profile and business model of "Champions" adopting 4.0 technologies;

• analyse the reasons, the results achieved and the critical points of the process of adoption of technology industry 4.0;

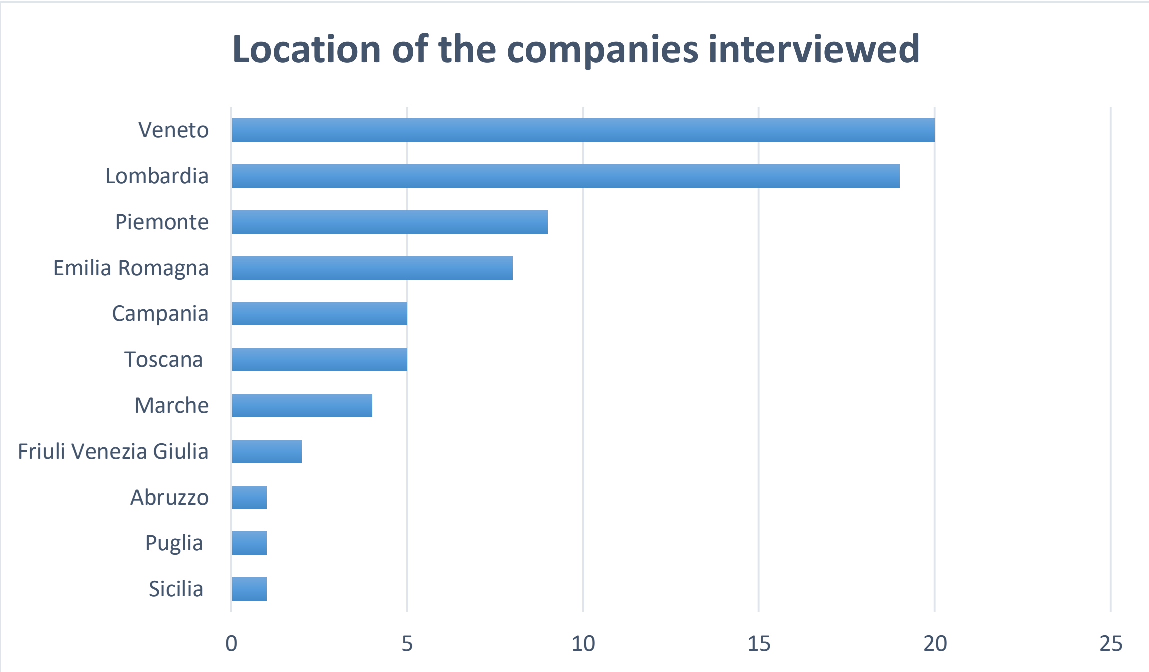
• explicitly investing in industry 4.0 and supporting the investment;

• highlight how the adoption of industry 4.0 technologies has affected business results.

This sample of 75 companies have the following characteristics:

Most of the companies of the sample, 52%, are located in Veneto and Lombardia. Overall, the locations of the all 75 enterprises are the following:

Table 2: Locations of the companies that answered the questionnaire



From now on the research will make a distinction for every field of analysis on the characteristics and differences that is possible to discern between **IoT adopters and not adopters.**

The sample analysed is composed of 75 companies, of which **22 are the adopters of Internet of Things**.

The following table illustrates other characteristics of the businesses of the companies analysed.

Table 3: Description of IoT and Not IoT companies

	Total	**IoT adopters**	**IoT non-adopters**
Number of companies in the sample	75	22	53
Average Turnover (2017)	59.3 mln Euro	99.93 mln Euro	45.73 mln Euro
Employees (average 2017)	138 (Total)	216 (Total)	114 (Total)
% Export average	60.48 %	70.3%	56.1%
R&D expenditure (% on turnover)	6.5%	7.95%	6.1%

Focusing on the distinction of IoT adopters and not adopters it is possible to notice how the companies that have invested on Internet of Things are characterised by higher Turnover, higher number of employees, a bigger percentage of Exports and higher level of expenditure on R&D.

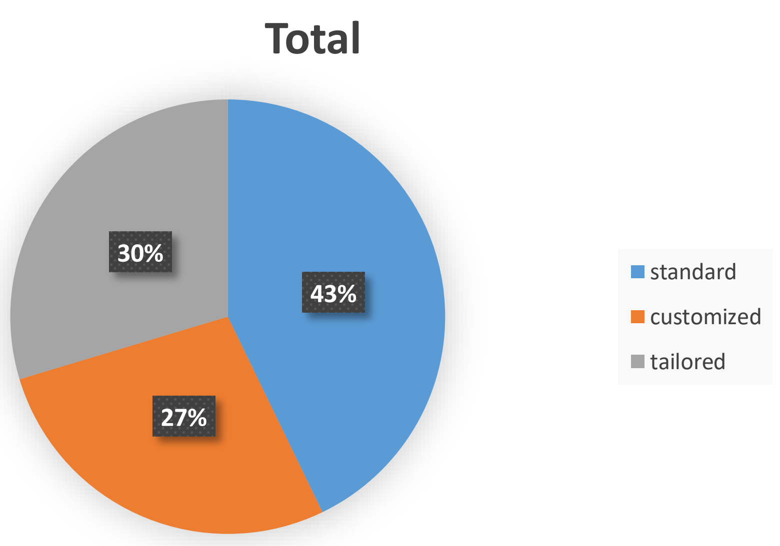
Percentage of Standard, Customized and Tailored products in the output

Table 4: Customized output of the companies

	Standard	Customized	Tailored
Total	42.83%	27.52%	29.65%
IoT	31.15%	32.35%	36.50%
Non IoT	48.26%	25.28%	26.47%

In this table are reported the portions of products that are Standard, that can be Customized from the standard model and that are Tailored based on the requests of the clients.

It is possible to notice, for the total sample, how the most part of the goods produced is Standard, 43%, while the Customized goods are the 27% of the total production and the personalized are the 30%.

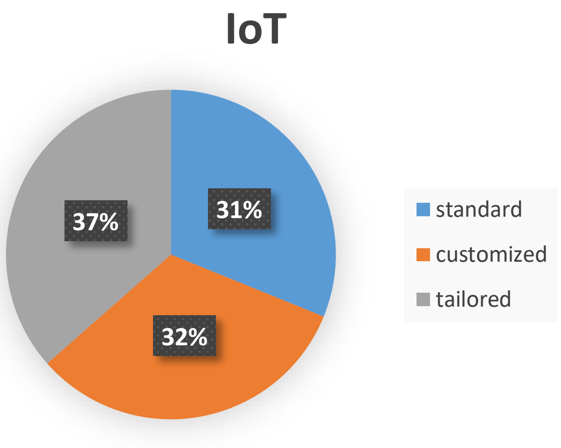


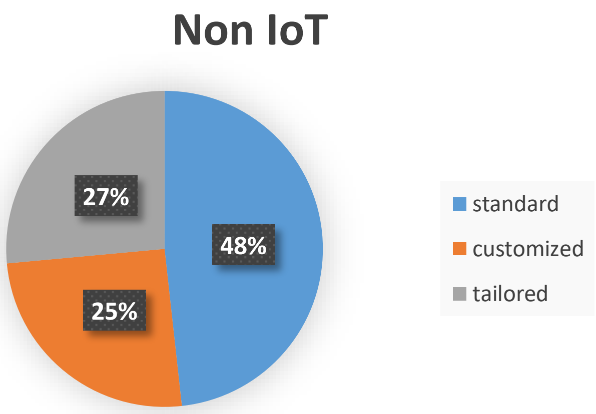
If we focus on the distinction based on the adoption of Internet of things technologies, it is possible to notice a significant difference in the percentages of the customized products.

Indeed, for the IoT adopters, the percentage of the Standard goods decreases at 31%, while for the non-adopters is 48%.

For the adopters, the sum of products that are **Customised and Tailored** amounts at the **70 %** of the whole production, while for the non-adopters of IoT, it counts only the 52% of the production, which is significantly lower.

From the analysis of these results, it is possible to understand how significant the Internet of Things technologies are for the purpose of the adoption of a strategy of Personalization and Customization of the offer.





The fields of analysis that have been taken in consideration are:

The **first source of competitive advantage** for the company. This part aims at analysing, for all the companies, which is the first source of competitive advantage among the listed ones, which are: Quality of the product, Innovation of the product, Design, Production Flexibility, Reduction of the production costs, Service to the client.

How Industry 4.0 technologies are involved in all the **different processes** of the company. In this part, the focus is on the study of how all the technologies of the Industry 4.0 are employed, and specifically in which processes. The possible options for the processes where the technologies can be used, are: R&D for the development of new products, Prototyping, Production, Management of the Production, Logistic and Supply chain, Marketing and commercial activities, Post sale Service.

Which are the **reasons** that have brought the company to invest in Industry 4.0 This part aims at analysing the motivations that have brought the company to make the investment in the technologies of Industry 4.0. The options given for the answer are: Internal Efficiency, Increase of Variety of products, new Products and new Markets, Keep the production in Italy, Reshoring, International competition, imitation of the competitors, improvement of the Service to the clients, request from clients, adaptation to standards.

The Interviewed had the possibility to answer, for all of these options, giving a score from one to five basing on the importance that each motivation constituted for them.

Which are the **results** obtained, by implementing Industry 4.0. This part analyses all the results that the interviewed champions obtained by the implementation of Industry 4.0 in their company. The options they can select are: Increase of the turnover, reduction of the Production costs / increase in Efficiency, increase in Productivity, Increase in the percentage of Personalized products, better Service to the customer, entry in New markets, reorganization of the activities between Italy and abroad, International competition, Environmental Sustainability.

What are the results that Industry 4.0 has brought, from the point of view of the **product offered.** This part aims at analysing which are the innovations of the products offered allowed by the adoption of the Industry 4.0.

In a scale from one to five, the companies had to answer if they could improve their Performances through the connected services allowed by smart products; if they could achieve a more active role of the client in the Project phase or in the Production phase; if they could get a higher Control on the products during its use, like remote maintenance or data collection; if they could adopt a different distribution process.

For all the sections, I analysed the changes in the answers according to the different types of Industry 4.0 technologies adopted.

In particular, I focused on the **Internet of Things**, as the results will suggest that this technology will be the most suitable for the aim of this research.

4.1.3 Companies competitive advantages

This paragraph investigates which are the competitive advantages that characterise the companies of the sample.

From the followin table, it is possible to understand which is the **first source of competitive advantage**. Focusing on the total of the companies, **Quality** represents the main competitive advantage for the 34.67 % of the sample. After that, **Innovation** follows with the 25.33% and **Flexibility** with the 14.67%.

Table 5: Source of competitive advantage

	Total
Quality	34.67%
Innovation	25.33%
Flexibility	14.67%
Service	10.67%
Other	6.67%
Reduction of prod costs	5.33%
Design	2.67%

If we focus on the distinction between the companies that adopt the Internet of Things and those that do not adopt it, it is possible to notice one important difference.

For the companies that do not adopt Internet of Things, the first source of competitive advantage is the "**Quality of the products**" and the second is the "**Innovation of the product**".

For the companies that adopt IoT, there is a difference on the first source of competitive advantage, which is the **Innovation**. Quality then follows as the second.

For the remaining sources, they follow the same order, both for adopters and non-adopters of IoT. The order is the following: **Flexibility of the production** as the third source of competitive advantage, **service** as the fourth, **Reduction of production cost** as fifth and the **design** as the last. Both in the adopters and non adopters, respectively 4.55% and 7.55%, there are companies that have pointed "**Other**" as the answer for their competitive advantage.

Table 6: IoT and Not IoT competitive advantage

	IoT	**Non IoT**	**Significance**
Innovation	40.91%	18.87%	Pr 0.0457
Quality	27.27%	37.74%	Pr 0.3857
Flexibility	13.64%	15.09%	Pr 0.8716
Service	9.09%	11.32%	Pr 0.7758
Reduction of prod costs	4.55%	5.66%	Pr 0.8456
Other	4.55%	7.55%	Pr 0.6354
Design	0.00%	3.77%	Pr 0.3560

From this table it is possible to see all the differences that there are from IoT adopters and not adopters in terms of importance of every competitive advantage.

The most relevant difference consists on the **Innovation**, which for the Iot adopters counts the **40.91 %** and for the non adopters counts only the **18.87%.** The significance of this difference is confirmed by the significance of the t-test calculated on the **differences of the proportions** which, for the Innovation, resulted with a **significant 0.0457 p-value**.

In conclusion, what can be understood from the answers to this question, is that companies adopting **IoT** are significantly more oriented to Innovation than the not adopters, which in turn, according to the results, seem to give more importance to the Quality.

4.1.4 Industry 4.0 Technologies adoption in different processes

This paragraph aims at investigating how all the different technologies of Industry 4.0 are adopted in the different processes of the company

The results emerged from the analysis are shown in the table below.

Focusing on the Internet of Things, it resulted that the main area of occupation of this technology is the **Research and Development** with a **21.21**% of the answers. After the R&D, it follows in order: **Production, Logistic & Supply chain**, both with **18.18**% of the answers, and, subsequently, **Production Management** and **Post sale Service**, both at **15.15%.**

Table 7: Technologies and processes

	IoT	**Robotics**	**Big Data**	**Additive manufacturing**	**Cloud Computing**	**3D Scanner**
R&D	21.21%	15.87%	16.05%	30.77%	13.21%	23.08%
Production	18.18%	33.33%	12.35%	12.82%	11.32%	15.38%
Logistic & supply chain	18.18%	11.11%	16.05%	2.56%	16.98%	7.69%
Post sale Service	15.15%	3.17%	8.64%	2.56%	9.43%	0.00%
Production Management	15.15%	19.05%	23.46%	15.38%	20.75%	7.69%
Prototypes	6.06%	12.70%	8.64%	35.90%	7.55%	30.77%
marketing	6.06%	3.17%	14.81%	0.00%	16.98%	15.38%
other	0.00%	1.59%	0.00%	0.00%	3.77%	0.00%
Sum	100%	100%	100%	100%	100%	100%

The results that emerge from the answers to this question are in line with the results of the previous one, confirming that IoT, as a technology, is incline with an attitude toward Innovation.

Other technologies that showed a significant application in the R&D activities are the **Additive manufacturing** and the **3D scanner.**

After this, it is possible to notice how this technology is also compatible with other processes inside the activities of a company.

In particular, IoT is relatable not only with processes concerning the production and its management and, hence, with the physical realisation of the products, but also with the processes like Logistic and Service that are related with the management of the external relationships both with Suppliers and Customers.

Another technology that has a relevant application in the production phase is the **Robotics**. For what concerns the Logistics, Big data and Cloud computing are the other technologies used for these processes.

From these first results, it is already possible to see how Internet of Things seems to be relatable with a strategy of personalisation and customisation of a product, as its inclination toward Innovation and its compliancy with Production and External Relations are all factors that, according to the theoretical analysis made in the previous chapters, contribute to the realization of a strategy of this kind.

4.1.5 Objectives and Results of the investment in Industry 4.0

This section will focus on the **objectives** that brought the companies to invest in Industry 4.0 **and the results** that came after the investment.

Generally, the main factors that contributed to this investment are: the improvement of the customer service, the pressure made by the international competitors, the improvement of internal efficiency and the pursuit of new market opportunities.

Table 8: Objectives of the investment

	Total	**IoT**	**Non IoT**
Improvement of customer service	3.93	4.35*	3.67
Internal efficiency	3.78	3.68	3.84
International competition	3.79	3.67	3.87
New market opportunities	3.33	3.41	3.28
Environmental sustainability	2.86	2.83	2.87
Increase in variety	2.76	2.75	2.76
Demand from customers	2.56	2.71	2.46
Sector standards	2.49	2.53	2.46
Keep production in Italy	2.40	2.22	2.54
Competitors imitation	1.86	1.82	1.88
Reshoring	1.32	1.35	1.28

Focusing on the answers given by companies that adopted the Internet of Things, it is possible to notice how even more importance is given to the **improvement of the service.** For what concerns the other factors, the scores are quite similar and there is not a significant difference from the IoT adopters and non-adopters.

However, it is possible to notice how the score given to the importance of the service changes quite significantly: **4.35** for IoT adopters against **3.67** for non-adopters, which gives a **3.93** of average total score.
In order to prove that this difference in the score is significant, a **statistical t-test** has been conducted (see the appendix). This two-sample t-test is a tool that compares the Means of one variable, distinguishing two samples defined by another variable.
It has been calculated the significance of the difference of all the means of the variables considered in the previous table. The variable considered for the distinction of the two samples is the dummy variable IoT, which assumes value 0 for the non-adopters and value 1 for the adopters of Internet of Things.
In the appendix is reported the table with the results of this statistical test.

This t-test has calculated the difference between the two means, which for the **Service** is 0.686 and, looking at the p value of the t test, it is possible to see if the difference between the two values is significant.
As the p value is 0.036, hence smaller than 0.05, the difference between the values of the mean of the improvement of the performance through the service between the IoT adopters and non-adopters is statistically significant. This means that there is a proved difference in the focus on the Service between IoT adopters and non-adopters.
Again, this result suggest that there is a strong correlation between the adoption of the Internet of Things technology and a focus on the improvement of the Service to the clients.
Like already said before, the focus on the Service is a characteristic that, according to the theoretical analysis, is relatable with the implementation of a strategy of customization and personalization and, for this reason, IoT is confirming its compliancy with the adoption of a strategy of this type.

The next table shows which are the **results** that Industry 4.0 has brought to the companies that have implemented it.

Looking at the total of the sample, the biggest improvements obtained are the increase in **Efficiency** (19.21%) and **Productivity** (16.75%) and the improvement of the **Service** (16.75%).

Table 9: Results of the investment

	Total
Increase in efficiency	19.21%
Increase in productivity	16.75%
Improving Service	16.75%
International competition	14.29%
Increase of turnover	10.84%
Diversification	6.40%
Personalization	4.93%
New markets	4.93%
Environmental sustainability	4.93%
Reorganize abroad activities	0.99%

Focusing on the distinction between IoT adopters and non-adopters, it is possible to notice how Productivity, Efficiency and Service still constitute the main improvements that industry 4.0 has brought.

However, there is a considerable difference in the importance that the IoT adopters give to the **improvement of the Service**, compared to the non-adopters. In fact, for the non-adopters of IoT, the improvement of the service constitute the 14.4% of the total improvements brought by the Industry 4.0 and, differently, for the adopters, this category constitutes the 20.5% of the total improvements, which shows again how the Service to the customers is one of the main focus for the adopters of the Internet of Things technologies.

Another significant difference that is possible to notice, is the importance that the category **Personalization** constitute for the adopters of Internet of Things.
In fact, for the non-adopters, Personalization constitute only the 3.2% of the total of the improvements, while, for the adopters of IoT, it constitutes the 7.7%, which is a quite significant difference.

Table 10: Results of IoT and Not IoT

	IoT	**Non IoT**	**Significance**
Improving Service	20.5%	14.4%	0.2575
Increase in efficiency	17.9%	20.0%	0.7117
Increase in productivity	14.1%	18.4%	0.4248
International competition	14.1%	14.4%	0.9526
Increase of turnover	10.3%	11.2%	0.8411
Diversification	7.7%	5.6%	0.5523
Personalization	7.7%	3.2%	0.1497
New markets	5.1%	4.8%	0.9234
Environmental sustainability	2.6%	6.4%	0.2243
Reorganize abroad activities	0.0%	1.6%	0.2616

In order to better show this relation between Internet of things, Personalization and Service to the customers, a correlation matrix has been executed (see the appendix). This correlation matrix takes in consideration the relations that are present among Personalization, Service and all the list of technologies of Industry 4.0.

As it is possible to discern, the technology that presents the best correlation with both Service and Personalization is the Internet of things, which confirms the importance of the role of this technology for the adoption of a strategy of Personalization and Customization of the offer.
After this, a further step has been executed in order to reinforce the analysis. The correlation between the two variable Personalization and Service has been tested with a Pairwise correlation in order to see if the relation between the two is statistically significant.
As it is possible to notice from the table in the appendix, the correlation is significant, with a value of 34.9% and a p value of 0.012.
In conclusion, what is possible to understand from the analysis of this topic, is that the Internet of Things confirms to be the best technology among the others of the industry 4.0 in order to implement a strategy of Personalization of the offer. In fact, in accordance with the results of the previous questions, the IoT results to be the technology with the best level of correlation with the improvement of the Service and the realization of personalized products. Moreover, it resulted that these two factors, Service and Personalization, are significantly correlated between themselves, which gives even more strength to the importance that IoT recovers in this field.

4.1.6 Interactions with the customers

This paragraph analysis which are the improvements that Industry 4.0 has brought, from the point of view of the interaction of the company with the customers.

From the answers of the total of the sample, it emerged that Industry 4.0 has allowed companies to reach a good improvement on the **control on the product during its use**. This means that companies are able, for example, to do remote maintenance or to collect data on the use of their products. All these features are made possible by the incorporation of software inside products, which can be controlled by remote and that can also send information and data to the developers of the company.

Table 11: Collaboration with the customers

	Total	IoT	Non IoT
More control on the product during its use	3.18	3.75	2.72
Enhancement of performance through services	2.91	3.58	2.37
More active role of the customer in project phase	2.17	2.55	1.87
Different distribution process of the products	1.86	2.05	1.69
More active role of the customer in production phase	1.74	1.89	1.62

After this, the companies of the sample have positively valued also the improvements that the industry 4.0 has allowed to reach from the point of view of the **improvement of the performance offered through the connected services**, which means by the use of smart products and similar. In fact, thanks to smart connected products equipped with different kinds of sensors, companies can anticipate and understand which are the needs of their users and give to them readily the service they require.

Industry 4.0 is hence giving an important advantage from the point of view of the connection of clients and companies and the possibility to **improve the customer experience with a better and targeted service**.

Moreover, the total of the sample of companies has also valued positively the increase of the possibilities that the customer has to take a **more active role during the project phase** of the product.

This means that the Industry 4.0 is allowing the clients to collaborate with the companies for the project of a product, which give also the possibility to the customers to design goods, according to their specific needs and requirements. For this reason, it is possible to understand how Industry 4.0 is opening the doors to new possibilities of personalization and customization of a product that will consequently give the possibility to better serve one client and hence increase the value that both the company and customers get from the relationship.

If we look at the differences between IoT adopters and non-adopters, it is possible to notice how the adopters give even more importance to all of the improvements allowed by Industry 4.0.

In specific, it is possible to see how significant is the difference of the score that the two categories have given.

In order to test the significance of the difference in the scores given by the IoT adopters and non-adopters, a two sample t-test has been conducted for the scores given to all the options (see the appendix).

As it is possible to notice, the differences of the means of the scores between adopters and non-adopters are significant, with p-values that are smaller than 0.05, for the scores given to: active role in the Production phase, Improvement of the performance through the service, control on the product.

This means that, for the adopters of Internet of Things, the improvement allowed by this kind of technology is even more important and significant. In specific for the enhancement of the service and for the way that companies can collaborate with their customers, having more remote control on the products and giving to people the possibility to project and personalize them.

Internet of Things is in fact the technology that gives the specific possibility to connect objects, making them smart, and collect data from them. In this way, Internet of Things allows to give to the customer a better and more targeted service, which will increase the value of the relationship.

Moreover, Internet of Things allows also to give a more active role to customers during the project phase, which means that it will allow to increase the possibilities of a strategy of personalization and customization of the offer.

In order to deepen this empirical analysis, in the conclusive part, three multiple regressions have been calculated in order to better understand which are the variables that are most significantly relevant in order to increase the level of the **Service** and the level of **Customization of the products**.
These regressions have been calculated in order to reinforce the findings of the previous part of the analysis, which have shown how the Internet of Things, among the technologies of the Industry 4.0, is the most suitable for a strategy of Personalization of the offer and for the improvement of the Service, two strategies that resulted to be also correlated and to have different commonalities.

4.1.7 Service and personalization

The analysis executed so far showed how the **Internet of Things** is significantly correlated with **the improvement of a service** that a company can ensure to its clients. Moreover, as it is shown by the correlation matrix referred to the table number 8 in the appendix, from the analysis of the sample, **Service** resulted to be significantly correlated with the **Personalization** variable.

This first regression has been calculated taking the score of the **enhancement of the performance through the service**, taken from the question number 27, as the dependent variable. For the independent variables all the **technologies of the Industry 4.0** have been used as dummies variables.
The objective of this first multiple regression is to show which are the technologies of the Industry 4.0 that have the higher influence on the improvement of the performance through the Service provided to the customers.

Coherently with what has been found in the previous part, the **Internet of Things** resulted as the most significant technology among the others, with a very significant P value of 0.006, in order to implement a strategy of improvement of the Service to the customer.

Regression on Enhancement of the Performance through the Service

VARIABLES	(1) Performance service
IoT	0.980***
	(0.337)
Robotics	0.356
	(0.350)
Innovative robotics	-0.448
	(0.341)
Additive manufacturing	0.538
	(0.379)
Laser cutting	-0.261
	(0.494)
Bigdata	0.397
	(0.337)
Cloud computing	0.427
	(0.388)
AI	0.585
	(0.566)
Dscanner	-0.359
	(0.470)
Augmented reality	-0.678
	(0.861)
Constant	1.819***
	(0.426)
Observations	43
R-squared	0.428

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The reason behind this is the fact that IoT is the technology that enables the companies and the consumers to be connected.

As it has been explained before, the IoT gives the possibility to the companies to obtain a huge amount of data on consumer behaviours that allows them to better understand their customer needs and hence to give them a better service.

The second multiple regression has been calculated keeping the score of the **Enhancement of the performance through the Service** as the dependent variable.
As independent variables there are the scores taken from the answers 27 and 34, which refer to **the relationship of the consumer and the company** through all the life cycle of a product.
The variables taken in consideration are:

- **Projrole**: the score, from 1 to 5, that the companies assigned to the increase in the active role of the client during the project phase.
- **Prodrole**: the score, from 1 to 5, that the companies assigned to the increase in the active role of the client during the production phase
- **Remote_Control**: the score, from 1 to 5, that the companies assigned to the possibility given by the tools of Industry 4.0 to get a higher remote control on their products.
- **Distribchange:** the score, from 1 to 5, that the companies assigned to the changes to their distribution process because of the Industry 4.0 investment.

Regression on Enhancement of the performance through service

	(1)
VARIABLES	Performanceservice
Projrole	0.666***
	(0.221)
Prodrole	-0.327
	(0.262)
Remote_Control	0.0285
	(0.154)
Distribchange	0.298
	(0.224)
Constant	1.389**
	(0.520)
Observations	41
R-squared	0.345

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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The variable that has resulted significant for the improvement of the Service is the **role of the consumer during the project phase.**

This confirms the fact that the possibility to project and possibly personalize and customize a product, can be considered as a way to improve the Service that a company gives to its customers, as it is a way through which consumers can project a product that is in line with their necessities and needs.

In this way, a company would improve the general **customer experience** of the client and hence to get a **higher value from the relationship**, which could imply a more long lasting relationship between the parts.

4.1.8 Degree of Customization of the offer

Gandhi, Magard, Roberts (2014) stated that **Mass customization** has the potential to help companies increase revenue and gain competitive advantage, improve cash flow, and reduce waste through on-demand production. Mass customization can also generate valuable data that may be used in the development of standard products and in online marketing and public-relations campaigns.

This strategy is reinforced by the development of the **instruments of the industry 4.0**, which allow to effectively put in place the personalization of a product.

Moreover, it is assumed that the **Service** should cover an important role for the aim of this strategy, as it is the way a company can install and improve its relationship with a customer.

The variables taken in consideration for the following multiple regression are:

- **Performanceservice:** the score, from 1 to 5, assigned by the companies to the improvement of their performance through the Service allowed by Industry 4.0 tools
- **Projrole:** the score, from 1 to 5, that the companies assigned to the increase in the active role of the client during the project phase.
- **All Industry 4.0 technologies used as dummy variables.**

Regression on quantity of customized goods

VARIABLES	(3) Customization
Performanceservice	-12.67**
	(5.969)
Projrole	-2.810
	(6.631)
IoT	38.48***
	(12.41)
Robotics	-24.90**
	(11.83)
Innovativerobotics	16.74
	(11.25)
additivemanufacturing	-27.85**
	(12.81)
lasercutting	20.07
	(14.92)
Bigdata	3.577
	(11.89)
Cloudcomputing	44.79***
	(13.16)
AI	-23.32
	(20.49)
Dscanner	9.283
	(15.88)
Augmentedreality	-35.44
	(26.74)
Constant	67.85***
	(17.53)
Observations	37
R-squared	0.558

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The third multiple regression that has been calculated takes as dependent variable the **quantity of customized and tailored goods** that are present in the offer of a company.
As independent variables, all the **technologies of the Industry 4.0** have been used in order to understand which are the ones that are more significant for the level of personalization of the offer of a company.

In addition to this, as from the previous analysis the performance of the Service and the active role of the customer in the projection phase resulted to be related to this objective, these two variables have been added in order to test their significance for the customization of a product. For what concerns the Industry 4.0 technologies, those that have resulted to be significant are the Internet of things, the Robotics, the Additive manufacturing and the Cloud computing. **IoT and Cloud computing** are those that resulted with a higher level of significance.
About the other variables, the level of the performance related to the **Service** has confirmed his significance for the concern of the implementation of a strategy of personalization of the offer. Although the coefficient of this variable resulted to be negative, it is important to notice how this variable plays a meaningful role for the aim of putting in place this type of strategy.
For what concerns the **role of the client in the project phase**, in this specific case the variable did not result to be significant. The reason for this can be explained by its correlation with the variable Performanceservice, which has also been demonstrated in the previous regression.

4.2.1 Qualitative analysis

The final section of this work is a qualitative analysis that aims at accomplish a further study on the **applications** that the Internet of things can have in the **products** that some companies are making for the use of their customers.
After the results of the quantitative analysis that showed the results and the traits of the companies that adopt this technology, this research aims at taking a deeper look at some examples of use and implementations of the Internet of things in some companies, understanding the **advantages** and the **challenges** that this innovation has opened.
The companies are using the IoT in order to increase the **value** that they are giving to their customers. With the integration of sensors and software in their products, they are aiming at the improvement of the experience of their customers.
With the innovation of the Internet of Things, the companies and the customer can reach now a new level of **interaction** in their **relationship**. The **connection** that this technology allows to put in place is opening new ways to serve the customer, to understand its needs, sometimes even before the person that is using the product has realised which necessities he has.
The **service** that companies can give to their clients can benefit a lot from this innovation, as the products themselves will signal to the company the requirements of the user, how he uses the product, what kind of problems could possibly verify.

Internet of things is a technology that is opening new ways and possibilities that today are only the beginning of its exploitation.
However, these new opportunities could bring also some **threats and challenges** that must be addressed and solved in order to avoid risky problems that IoT may cause to its adopters.

This section aims at analysing some examples of applications of the Internet of Things to the products that three companies are offering to their clients. This research will focus on the improvements and the **added value** that this technology is allowing to achieve from the point of view of the **customer experience** and of the improvements of the **service.**

This qualitative analysis was carried out by making an interview to a group of three different companies:
Electrolux Italia S.p.A.: it is the Italian branch of the well known Swedish multinational home appliance manufacturer, located in Pordenone, with its headquartered in Stockholm. It is ranked second as appliance maker by units sold after Whirlpool.
Electrolux products sell with different brand names (including its own), and are primarily major appliances and vacuum cleaners intended for consumer use. The company also makes appliances for professional use.
Xylem Lowara: located in Montecchio Maggiore, Xylem offers a complete range of pumps, boosters, drives, valves, controllers, water systems, and other solutions for numerous applications, residential and commercial, in the following industries: Agricultural & Landscaping, Building Systems, Industrial Water, Public Utility Water Systems.
Some of Xylem’s well-known brands serving Applied Water Systems markets include A-C Fire, Bell & Gossett, Flojet, Flowtronex, Goulds Water Technology, Jabsco, Lowara, and Rule.
Carel Industries S.p.A.: located in Brugine, produces systems for control technology and humidification for air conditioning and refrigeration. Operates in the market of HVAC and in the refrigeration market, Carel projects produces and offers solutions that can integrate in single units and in complex systems.

	Industry	Net Sales 2018	Headquarter	IoT application
Electrolux Group	Appliances (home and professional)	$14.3 B	Stockholm	Smart home
Xylem Lowara	Water pumping and circulating	$5.2 B	Xylem group: USA Lowara: Montecchio Maggiore (VI)	Smart watering
Carel	Hvac and Refrigeration	€280 Mln	Brugine (PD)	Smart cells, Total store

These three companies have been selected for this analysis as I had the opportunity to visit them with a Company tour organized by **Auxiell**, a lean management consulting company. Auxiell organized this tour as a reward for the winners of their context "Leanfluencer".
The contact with the companies took place first with the visit of their plants during the tour that took place in September of 2019. During this visits I had the possibility to see their production plants and their offices and I had the possibility to talk with many people of different departments. After every visit I left to these three companies the questionnaire that I elaborated for a following interview.
The second step of my research consisted on a telephonic interview with a person from the IoT department of these three companies who answered to my questions and gave me additional information for the aim of the research.
Before the company tour, I realized, with the contribution of Professors Bettiol and Di Maria, a general questionnaire which was focused on the analysis of the following topics:

- General description of the activity of the company, its products and its reference market

- Which kind of products are integrated with IoT systems

- Which data is the company able to collect and how they use them

- Which are the applications that these tools have
- How do they develop the personalization of a relationship
- Does the company have a dedicated IoT department
- Which are the advantages allowed by the IoT
- Which are the problems and the challenges that this innovation has introduced

4.2.2 Electrolux Italia S.p.A.

The study concerning Electrolux took place with an interview to Giuseppe Bisognin, Global R&D Quality Assurance Director.

The Italian production plant is located in Porcia (PN), where there are the two departments dedicated to the consumer and professional appliances.

Electolux was formed in 1918 following the merging of Lux AB and Svenska Elektron AB. It is a multinational appliance manufacturer with its headquarter in Stockholm, Sweden. The company now employs over 54,000 people worldwide. Electrolux used to make only electric vacuum cleaners when it was formed, but today it manufactures all major appliances for both consumer and professional use.

Electrolux’s total revenue has increased from around 12.67 billion U.S. dollars in 2014 to over 14 billion U.S. dollars as of 2018. The company generates the majority of its revenue from its kitchen equipment segment, which accounted for 60 percent of sales in 2017. The company’s largest regional market for major appliances was Europe, where 39 percent of its total revenue was generated in that year. In the U.S. alone, Electrolux generated over 4.3 billion U.S. dollars in revenue in 2018. The major appliances in the North American region is the company's second largest business area, Electrolux generated 31 percent of its revenue here in 2018. Electrolux ranks fifth amongst the leading household appliance companies based on sales worldwide in 2019.

In its wide range of products, Electrolux is now pushing toward the direction of **connected and smart products.**

In their web page there is a specific section dedicated to the concept of smart house and connected appliances. With its range of connected appliances, Electrolux is dedicated to creating **unique experiences** for consumers, ranging from recipes and advice on how to improve in the kitchen, to personalised laundry care to keep the clothes looking new for longer. The Electrolux connectivity experience is designed to make the user feel in control both at home and away, through features such as monitoring, remote control, voice commands, images and more.

[11]Electrolux works with leading global players such as Google and Amazon to ensure simple and seamless connection experiences. They are also part of the **Open Connectivity Foundation (OCF)**, which is an industry organization having as its stated mission the development of specification standards, the promotion of a set of interoperability guidelines, and the provision of a certification program for devices involved in the Internet of Things (IoT). OCF consists of over 300 companies and is dedicated to ensuring interoperability through the creation of open-source standards, platforms and implementations for connectivity.

These smart products can also be integrated with their mobile application **"My Electrolux"**, where it is possible to register the appliances, access to customized information and services, get in touch with Electrolux, download manuals and much more.

The app can work both with kitchen and washing appliances, and it gives advices to the customers related to how to cook some foods or it allows to remotely control laundry appliances from the smartphone. The Care Advisor feature enables to get expert advice on how best to wash clothes. In addition, Custom Favorites allows to save settings for specific items to save time.

Giuseppe Bisognin, talking about the connected machines, said that this concept aims to give **added value** to the customer. In fact it allows to determine if there are any malfunctions in the machine, it enables to do remote online software updates or diagnosis and, in this way, when service goes to perform the intervention, they already know where to go to work and what components it needs.

The interviewed then explained how Electrolux collects and uses all the **data** that the IoT allows to obtain in order to improve and personalize the Customer experience and the service to their customers.

For what concerns the data about the **Quality**, there is a global database that collects **7/8 terabits each month**. Every time that a technician goes to perform an intervention on a

[11] Image source: https://openconnectivity.org/

household appliance, this is recorded and this provides information on how the products are performing in terms of quality. Subsequently, the data are transferred to the databases and put in standard format via a processing system.

In this way, Electrolux knows the level of defectiveness of the specific model possessed by the customer.

It is also possible to find out what works have been carried out, which parts have been replaced, how much these service interventions have cost the company, how many and which spare parts have been requested.

In this way, the quality department of research and development can interact with the suppliers and then it will be possible to understand the roots of the problems. These issues can be of a technical nature or can be linked with the processes of the suppliers, or with the environment for which the product is intended. This is a process of **continuous improvement**. It is possible to understand through monitoring systems how much a problem can affect and become important for the company.

Other quality indicator data are the evaluations on the Internet. Electolux performs two types of analysis. First, the analysis of **internet ratings**, which are the scores given by the users, distinguishin by market, brand and model.

Then, there is the **sentiment analysis**, a tool managed by Business intelligence systems that reads user's comment and interprets the polarity of the word, as the same word can have positive or negative meaning. Then, it gives a score to evaluate the satisfaction of the consumers related to a specific product.

This survey is carried out in some areas called **Net Promote score (NPS)**, where the customer registers as a user by entering his personal data, enters information and carries out a questionnaire, which is carried out when the customer buys the product. The company then asks the customer to carry out a questionnaire about a year after the purchase.

The number of customer visits to the site is monitored to ask for their feedback and to identify which problems occur in the products most often. Once a month, data that can give indications on how to improve the product is received.

Moreover, for washing machines, washer-dryers, dryers, it exists a test protocol that simulates what laboratories working in consumer institutes and consumer magazines do. This test protocol allows to predict what score will be assigned to a machine.

For the management of this quantity of data, Giuseppe Bisognin explains that Electrolux relays both on an internal department and on external companies as the capacity of the data loads is difficult to predict.

Thanks to external expertise it is possible to be more effective and faster. The access to the databases of retailers and online sellers such as Amazon, allows to obtain information.

The Business intelligence team tries to put together in a structured way the huge amount of data obtained and try to understand which are the indicators that most influence the improvement of the consumer experience.

At the end of the interview, Giuseppe Bisognin concluded speaking about the trend of the market for the Internet of Things and the smart appliances. He stated that for the consumers, the interest towards machines that can be connected to other smart devices is a bit decreasing compared to some years ago. In his opinion, for what concerns their market, the consumer does not have a real concern on having a machine that he can control with his app.

According to the interviewed, the main application for the IoT is the one related to **the post sale Service**, which consists mainly on the maintenance and on the detection and solution of the problems.

Another relevant application is then the one that aims at increasing the **environmental sustainability** and the energy savings, which is possible to achieve thanks to the sensors that monitor all the parameters of consumption of energy and resources.

4.2.3 Xylem Lowara

The study on Xylem Lowara took place with an interview to Giovanni Mugnolo, the Business development manager for Europe and emerging markets.

Xylem's Lowara brand is a leader in providing solutions for pumping and circulating clear and contaminated water.

The Xylem group registered in 2018, 5.2 billions of revenues, with a net income of 549 millions

The main industries served are:

Agriculture. The company offers solutions for water supply, water treatment and water analysis even in particularly difficult conditions.

They offer pumps, mixers and other water treatment systems that have applications for all parts of the field and that can adapt to every local conditions

Aquaculture. Xylem provides instruments and software for monitoring the main process parameters such as water flow rate, dissolved oxygen (DO), ammonia, temperature and pH. Real-time data provided by Xylem provides producers with a complete picture of the activities, tools and controls needed to ensure the health of the harvest.

Commercial buildings. Xylem provides Solutions for HVAC, water and wastewater treatment and fire fighting for buildings**.** Commercial buildings include hotels, shopping malls, schools, offices and hospitals. They usually host large numbers of people at the same time. This increases the demand for reliable, energy-efficient solutions that are able to handle the constant flow variations of various liquids.

Industrial Wastewater and Process Water Treatment. Xylem provides solutions that enable the industry to meet a wide range of raw water supply and wastewater and rainwater treatment needs. Xylem is the leading supplier of pumps and equipment for moving any type of liquid in industrial environments.

Mining Water Pumps and Drainage Systems. Xylem offers solutions for open pit mining, underground mining and materials processing. This is a complete range of rental pumps designed for water resistant treatment systems and precision analysis to ensure process control and compliance

Water Treatment for Oil and Gas. Xylem offers solutions for separation, treatment and disposal of wastewater. Xylem provides Innovative methods that can reduce corrosion and fouling, improve energy efficiency, enable water reuse and reduce downtime.

In the interview with Giovanni Mugnolo, it has been possible to analyse how the company approaches to the Internet of Things and how these technological systems are integrated and used in their products.

The interviewed has first made a distinction on how IoT is adopted at Xylem. In fact, Internet of Things is applied both for their internal processes and for the integration with products in order to make them "smart".

About their **internal processes**, a project was launched in 2017 at a corporate level, which brings together all the companies and all the segments in which they operate. A year-long analysis has been made and it has been decided that the first implementation of the IoT will be done on the **supply chain**, hence on the suppliers.

The aim is to create a **predictive model** that takes into account those events that cannot be predicted on a standard analysis. The situations of interest are: geopolitical situations that can create supply problems, natural disasters, sudden peaks in demand.

This predictive model must be able to **automatically modify the supply chain**, according to a possible problem that may arise, to ensure the supply of material and thus avoid overstock, which would increase the working capital. The objective is to keep their supply chain structure as it is today and be able to adapt to situations that may arise.

The following step after the implementation of the predictive model is to align the suppliers with their idea of retail system: guaranteeing complete traceability of components for a vision of green impact, carbon footprint reduction, product life cycle cost reduction. This consists on going back up the raw material chain. Xylem aims at **Sustainabilit**y and **reduction of the environmental impact** linked to **full traceability**.

Xylem has just started with the IoT because they are an engineering company and, according to Mr Mugnolo, because the applications of the IoT are still seen with suspicion today. Everything that travels within the industrial environment has extremely important protection and safety systems and for this reason the technology has not yet reached the level of safety that the industry expects. The big problem is the **security of the data.**

For what concerns the **products**, Xylem started in 1994. Systems with wired data transmission are used, with 3 communication protocols. For wireless systems they use 1 to 1, bluetooth and 5. 0 point control systems. One of their products called Universal gateway is passed through a wireless network.

They have their own cloud that relies on an external server for data collection and transmission. They have found the best application field for this technology in the **municipalities**, so companies that deals with water and wastewater.

In the construction industry there is a tendency to stay on a wire system, for control.

In the world of pumps and water handling, the IoT is seen as a possible tool for **predictive analysis**, so to understand when a pump might have problems. In the industrial and municipal areas the objective is to have control and prediction system because the maintenance costs of the plants are much higher and the management of resources is higher.

The Software is **developed specifically for the customer** because the systems are different from each other. There is a significant increase in sensor technology on board to obtain data. The new trend is **wireless sensors**.

For what concerns Spot analysis system, one of their products came after the acquisition of PURE, a Canadian company. They produce a ball system with the size of a bowling ball, where inside there are sensors that with ultrasound, identify points of discontinuity to understand where there are leaks. Software recognizes waveback differences and therefore understands where there is a breaking point and makes tube thickness analysis and understands where the tube is breaking and can prevent the breakage.

This system guarantees to have important savings, as it is possible to do emergency intervention rather than extraordinary maintenance.

Another product they make has the shape of an umbrella that gives a complete analysis of all the thickness of the tube and all the roughness.

For the Continuous Analysis System, they collaborate with a Singapore company, producing fixed systems on pipes. Detecting up to 1% of the total water passing through. It is specific for areas where little water passes, like Southeast Asia, India.
Another Smart system is **Flexinet**, which is not allowed in Europe. It uses radio waves that are allowed only in USA and Uk. It is important because with these antennas it is possible to collect all the info from the counters, which transmit automatically. It is possible to collect water, gas and electricity at any time in a house. Moreover radio transmission is stable by nature and it can't be intercepted. It consists on a Smart gateway that collects data from every source, it is the hub for smart cities and smart watering.
Another important application for IoT, according to Mr Mugnolo, could be the smart lighting, which consists on switching lights off through data transmission. For example, San Francisco will save $50 million a year with smart lighting.
IoT for Xylem can be used for the development of the concept of Smart city, which means smart gas and gas consumption remote control, smart grid, smart water and smart lighting.

The main problems are related to **data security** and to ensure data protection. That is why there is not market readiness to pay for it.
In the short term, says Giovanni Mugnolo, the IoT constitutes an opportunity **to integrate more systems** and thus increase their **optimisation and efficiency**. Especially with regard to the water supply on the one hand, to understand if the water goes through the pipes, if there are leaks, where they are, and on the other hand the reduction of energy used for heating and air conditioning.
When talking about the challenges that they are facing with IoT, Mr Mugnolo sais that the big question nowadays is: what are we going to do with all this data, how can we use it? Any kind of information can now be detected from a system. The understanding of the data is being developed and it is necessary to understand what kind of data is needed.

[12]The other question is: is it necessary to load a server with terabits of data or can megabits of data be enough to achieve the same purpose?

Mr Mugnolo then explained that they have dedicated department IoT and that 4% of turnover is reinvested in innovation (20 million per year).

Mr Mugnolo also added that they seek to develop together with their suppliers rather than changing them, they aim at **collaboration**, they want to have strategic and related partners with whom they can realise a **co-development** of business processes.

Xylem also aim at the evolution of their Customers, they want to increase speed of delivery, reduced response time and give new services

In conclusion, Mr Mugnolo gave his overview on IoT as an excellent tool for efficiency of systems to **reduce environmental impact**. The real change consists on reduction of waste and carbon footprint and on approaching circular economy. The objective is to reach **sustainability** in comparison with countries that do not have this attention.

4.2.4 Carel Industries S.p.A.

The study on Carel took place with an interview to Ivan Favaro, the Group Head of IoT department.

Carel registered 280 million of revenues in 2018, with an Ebitda of 55.2 million (19.7% ebitda margin) and 37.5 million was the net profit.

CAREL is active in the design, production and global marketing of technologically advanced components and solutions (hardware and software) to achieve energy-efficient performance in the control and regulation of equipment and systems in the air conditioning (HVAC) and refrigeration markets (HVAC/R). In this context, CAREL designs, manufactures and markets control and humidification solutions within the application segments: **Residential, Industrial, Commercial.**

Over the years, CAREL has been able to create systems and applications for some vertical market niches, characterised by extremely specific needs to be satisfied with highly dedicated

[12] Image source: https://www.xylem.com/it-it/brands/lowara/

solutions. In particular, in the HVAC market, CAREL offers solutions to be integrated into individual units, such as heat pumps, shelters, rooftops, Computer Room Air Conditioners (cd. CRAC), chillers and air handling units, both in complex systems, such as entire systems/systems for shopping centres, supermarkets, museums and data centres. In the refrigeration market, CAREL is active in the design, production and marketing of control and humidification systems in the food retail and food service application segments. As with the HVAC market, CAREL designs, manufactures and offers solutions to be integrated both in individual units, such as bottle coolers, plug-in refrigerators, multiplexed refrigerators, compressor racks and condensing units, and in complex systems, such as entire systems/systems for supermarkets of all sizes, convenience stores and restaurants.

The offer is completed by the provision of services linked to CAREL solutions such as, for example:

- commissioning or contract work;
- subscriptions to the tERA service platform, i. e. the service for the remote management and monitoring of the Group's HVAC/R systems and application components, which enables “dialogue" between the company's service centres and end customers;
- subscriptions for services dedicated to the remote management and control of plants and machinery through the processing of data collected by exploiting the **Internet of Things** properties of the solutions proposed both in the cloud and on site.

Through benchmarks, statistics, alarms and standard reporting, each user can optimize daily activities and become more effective in achieving their goals in terms of services, energy, quality and marketing. The development of these activities is of strategic importance for CAREL, also in the future.

For what concerns the IoT, Carel gives a lot of importance to the applications and use of Internet of Things in their business.

The objectives that they aim to achieve with the application of this technology are:

- **Easy control**: Remote control of any equipment through the simplest interaction with the unit. Make all of the system's technical capabilities available in an easy and effective way
- **Maintenance cost reduction**: thanks to alarm priority and filters it is possible to reduce journeys on site with in-depth, remote technical analysis
- **Energy savings**: reduce energy consumption by analysing working conditions, identify and adopt the most virtuous consumption profiles to maximize the benefit

- **Unit performance**: capture most critical data by monitoring the behaviour of machine components, their effective working hours, so to "measure" their reliability, predict the need of spare parts and develop new algorithms able to make unit's or plant's overall lifetime longer
- **Quality improvement**: Get reports on product quality by analysing overall life cycle or individual critical components. Avoid malfunctions to maintain performance over time and retain the user thanks to the high quality perceived

Mr Favaro gave an overview on how IoT technology is applied at Carel. IoT is the collection of data from controllers that are memorized in a cloud and then become the object of processing. There is a **Machine learning** system aimed at the creation of statistical models that calculate the ideal behaviour according to the conditions of the environment. This makes possible to compare, for each individual machine, the actual behaviour with the ideal one and identify any deviations.

First, you identify whether there are these deviations and investigate the reason for them, in the second phase you look for the causes of the problems and in the third phase you look for a way to solve these problems. You start by creating what is called a "field" with controls. There are several in the company that use different technologies.

The Data that Carel has a concern on are Temperatures, alarms and other various types of trends. It depends on the application that creates different lists of data because the tool is used to give a series of dashboards based on alarm, consumption, quality. The data collected are also used to verify the correct setting and operation of the bench.

The three main parameters used to evaluate the functioning of their products in Carel are **Consumption**, **Quality**, i. e. temperature range that must be maintained, **Alarmistic** i. e. not working.

It is necessary to have a navigation system that allows to have a summary, because an huge amount of data is available for many different products.

The **main problem** today, according to Mr Favaro, is the **quality of the data**. Maybe because it may depend on how the probe is mounted or because there are contextual situations that may alter it and make it not significant. There is a lot of data and there's a lot of low quality data. In order to implement synergy logics and to take full advantage of data collection systems, it is necessary to make these data uniform and unaltered.

For what concerns the projects related to smart and connected elements, Mr Favaro said that they work in the cold chain, food, air conditioning, refrigeration and what could be achieved with the IoT is the **Total store**: manage cold food, lights, air conditioning.
This concept aims at the Smart control of the supermarket and it is the closest thing to a smart building.
Talking about their relationships with their customers, Mr Favaro said that there is **collaboration with customers**, on one hand we sell them controls and on the other hand they make it a system of service.

4.2.5 Qualitative research: cross case analysis

In this section, a comparative analysis will be executed in order to frame all the characteristics and commonalities emerged from the study of these three cases.
An overview on the uses of IoT, the benefits and the challenges created by this technology will be highlighted.
All these three companies, which operate in three different industries, showed a real concern for the development of the concept of the Internet of Things by the integration of technological components on their products and the consequent work and calculations made on the amount of data that these systems make available.
All the companies have a **dedicated department** for the implementation and the management of projects related to development of the Internet of Things. They all dedicate resources and interest for the development of this innovative concept, which is demonstrated by dedicated web pages like it is for Carel or by the participation to specific organizations aimed at the development of the IoT like it is for Electrolux and the Open Connectivity Foundation (OCF).
All the companies have in their offer **smart products** that can be connected and controlled via app in order to improve the user experience and to give a better Service to their consumers.
What emerged from this analysis is that the main concern for the companies is on the **data related to the Quality** of their products. This means data related to eventual defectiveness, consumptions rates and alarmistic that characterise the life of their products.
Basing on this data, the companies can then operate to improve the service to their customers, elaborating **predictive models** that will allow them to implement systems of preventive maintenance that enable to reach important savings for the repair of the machines and hence a better user experience.

Moreover, IoT allows to monitor all the wastes and consumptions rates related to their products and hence it is an important instrument to improve the approach to the **environmental sustainability**, the reduction of the environmental impact, the reduction of the carbon footprint and the reduction of wastes and consumptions. All of these are particularly relevant factors that nowadays every company should keep in consideration.

For what concerns the relations with the external organizations, all the companies analysed highlighted their propensity to the **collaboration and co-development** with all the other subjects of the supply chain.

They aim at realise a connected and **integrated supply chain** system with their suppliers, in order to reach higher levels of efficiency and optimisation of the production processes.

Moreover, the companies also aim at collaborating with their customers, giving them the possibility to develop and adapt their products according to their necessities and requirements.

For the management of the data, the three companies adopt the same structure based on a mix of **internal and external competences**. All these companies are collecting every day a huge amount of data and for this reason it is necessary to collaborate with external experts for the management of them.

For what concerns the problems and the challenges opened by the innovation of the Internet of Things, two main issues emerged from the interviews that will need to be addressed in the future.

First, the **security of the data**. A huge amount of confidential data is being continuously transferred across different platforms. This inevitably creates the risk of the interception and the steal of data and the necessity to secure them with appropriate tools.

Second, huge amount of data are collected and stored everyday. Terabites everyday means an enormous quantity of data. The issue that emerges from this is that this incredible amount of data is difficult to manage and possibly also useless. It is costly to manage databases with this huge amount of data and for this reason, it is important to understand if all these information are really necessary.

What emerged from the analysis is that a big challenge for the future will be to focus on the **quality of the data** instead of the quantity.

	IoT Products	Applications of IoT	Personalization features	Problems
Electrolux Group	Smart connected appliances	• Preventive maintenance • Assistance service • Data analysis (sentiment analysis) • Control via app • Environmental sustainability	Personalization of settings and uses via app	• Security of data • Quality and Quantity of data
Xylem Lowara	• Smart pumps • leaks detection systems	• Preventive maintenance • Integration of supply chain with predictive model • Environmental sustainability	Adaptation of products and software to the requirements of the client	• Security of data • Quality and Quantity of data
Carel	Smart cells	Detection of: • Consumption • Quality • Alarms	• Personalization of settings and uses via app • Adaptation of products and software to the requirements of the client	• Security of data • Quality and Quantity of data

Conclusions

This thesis has performed this analysis for the aim of understanding how Industry 4.0 can be used in the optic of a strategy of Personalization and Customization of goods and services in order to better serve a customer and to improve his consumer experience, ensuring a relevant added value to him.

From this analysis, it emerged how for the aim of a strategy of **Personalisation and customization** of the offer, the Internet of Things turned out to be the most suitable technology among all the others of the Industry 4.0.

The reason for this is that the IoT resulted to be a technology that has the characteristic of being **oriented toward innovation** and also very **versatile**, with the possibility to be adopted in different areas like R&D, Production and Logistic, all areas that resulted to be relevant for a strategy of personalization of the offer.

After this, Internet of Things turned out to be the technology with the highest implication in the area of **Service** to the customers, which is a key function in the optic of installing a close relationship with a client that is looking for a personalized good that answers to all his specific necessities and requirements.

Moreover, IoT resulted also to be relevant for those companies that are aiming at the application of a strategy of **Personalization** of the offer, which also turned out to be significantly correlated with the objective of the improvement of the Service. This reinforces even more the importance that this technology covers for the goal of a strategy of Customization of the offer.

IoT also allows the customers to take an **active role in the project phase**, thing that is relevant for the implementation of a relationship between two companies that are developing a product that will be in line with the necessities and requirements of the client.

Finally, the IoT adopters have shown that they have a higher percentage of customized goods in their offer than the average of the total sample.

The final multiple regressions have confirmed these results, highlighting the compatibility of the Internet of Things with a strategy that aims at realizing personalized products through an improved service and an active role of the customer in the project phase.

This thesis has also performed a further qualitative analysis to understand which are applications of the Internet of Things, from the point of view of the products and the relation with the client but also from the point of view of the internal processes of the companies. The common characteristics and the results that emerged from the study based on the interviews to the three companies that adopt the IoT are the followings:

- **Dedicated IoT department:** implementation and the management of projects related to development of the Internet of Things. They all dedicate resources and interest for the development of this innovative concept;
- **Smart connected products in their production offer**: products connected and controlled via app in order to improve the user experience and to give a better Service to their consumers
- **Work with huge databases where the data on the Quality are the most relevant:** data related to eventual defectiveness, consumptions rates and alarmistic that characterise the life of their products;
- **Elaboration of Predictive Models developed from the data: this** will allow them to implement systems of preventive maintenance that enable to reach important savings for the repair of the machines and hence a better user experience;
- **Application for Environmental sustainability and Energy consumption reduction:** IoT allows to monitor all the wastes and consumptions rates related to their products;
- **Integration and connection with external actors:** All these companies are collecting every day a huge amount of data and for this reason it is necessary to collaborate with external experts for the management of them. Moreover, these company aim at the integration of the supply chains with their partners.

Moreover, from this analysis emerged also some challenges that these companies are facing in relation to the Internet of Things:

- **Security of the data**: risk of the interception and the steal of data and the necessity to secure them with appropriate tools;
- **Quality of the data**: many data are collected every day, but only a small percentage of them are really useful.

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Appendix

T test for table 8

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Efficiency by IoT:~1	31	19	3.838	3.684	.154	.274	.55	.575

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Variety by IoT: 0 1	25	16	2.76	2.75	.01	.353	.05	.978

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Newmarket by IoT: ~1	28	17	3.285	3.412	-.126	.296	-.45	.672

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
KeepIT by IoT: 0 1	22	18	2.546	2.222	.323	.451	.7	.478

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Reshoring by IoT: ~1	21	17	1.286	1.353	-.067	.244	-.3	.784

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Internationalcomp ~1	30	18	3.866	3.667	.2	.296	.65	.503

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Competitors by IoT~1	25	17	1.88	1.823	.057	.362	.15	.877

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Service by IoT: 0 1	27	17	3.667	4.353	-.686	.317	-2.15	.036

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Envsustainability ~1	24	18	2.875	2.833	.042	.416	.1	.92

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Demand by IoT: 0 1	24	17	2.458	2.706	-.247	.411	-.6	.55

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Standards by IoT: ~1	24	17	2.458	2.53	-.071	.413	-.15	.864

Pairwise correlations

Variables	(1)	(2)
(1) Personalization	1.000	
(2) Service	0.349* 0.012	1.000

* shows significance at the 0.05 level

Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Personalization	1.000										
(2) Service	0.349	1.000									
(3) IoT	0.210	0.227	1.000								
(4) Robotics	0.089	0.055	-0.176	1.000							
(5) additivemanufa~g	-0.055	-0.174	0.079	-0.261	1.000						
(6) lasercutting	0.090	0.161	0.030	0.049	0.182	1.000					
(7) Bigdata	0.031	0.224	0.051	-0.062	-0.019	0.117	1.000				
(8) Cloudcomputing	0.140	0.118	0.142	-0.028	0.174	-0.081	0.056	1.000			
(9) AI	0.003	0.093	0.275	-0.204	-0.106	0.060	0.021	0.233	1.000		
(10) 3D scanner	-0.077	-0.038	-0.126	-0.008	0.246	0.298	0.049	0.076	-0.142	1.000	
(11) Augmentedreal~y	0.409	0.143	0.045	0.198	-0.149	0.213	0.176	0.143	-0.067	0.191	1.000

T test for table 11

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Distrib by IoT: 0 1	23	19	1.696	2.053	-.357	.293	-1.2	.231

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Proj role by IoT: 0 1	23	18	1.869	2.555	-.686	.323	-2.1	.04

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Performance service by IoT: 0 1	24	19	2.375	3.579	-1.204	.319	-3.75	.001

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Control by IoT: 0 1	25	20	2.72	3.75	-1.03	.351	-2.95	.005

Two-sample t test with equal variances

	obs1	obs2	Mean1	Mean2	dif	St_Err	t_value	p_value
Product role by Io~1	24	18	1.625	1.889	-.264	.277	-.95	.345