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"DIGITAL TRANSFORMATION AND BUSINESS MODEL INNOVATION IN MANUFACTURING: THE CASE OF THE CAPITAL EQUIPMENT INDUSTRY"

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FIRST CHAPTER: THE SERVITIZATION OF MANUFACTURING FIRMS

Introduction

In this chapter, the concept of servitization and its importance in academic literature will be exposed; actually, although it has gained recently a great interest, servitization is not a completely new phenomenon, both in managerial practice and academic research. As a matter of fact, starting from the 80s, hundreds of publications have been made on the topic.

One important study about the role of servitization in manufacturing, the one that is usually considered as the first mainstay of the field, is the one by (Vandermerwe & Rada, 1988), which first dealt with the "servitization of business"[1].

Scholars have given through time different definitions of servitization; according to (Baines, et al., 2017) these definitions have coalesced into the following; *servitization is the process of building revenue streams for manufacturers through services*.

Finally, after having described the main publications and related concepts (with a special emphasis on the closely related concept of Product-Service System), will be shown the main drivers and strategic implications of servitization, followed by the apparent contradictions coming from empirical analysis of the phenomenon, generally known with the term of *servitization paradox*.

1.1 Servitization: concept and definitions

In this discussion, the terms product and service are fundamental. If a product can be defined easily as typified by a material artefact, the same is not true for services, since they are usually defined taking into consideration the fact that they are not products. They can though be defined as the "*economic activity that does not result in ownership of a tangible asset*" (Baines, et al., 2009).

The discussion on services and their potential to benefit business is huge, and encompasses different disciplines and schools of thought. According to (Baines, et al., 2013) the research on services and servitization can be categorized into five different schools of thought: services

[1] In describing the creation of product-service bundles, interestingly, they do not only speak about manufaturers that are servicizing, but also about service companies that are producticing their offer, coming, as they say, "from the product end" and from "the service end".

marketing, service management, operations management, product-service systems and service science management and engineering.

The most interesting ones in our discussion are the ones on service marketing and product-service systems; especially this last one has a lot of similarities to the research community on servitization. According to (Baines, et al., 2013), actually, the difference between the two school of though is mainly geographical and related on the attention given to the environment.

1.1.1 Services and marketing: from the IHIP paradigm to the service-dominance logic

Marketing, as an independent discipline, has seen a great development and dynamicity in its history. As highlighted by (Baines, et al., 2013), at its inception, marketing was dealing mostly with the economic exchange and distribution of commodities, exemplified according to the authors, in the work of (Taylor, 1936). Over the intervening years, the emphasis of marketing moved from economic exchange to marketing management with a stronger focus on satisfying the customer needs. In the 60s, the marketing mix (or the 4P's of product, price, place and promotion) provided more insights in how a firm could adjust its offering to satisfy customers (Kotler, 1967).

After that period, the acknowledgements of the peculiarities of services lead to a development in the services marketing discipline, whose analysis culminated in the "crawling out phase" of the research on service marketing, as posed by (Fisk, et al., 1993), where the so called IHIP paradigm was defined. According to this point of view, services are different from goods because of their peculiar characteristics of intangibility (or immateriality), inseparability (or simultaneity of production and consumption), and perishability (with its implications of inability to inventory service output).

With the beginning of the 21th century, the 4P's paradigm was challenged by many scholars, since it lacked, as conceived at that time, of the flexibility and adaptability needed by the new market circumstances. In this situation, also the IHIP paradigm for services was criticised as too much reductive to provide useful insights into contemporary reality. According to (Lovelock & Gummesson, 2004) it is too simple to assert that just four characteristics distinguish goods from services. In their view, a new perspective must be opened, starting from the assumption that exchanges not resulting in the transfer of ownership from seller to buyer are fundamentally different from those that do; and that service provision offers benefits through access or temporary possession, not ownership.

This situation saw also the rise of the so called service-dominant logic (Vargo & Lusch, 2004), which gave an even more drastic perspective, since the peculiarity of services, according to the authors, needs the practitioners to completely avoid the view according with

which the value of the firm must be included in a specific output offered by the firm to the customer; a service must be the result of a work of co-creation.

The authors focused firstly on the influence of the classical economic theory on marketing, stating from the functional view of the beginning of XX century, the Marketing Management view of the 50s-60s, stating at last that a new shift in perspective has come, leaving the strong ties with microeconomics concepts of the past, first of all its product-centered view.

(Vargo & Lusch, 2004) then provide their specific definition of services, as *the applications of specialised competences, obtained through deeds, processes, and performances, for the benefit of another entity or the entity itself.* In that they are not, then, simply something that is not physical products (residual definition), services used to enhance a product (value-added services) or the service industries (like healthcare).

(Vargo & Lusch, 2004) also made a distinction from operand and operant resources; *operand resources* are resources on which are acted some actions, to obtain an effect; *operant resources* are resources that are used to operate on the operand resources. One of the main shift happened in contemporary times, for the service-dominant logic, was that customers, instead of being considered as operand resources to be captured, are considered operant resources with which achieve value.

One of the main consequences of this shift is that value creation is not simply a process internal to the firm, that is then simply transferred to the customer, but is instead a process in which the customer plays an active part; according to the authors, actually, one main feature of the Service-dominant logic is co-creation. From this a strong focus on the customer and, especially, its relation with the provider.

The view brought by the service-dominant logic was criticised by (Stauss, 2005) who consider its adoption as a new marketing paradigm "a Pyrrhic victory" since, if in the service sector is not possible to distinguish between production and consumption, in the goods sector surely it is. According to the author, it is just an alternative perspective on marketing, among the many needed to fully explain the tasks facing marketers.

1.1.2 Defining servitization

Although in the recent decades the hype for services has been high, at the beginning, instead, they were seen as a "necessary evil" by manufacturing; in facts, the main part of total value creation was considered to stem from physical goods, and services were assumed purely as an add-on to products. Then things changed, and manufacturers began to provide services with a conscious and explicit strategy, with services becoming a main differentiating factor in a totally integrated products and service offering.

As a matter of fact, services have been recognised as a powerful element through which consolidating the relationships with the customers and buttress the competitive advantage of enterprises in an environment in which price is no more a source of advantage, and even technological superiority is less powerful than once.

Not surprisingly, one key feature of servitization strategies is a strong customer centricity. Customers are not just provided with products but broader more tailored "solutions". These deliver desired outcomes for specific customers, or types of customer, even if this requires the incorporation of products from other vendors.

(Oliva & Kallenberg, 2003) think this customer orientation consists of two components.

First, a shift of the service offering from product-oriented services to "user's processes oriented services" (i.e. a shift from a focus on ensuring the proper functioning and/or customer's use of the product, to pursuing efficiency and effectiveness of end-user's processes related to the product).

Second, a shift of the nature of customer interaction from transaction-based to relationship-based (i.e. a shift from selling products, to establishing and maintaining a relationship with the customer).

Because of the large variability of services, it does not exist a single way to servitize.

The literature identifies potential applications along the so-called "product-service continuum" (Figure 1.1).

This is a continuum with, at one end the pure-product extreme and, at the other, the pure service firm configuration; firms move along this axis as they incorporate more product-related services, from the service as an add-on (as in the traditional view of firms) to the product as an add-on (in the most extreme forms of servitization).

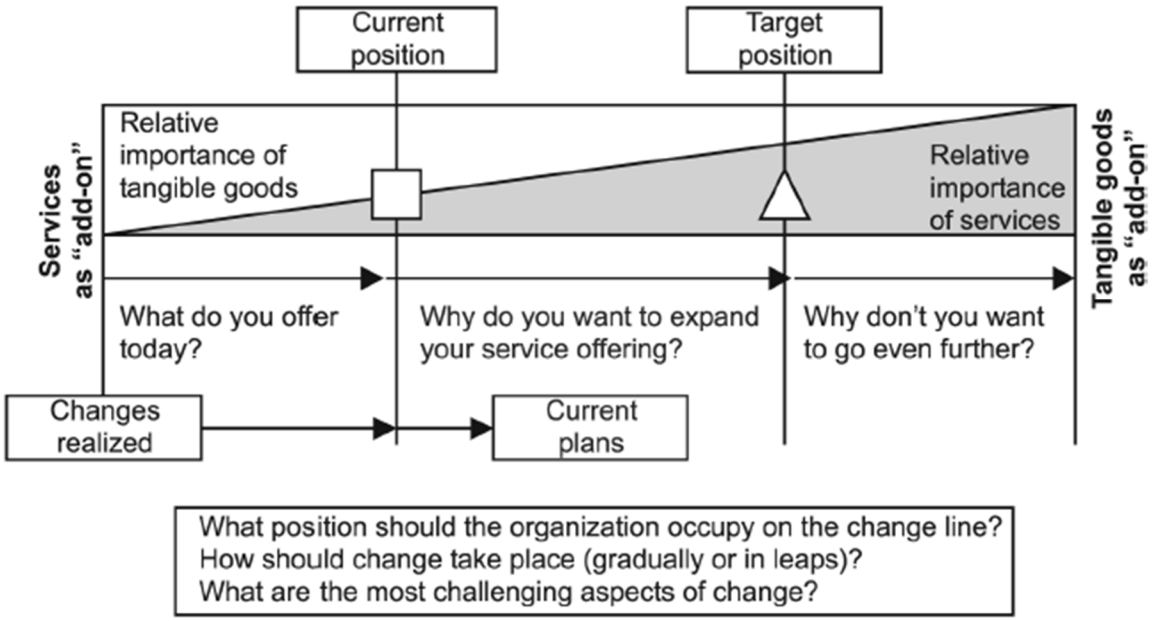

Fig. 1.1 The product service continuum (Oliva & Kallenberg, 2003)

As already said, the term servitization was coined by (Vandermerwe & Rada, 1988).
They defined servitization as "*a more holistic approach by managers to their businesses and their customers problems*.[…] [The managers are] *looking at their customers needs as a whole, moving from the old and outdated focus on goods or services to integrated "bundles" or systems, as they are sometimes referred to, with services in the lead role.*"
(Baines, et al., 2009) synthesise their view of the concept of servitization as "the increased offering of fuller market packages or 'bundles' of customer focussed combinations of goods, services, support, self-service and knowledge in order to add value to core product offerings", underlining the fact that they took the view according to which services are performed and not produced and are essentially intangible.
Theirs has not been the only one definition, though.
In Table 1.1 it is possible to see and confront the main definition of the phenomenon, according to (Baines, et al., 2009).

Authors	**Definition of servitization**
(Vandermerwe & Rada, 1988)	"Market packages or 'bundles' of customer-focussed combinations of goods, services, support, self-service and knowledge"
(Desmet, et al., 2003)	"A trend in which manufacturing firms adopt more and more service components in their

	offerings"
(Tellus Institute, 1999)	"The emergence of product-based services which blur the distinction between manufacturing and traditional service sector activities"
(Verstrepen & van Den Berg, 1999)	"Adding extra service components to core products"
(Robinson, et al., 2002)	"An integrated bundle of both goods and services"
(Lewis, et al., 2004)	"Any strategy that seeks to change the way in which a product functionality is delivered to its markets"
(Ward & Graves, 2005)	"Increasing the range of services offered by a manufacturer"
(Ren & Gregory, 2007)	"A change process wherein manufacturing companies embrace service orientation and/or develop more and better services, with the aim to satisfy customer's needs, achieve competitive advantages and enhance firm performance"

Table 1.1 – Definitions of servitization (Baines, et al., 2009)

Although they slightly differ from one another, it is possible to say that they all agree with what was said by (Vandermerwe & Rada, 1988), giving stress to the delivery of product-based services. One slight deviation is in (Lewis, et al., 2004) who refers to the idea of a functional product. This is a specific PSS configuration, according to (Tukker, 2004), just to show the similarities between the two research communities.

Actually, since these two research communities (servitization and PSS) both agree on the fact that companies should be focusing on selling integrated solutions or PSS, it seems legit to refine the servitization definition to encompass the PSS theme. So servitization can be then defined, according to (Baines, et al., 2009), as "*the innovation of an organisations capabilities and processes to better create mutual value through a shift from selling product to selling PSS*".

1.2 Product-Service Systems (PSS)

1.2.1 Concept and definitions

As stated before, an important concept related to the theme of servitization is the Product-Service System (PSS); both these terms are sometimes used as synonyms of each other. According to (Baines, et al., 2009) many of the underlying principles are identical: the difference arises in the motivation and geographical origin of the research communities. PSS is a Scandinavian concept which is closely coupled to the debates on sustainability and the reduction of environmental impact.

There is no general accordance on the exact definition of PSS.

One of the first foundational work on PSS is (Goedkoop, et al., 1999). According to them one a PSS is a combination of products and services in a system that provides functionality for consumers and reduces environmental impact. According to (Mont, 2002) the PSS offers a product and system of integrated products and services that are intended to reduce the environmental impact through alternative scenarios of product use.

According to (Brandstotter, et al., 2003) "*PSS consists of tangible products and intangible services, designed and combined so that they are jointly capable of fulfilling specific customer needs. Additionally PSS tries to reach the goals of sustainable development*"; according to (Baines, et al., 2007) "*PSS is an integrated product and service offering that delivers value in use. A PSS offers the opportunity to decouple economic success from material consumption and hence reduce the environmental impact of economic activity*".

It is possible to say that all definitions in general agree on the main features of a PSS: the fact of being bundles of product and services and a special attention given to environmental sustainability, through a process of de-materialisation of the offering. In recent years, the discussion on PSS was also enriched by the analysis of the so-called Industrial Product Service Systems (IPSS or IPS[2]) in the B2B context[2] .

But PSS are considered more than that.

Actually, in the opinion of (Gaiardelli, et al., 2014) the concept of PSS is a comprehensive business model, able to fulfil user requirements by providing increasingly dematerialised systems. So, again, we can see the similarity with the concept of servitization. According to (Baines, et al., 2013) PSS is a special case in servitization, with a major emphasis on asset

[2] The Industrial Product Service System is a developing subset of PSS, representing PSS business-to-business solutions, particularly in the field of high technology products. Actually, in those markets the customer is not able to exploit the product features available, and so the products are purchased as though they were commodities; for this reason technological market leadership may not directly result in market success. IPS2 permits to solve this problem, helping the firm to permit to the customer to fully exploit the potential of the products.

performance or utilisation rather than ownership, and that achieves differentiation through the integration of product and services that provide value in use to the customer.

In any case, it is possible to say that, generally, while the term servitization relates to the process, the term PSS relates to the final objects of that process.

More precisely, (Neely, 2008) states that, while PSS is "*an integrated product and service offering that delivers value in use*", servitization "*involves the innovation of an organization's capabilities and processes so that it can better create mutual value through a shift from selling product to selling PSS*".

According to (Gaiardelli, et al., 2014) the concept of PSS has four main characteristics:

1. The value proposition concerns the bundle of products and services offered, with the aim of representing the benefit for which the customer is willing to pay.
2. The infrastructure and network, such as the internal and external organisational structures, resources and capabilities, determine how products and services can be produced and delivered to customers.
3. The relationship capital that exists between the parties allows companies to target customers and distribution channels and determine how their products and services will be delivered; building strong relationships with the customers is also a major focus.
4. The sustainable aspects of the PSS are related to the three pillars of sustainability: economy, society and environment.

1.2.2 PSS typologies

In literature, different taxonomies of PSSs exist. One of the most cited is the one by (Tukker, 2004) which categories PSSs in three categories (Figure 1.2):

- *product-oriented*: in these types of bundles the property of the product is transferred to the customers, with some services, usually related to the maintenance and monitoring of the physical product.
- *use-oriented*: in these types of PSS the property of the product is not transferred and the customer pays for its usage and the services related to it; typical examples are car-sharing and rental systems.
- *results oriented*: in this case the provider and the customer agree on a specific result, without even specifying the physical means that are used to achieve it

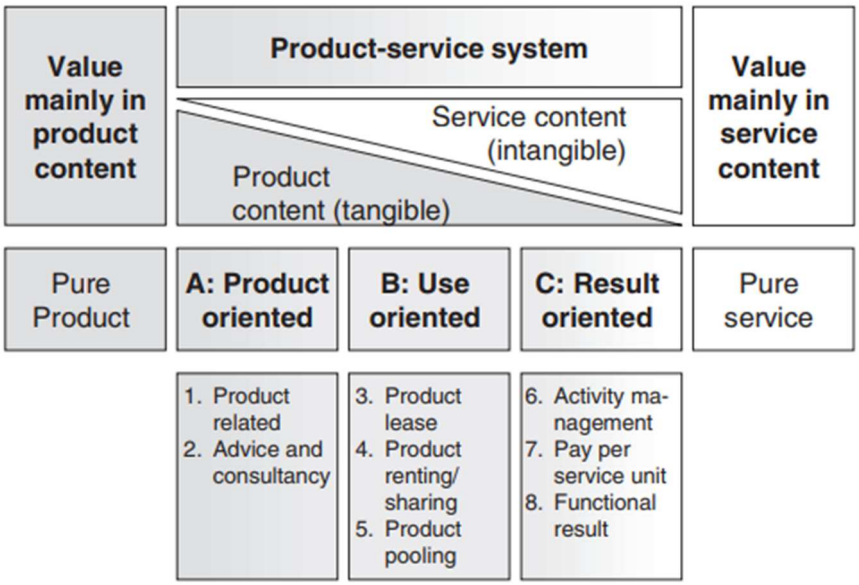

Figure 1.2 PSS typology in (Tukker, 2004)

Based on these types of PSS the authors propose a sequence of service-based business models, that rely on these different types of PSS. Firstly, the PSS could offer services in addition to a product (product-related services) or giving advice on how to use it (Advice & Consultancy). Secondly, the product could be given in use to the customer without transferring the property; the product could be given with unlimited and individual use (Product Lease), be sequentially (Product-renting/sharing) or simultaneously (Product pooling) used by many people. Thirdly, focusing on the activity done by the customer, a part of it could be outsourced and done by the provider (Activity management/outsourcing), the customer could pay not for the product per se but for its outcome (Pay per service unit) or for the delivery of a previously agreed result (Functional result).

The typology given by Tukker has been a mainstay in the PSS literature. According to many, it is though limited in explaining the complexity of service offerings of the different types of firms. Some authors tried then to better it: for instance, (Neely, 2008), starting from an empirical analysis of the services offered by manufacturing firms around the world.

They found out a list of twelve of them:

1. design and development services;
2. systems and solutions;
3. retail and distribution services;
4. maintenance and support services;
5. installation and implementation services;
6. financial services;
7. property and real estate;

8. consulting services;
9. outsourcing and operating services;
10. procurement services;
11. leasing services;
12. transportation and trucking services.

From those, they propose an enlargement of the Tukker's typology, adding two further PSS types, the Integration-oriented PSS and the Service-oriented PSS (Figure 1.3)

The *Integration-oriented* PSS involves, in substance, moving downstream, following the suggestion made by (Wise & Baumgartner, 1999), so adding services to a product through vertical integration. The property is still transferred to the customer, but the provider vertically integrate, moving into retail and distribution, finance services, consulting services real estate services and transportation and trucking services.

The *Service-oriented* PSS relates instead to incorporating services inside the products, so that the manufacturer does not simply sell goods but bundles of product and services which constitute systems and solutions to the customer's problems.

Figure 1.3 Scheme of the typology proposed by (Neely, 2008)

We can see, in this categorization, a slightly stronger focus on the transferability or not of the property from provider to customer (as stated, the first three PSS types operate this transfer while the last two do not).

This is a very important point, since, in the most advanced models of PSS, the product is simply a means for the provision of product, and so is retained by the provider; in a certain sense, it becomes an extension of the manufacturer inside the shop floors of its customers.

A typology that focus with decision on this frame is the one by (Adrodegari, et al., 2015). The main focus of this categorization is whether or not the property is transferred to the customer; for this reason are proposed two groups which collect five PSS types (Figure 1.4)

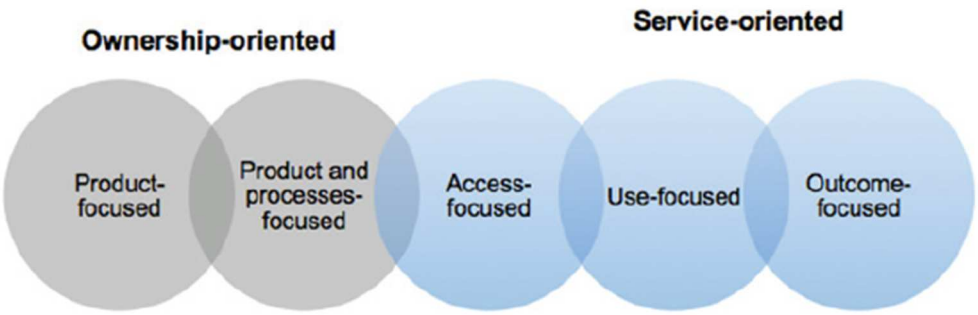

Figure 1.4 PSS typology by (Adrodegari, et al., 2015)

The first group contains the so-called *Ownership-oriented* PSS. In this group, property of products is retained by the manufacturer, product sales are the main source of revenues, and services are sold as simply an add-on to the product. It contains two PSS types.

The first is the *Product-focused* PSS type; the provider sells the tangible product to the customer and, separately, during the use phase of the product, it sells the services needed by the customer. This is a scheme typical of traditional industries, where are sold combinations of products and services that are not customized, with the aim to improve or maintain the full functionality of the product through its lifecycle. Revenues come mainly from the product sale phase.

Secondly, the *Product and processes-focused* PSS type. Is in many ways similar to the previous PSS type. The main difference is that services are given both before and after the act of selling, with the aim to optimize customer processes. In any case, the main revenue stream continues to be the one coming from the selling of the product; often in the product price is included a pre-sales service component (customization or configuration of the product.

The second group contains instead the *Service-oriented* PSS types. Here the main source of revenues are the services given together (or, more correctly, through) the product. The product is not even subject to a transfer of property, since it remains owned by the provider. There are many challenges related to this type of business models, above all the ability to correctly understand and predict the behaviour of the customer, together with the necessity to generate new revenue structures, that often include a risk premium. Actually, in these models, the payback period is usually longer, so the firm must find a way to have the necessary financial resources, finding for example an appropriate financial partner. This group contains three PSS types.

The first is the *Access-focused* PSS type. The customer does not buy the product but pays a fixed regular fee to gain access to it. This fee is not linked to the product usage and may include additional services. Since the provider company keeps the property of the product, it

gives additional services apt to extend its life cycle, like preventive maintenance, retrofitting and revamping. The interaction between provider and customer stops being transactional (the interaction is not regulated by contracts) to relational (i.e. it's specifically regulated).
Then there is the *Use-focused* PSS type. Here the customer pays a fee depending on the use of the product (could be a pay-per-usage time or a pay-per-usage unit). One great source of value for the customer is that, since the provider is responsible for all the lifecycle costs, it has a strong incentive to have it optimized from that point of view.
At last, the *Outcome-focused business* PSS type. In this PSS type, the customer pays a fee that depends on the achievement of a contractually set result in terms of product/system performance or outcome of its usage. The value for the customer is provided by the minimization of three main areas: initial investment, operational costs and of the risks to achieve an expected outcome with the product usage. One of the main feature of this model is an absolute peculiarity of each case, and the almost impossibility to adopt standardised solutions.

As was possible to note earlier, the discussion on PSSs not only relies on the final bundles of product and services, but on the entire business models (and this is, as already said, one of the main points of contact with the servitization discussion).
This discussion, however, lacks a very important element, that is business model transformation, i.e. passing from a form of manufacturing focused on products to a form of manufacturing centered instead on services.
Actually, business model innovation is a very important topic in a world like the one we are living characterised by increased competition; it is also very important for the technological development that is occurring nowadays, that brings new opportunities for manufacturers. For example, the possibility of implementing Outcome-based contracts and Service-Level Agreements (SLA) is now more at hand than before, because data (gathered and analysed) permit to make better forecasts and to properly charge for the risks that are involved in this type of long-standing contractual relationships.
In addition to that, the main important global manufacturing firms are more and more requesting advanced services in order to make agreements, and so, by being outside of this world, firms risk to lose a lot of opportunities.
This is especially true for SMEs, that find difficult to embrace the transformation and face its related challenges, like the need to redesign products and processes and the need to adapt their supply chains in order to be able to deliver upgraded service components in the offering.

1.3 Strategic implications of servitization

The academic literature has provided a lot of reasons why a manufacturing firm should move to services, reasons that have been also shown by a lot of empirical analysis.

According to (Mathieu, 2001) and (Baines, et al., 2009) the opportunities that servitization can offer can be grouped into three categories: strategic opportunities, marketing opportunities and financial opportunities.

1.3.1 Strategic drivers

From a strategic point of view, services permit to achieve a more sustainable competitive advantage since, being less visible and more labour dependent, services are more difficult to imitate (Oliva & Kallenberg, 2003). This is especially true in a world characterised by an increasing commoditization of the offerings, where price can no more constitute a differentiating factor, and where also the material and technological innovations very difficultly permit to maintain a sustainable advantage. From this, the necessity to try to rethink the usual feature of competition and strategy.

The main authority in describing competition and corporate strategy is considered to be Porter, who, in one of his famous works, said every firm has two way to compete with other firms: by differentiation and by costs; according to him, it is very difficult for a firm to compete along both those two lines.

This thesis has been a mainstay in corporate strategy debate, and, as usually happens, also object of criticism.

For example, according to (Mathur, 1988) one of the main problems of this point of view is the excessive focus on the firm itself and its physical products, and not on its environment and, especially, its customers. Every proper strategy must always be a matter of differentiation, since competing just on costs leads to a situation of homeopoly[3], where every merchandise is a commodity. It is also deviant the idea that a firm, to differentiate, can't also achieve cost leadership.

According to the author, differentiation can occur along two lines, merchandise and support.

Merchandise consists of the items made available to the customer (*what* is sold), support is understood to be the advice, training or assistance offered to customers (*how* it is sold).

Merchandise differentiation can be understood in terms of *content* (what the merchandise will do for the customer, it is related to the perception of having unique performance capabilities, probably based on distinctive technical, physical or aesthetic features) and *image* (what it will

[3] In market theory, a market configuration in which, for the consumer, the goods or services offered have the same economic value, since the differentiation of the offerings is absent.

say about the customer, it relates to the reassurance it gives him/her about the kind of person he/she is.).

Support differentiation can be analised in terms of *personalisation* (giving attention to each customer) and *expertise* (reputation for possessing the brain-power, talent, skills and experience that, in the eyes of customers, sets it apart from its competitors).

Services can play a great role in differentiation, especially in the one which occur in the support dimension, in which the customer is directly involved.

Not by chance, even in the work by (Vandermerwe & Rada, 1988) is explained that servitization "*is led by the customer*". It is the result, then, of a market-driven approach to corporate strategy. Here comes the importance of enlarging the offering with services in order to build and maintain a strong relation with the customer. Customer that is becoming more and more informed about the opportunities she can gather.

In this sense, servitization is powerful since it permits to lock out the competitors, because strong relation means high opportunity cost for switching for the customer; on the other part, servitization permits to lock in customers, leading to a high level of differentiation.

(Baines & Shi, 2015) would see this last view as a defensive driver of servitization (anticipating a threat); however, there are also offensive drivers (intended for attack). In the empirical analysis made by (Baines & Shi, 2015) firms showed a major focus on defensive reasons, because of an always increased and globalised competition. For the UK OEM manufactures analysed in the paper the main defensive driver of servitization was to protect their commercial viability; this was one of the main initial driver of OEM early adopters in servitization, in order to prevent competitors from entering their market. In addition to this, there was also a more "offensive" will to assert their capabilities in the market, leading to a growth of revenues, helping to gain more market acceptance for the product and the business innovations they could offer.

Looking at the other side of the relation, also customers find interest in paying for these types of contracts both for reasons that can be defined as defensive or offensive. As for defence, servitization permits to them to improve financial, risk and asset management, leading to cost savings. As for more offensive reasons, customers are guided by the will to improve focus and investment, putting more effort on core capabilities and gaining access more easily to high level technology.

These expectations were mostly met in the study, even though other drivers have emerged along the servitization process. Actually the firms found that giving more services permitted to increase their customers (also new entrants) through improved customer intimacy brought about by closer and stronger relationships. As for the customers, there have been

improvements in safety and environmental sustainability, and, from an offensive perspective, customers have also improved their own competitiveness through improved service quality to their own customers.

The shift from products to services has huge consequences on the management of the firm. Actually, according to (Gronroos, 1990) the strategic drivers of services are different from those of products. In traditional product industries one of the main strategic drivers was the so called "*internal efficiency*", that is the search for economies of scale and the increase of the productivity of capital and labor. When it comes to services, the imperative to be followed is instead the so-called "*external efficiency*", that is the customer satisfaction with the operations of the organizations; this is due to the specific characteristics of services, namely inseparability of production from consumption, the role of customers as co-producers and the broader interface between the service provider and the customer.

One important strategic principle that should guide servitization regards decision-making. Actually, it must in general made as close as possible to the customer; ideally, the front-line employees involved in the *moments of truth* (i.e. an instance wherein the customer and the organization come into contact with one another in a manner that gives the customer an opportunity to either form or change an impression about the firm) should have the authority to make prompt decisions. Their empowerment and training to recognise the diversity of customer interaction permits to transform these moments of truth into "moments of opportunity". It is anyway important to centralize the interaction of front-line employees and centralising the knowledge that comes from them, to avoid a situation of chaos.

1.3.2 Marketing drivers

Secondly, services also play a great role in marketing. Usually, they are considered as a means for selling more products.

In addition to this, services permit also to create customer loyalty, according to (Vandermerwe & Rada, 1988), to the point where the customer can become dependent on the supplier. Services tend then to induce repeat-sale and, by intensifying contact opportunities with the customer, can put the supplier in the right position to offer other products or services. Finally, by offering services, firms can get more insights on the customer needs and prepare more tailored offerings.

Not by chance, according to (Lele & Karmarkar, 1983), one of the main tenets of a successful marketing strategy is the identification of customer expectations regarding post-purchase product support and the development of cost-effective strategies for meeting those

expectations. This has been, historically, the main reason of success of firms like Caterpillar Tractor and John Deere.

Actually in the business-to-business context, product service strategies influence overall client satisfaction, improve new product adoption and strengthen the the client's confidence and the supplier's credibility.

The view according to which services permit just to sell more products is reductive, though, according to (Oliva & Kallenberg, 2003); more than that, services permit to exploit the potential coming from the installed base.

This is especially true in a B2B context, where, most of the times, the items sold have a very long useful life; they then require an all gamut of services as they advance through their life cycle. In addition to this, they also have a series of costs that relates to the ownership of the items, beyond the initial purchase price.

Exploiting the installed base brings some challenges, like the close relationship with the market of new sold items, and so a reduction in potential future revenues coming from that source.

However, it brings also unique advantages. First of all, the acquisition cost of the customer is lower, because, since firms are also selling new products, they already know the information on the new equipment. Secondly, a lower knowledge acquisition cost, since the manufacturer can know better the requirements of the equipment during its useful life. At last, a lower capital requirement, since the manufacturer already possess the specialised technologies used to fabricate spare parts or to upgrade the existing equipment.

1.3.3 Financial drivers

At last, for economic arguments. Actually, it is fundamental to point on services since they provide higher margins than product and they constitute a more stable source of revenues since they are resistant to the economic cycles that drive investment and equipment purchases (Wise & Baumgartner, 1999).

In addition to this, (Wise & Baumgartner, 1999) also point out that in some sectors, since the ratio installed base/new sales is quite high, the opportunities arising from the development of services are far greater.

For example, the number of U.S. automobiles in service has grown from 60 million in 1950 to 200 million in the 90s, while contemporary sales have been essentially flat at 15 million vehicles a year. That had created an installed-base-to-new-unit ratio of 13 to 1. This pattern is repeated across many other sectors, including locomotives (a ratio of 22 to 1), civil aircraft (150 to 1), and tractors (30 to 1). Financial benefits, though, come not simply with an

appropriate cost planning, but especially with a consistent pricing strategy; this last especially proves to be difficult to manage.

(Gebauer, et al., 2006) highlights what they believe to be the six factors that permits to a firm to achieve higher revenues, based on an empirical analysis on ten case studies of companies, five that had successfully servitized, and five who didn't.

First of all, it must have a *market-oriented service development* and a clearly defined *service development process*. Secondly, a *service offering focusing of the value proposition to the customer* (starting from product related services and then moving to services supporting the customer).

Thirdly, *relationship marketing*. In addition to that, *an appropriate service strategy*.

A *separate service organization*. At last, *an appropriate service culture*.

It has been suggested that product services tend to reduce the vulnerability and the volatility of cash flow, thus allowing for a higher shareholder value. Actually, they can be considered, according to (Srivastava, et al., 1998) as a part of *market-based assets*, i.e. assets coming from the interaction between the firm and other external entities. These assets are usually intangible, and tend to constitute the most part of the value of a firm, usually not recorded explicitly in balance accounts.

They can be mostly of two types, *intellectual* (the types of knowledge the firm possesses about the environment) and *relational*. Relational market-based assets are outcomes of the relationship between a firm and key external stakeholders, including distributors, retailers, end customers, other strategic partners, community groups, and even governmental agencies.

Following the Discounted Cash-Flow method, the value of a certain strategy for shareholders can be seen as driven by:

1. an acceleration of cash flows (earlier cash flows are preferred because risk and time adjustments reduce the value of later cash flows);
2. an increase in the level of cash flows (e.g., higher revenues and/or lower costs, working capital, and fixed investments);
3. a reduction in risk associated with cash flows (e.g., through reduction in both volatility and vulnerability of future cash flows) and hence, indirectly, the firm's cost of capital;
4. the residual value of the business (long-term value can be enhanced, for example, by increasing the size of the customer base).

Services, in the measure in which they are used with the intent to enhance customers' relation, permits first of all to enhance the cash flows by reducing the level of working capital and fixed investment; actually, the close relationships between suppliers and customer have enabled both parties to achieve efficiencies by linking their supply chains.

In addition to this, services permit to reduce the volatility and vulnerability of cash flows when they permit to increase customer satisfaction, loyalty and retention of customers. Actually, when the firm has a satisfied and loyal base of customers, the cash flow from these customers is less susceptible to competitive activity. As a relatively rare and inimitable asset, the loyalty of the installed base represents a significant entry barrier to competition and makes the firm's cash flow less vulnerable. For example, the average retention rate in the automobile insurance industry is 80%. San Antonio-based USAA has a retention rate of more than 99%. So whereas the average insurance company must replace approximately 50% of its customers after three years, USAA must replace less than 3% .

Very important is also the practice of cross-selling, since it augments the switching costs, increasing the number of bonds between the customer and its supplier.

Most of the reasons underlined previously can also explain how services can contribute to enhance the residual value of cash flows. For example, a larger customer base with an higher quality (measured for example by usage volume, willingness to pay a price premium, lower sales and service costs) permits to have an higher customer quality (and then an higher residual value). This is an important point, since to create value, firms must not simply increase their customer base, but also refine it (by eliminating the less profitable ones). Also, this point out that customer retention (instead of customer acquisition) should be prioritized, because customer loyalty is associated with more willingness to pay a price premium and lower sales and service costs.

To illustrate these potentialities, the example of General electric is quite significant. Actually, during the 90s, it saw an incredible growth. Its CEO of the time, Jack Welch, saw services as the key for the company current and future revenues. At the end, services constituted the majority of GE profits.

Although studies exist that show the importance and convenience of introducing services in the firm’s offer, in reality the question is debated, since a lot of empirical analysis instead shows that a lot of firms seem not able to increase their profits after having servitised; this fact gave rise to the discussion about the so-called “*service paradox*”.

1.4 The Service Paradox

In the analysis of the phenomenon of servitization it is very often remarked that the addition of services permits to increase the revenues and the competitiveness of the firms which decide to follow this path. However, when the revenues and costs of the servitized firms are empirically analysed, very often the result is that those firms have less profits than the ones that have not decided to servitize. Since it is a clear contradiction of the strategic theory implications of servitization, this was called the *service*, or *servitization*, *paradox*.

The term was coined by (Gebauer, et al., 2005) after an empirical analysis on a sample of firms from German and Swiss machinery and equipment manufacturing industries. They found that, among the firms which decided to servitize, a very little part was able to have a considerable percentage of revenues coming from the provision of services.

In their opinion, the un-success of a servitization process comes from both the lack of right managerial motivation and organizational arrangements.

As for the first, the model by Vroom on managerial motivation was adopted as a framework. According to this scheme, the motivation of managers comes from three factors: valence (how much they want a reward), expectancy (the perceived probability that the effort will translate in success) and instrumentality (the perception that, in case of success, a reward will be received).

According to the authors, in the case of servitization three cognitive phenomena occur that make the motivation of managers dwindle, because of their self-fulfilling nature.

The first is the *overemphasis on obvious and tangible environmental features*, so that the valence of them is very low with respect to investments in services compared to investments for physical products.

Secondly, *scepticism of the economic potential of services*, so that they consider very unlikely that efforts in investing in services will translate in higher profitability.

Thirdly, an *high risk aversion*, so that they consider less probable that their efforts in investing in services will translate in a reward for them.

As stated before, anyway, managerial motivation is a necessary but not sufficient condition for having a profitable process of servitization: also changes in the organization are necessary, as also noted in (Gebauer, et al., 2006).

(Gebauer, et al., 2005) noted a commonality in their analysis of the successful cases of profitable servitizations.

They found that these firms usually: have a market-oriented and a clearly defined service development process; have focused the service offers on the value proposition to the

customer; have initiated a relationship marketing; have defined a clear service strategy; have established a separate service organization; have created a strong service culture.

First of all, is underlined the fundamental importance of having a market orientation developing new services always starting from the customer needs, gathering information through market research or focused workgroup with single customers. It is also very important to clearly define a service development process, understanding the different phases and quality gates in developing a new service, and selecting new services in accordance to the general strategic goals of the company.

Another fundamental aspect is the focus of service offerings on the value proposition of the clients. The first services to be offered should be related to the product, moving after to assistance and support for the customer. This, besides increasing the efficiency of the machines for the customers, involve also initiating an interaction based on the relationship, instead of the transaction.

Actually, another aspect necessary in initiating a process of servitization is also the capability of building effective relationships with customers, not just efficient transactions. In order to build a strong relational marketing, three dimensions must be considered: external marketing (i.e. making promises), internal marketing (enabling promises) and interactive marketing (dealing to the interaction's interfaces between customer and service provider).

All these aspects must be created according to a precise service strategy, since otherwise it is very difficult to build internally a strong promotion and offer externally new services. In this sense, the firm must collect the right information about the market and the customer needs, involve all the functions of the firm in its development and monitoring, and make the procedure transparent and systematic.

Then, according to the authors, from the organizational point of view it is best build up a new function, with profit and loss responsibilities and dedicated workforce; although some scholars share the same opinion, in reality a lot of firms prefere not to have a so distant function from the core business of the firm.

At last, none of these aspects could be successfully applied without the presence of a strong and identified service culture in the firm. That does not mean the culture of a products'firm has to be fully changed, but that it must be integrated with service culture, both at the level of managers and employee.

The reason why firms most of the time are not able to implement all these organizational arrangements, is the fact that, most of the time, in a servitization process, there are some un-anticipated side effects that bring to a low level of implementation.

The first is a *credibility gap*, due to the fact that, sometimes, the goals decided at the beginning of the process are too high or not adapt to the necessities of the business. In this way, the employee believe that the goal is not achievable, or they do not have the capacity to. Actually, after the management decided to extend the business to services, then this managerial-push always translate in a pull by the employee; and this employee-pull effect is a cycle, which could be positive if they too become and continue to be motivated, or vicious, if the motivation disappear from the employee after having disappeared from the management.

The second is a *short-term effect of service quality erosion*. This is caused by the fact that, in expanding the service offer and implementing these changes, the workforce deployed to services has less time for dealing with ordinary services, because they must change their usual methodology of work. This bring a short term decrease in quality, which could be problematic in relation to customer relation and workforce motivation.

The third underlined side-effect is the *concentration on first order, rather than second order, improvements*. First order improvements relate on a day-by-day basis, trying to eliminate the symptoms, rather than understanding the deeper causes of the problems (as in the second-order improvements) leading to structural changes in the organization. This is problematic since make the workforce lose time on trivial matters and is not able to adapt the servitization process to the customer needs.

Another analysis on the servitization paradox was made by (Neely, 2008) on a sample from a worldwide database of publicly listed companies. He found results that seem to confirm the exixtence of that paradox, showing that firms with an higher number of services offered, on average, seem to have lower profits; this because of higher average labour costs, higher working capital and higher net assets, compared to pure manufactured ones. This is especially true if the firm is of very high dimensions, whilst the more little firms instead were more able to have higher revenues compared to the pure-manufacture counterparts.

The paradox of servitization is here explained not just with a mostly behavioural approach (as in (Gebauer, et al., 2005)) but with a more overarching point of view.

A process of servitization is very delicate, and the challenges that might occure can be grouped into three categories: the shift of mindsets, the timescale and the business model and customer offering.

The shifting of mindsets apply especially to determinate functions of the firm, namely the marketing and sales one.

As underlined also by (Gebauer, et al., 2005) the shifting of mindsets first of all involve the transition to a relational (instead of transactional) marketing. Secondly, the mindsets must change in relation to sales, since "*many of the sales staff either gave away services as an*

incentive to buy the product, or did not see the sale of a $50,000 service contract, as compelling as the sale of a $1 million machine tool". Thirdly, also the customers should change the mindset, since they should abandon the logic of owning the product moving to the logic of enjoying the services coming from it and offered by the provider.

The second group of challenges related to servitization comes from timescale. Actually, servitization implies new types of contracts, with multiple difficulties. First of all, firms must be able to manage multi-years partnerships (apart from relational marketing, also from a legal point of view this becomes more difficult). Secondly, becomes more difficult to manage the risks and the financial exposure, since the time to regain the investments become longer. Thirdly, the difficulty of modelling and understanding the profitability of these long-term partnerships, and the risk posed by environmental factors not controllable by the firm.

The last group of challenges relates to business model and customer offering. Actually, it becomes fundamental understanding what constitutes value for the customers and consumers, developing services instead of products and, as underlined also by (Gebauer, et al., 2005), since there is little experience on how to develop personalised, complex engineering services. At last the importance of introducing a service culture and embedding all these improvements in a service organization.

A new wave of servitization

So, as it has been possible to see, the role and the importance of services has long been analised and tried to be understood, leading to the recognition of servitization as a fundamental phenomenon in manufacturing in the last decades.

In recent years, though, the advent of what has been called “Industry 4.0” has given further opportunities to apply the principles of servitization, bringing a renovated interest in the topic.

So, in order to understand the contemporary process of servitization, it is fundamental to introduce the innovations brought by the so-called Fourth Industrial Revolution, with a special emphasis on the Internet of Things and on the Cyber-Physical Systems. Actually, the so-called “digital Servitization”, to be fully understood, needs to be coupled with the technological innovations that has occurred in this last decade.

As a matter of fact, these new technologies has permitted the diffusion of new business models, that in the previous “analogic” servitizations were seen as general, theoretical possibilities.

For example, nowadays we can see the inception of the diffusion of the so-called Outcome-Based Contracts, or of the so called Service Level Agreements, business models in which the product itself has become a minor source of revenues, whilst the gains are more centered on the customer/-provider relationship and the services involved in this relationship.

CHAPTER 2: DIGITAL SERVITIZATION

Introduction

Usually, when it comes to enumerate the properties that an average person owns, two come immediately to mind: a house and a car. At least.

It is then surprising, in a certain measure, the new initiative by Volvo: "*Care by Volvo*". This is a very innovative plan, that challenges our normal relationship with automobiles.

This plan permits to have, in exchange of a flat monthly fee, an entire gamut of services related to the automobile, from tax payments and insurance to tires and maintenance.

The plan "Care by Volvo" is one of the facets of the strategy that Volvo is implementing thanks to the new capitals coming from its Chinese acquisition in 2010, with the aim to exploit the new possibilities offered by the Internet of Things and the information that is possible to extract from the data gathered from the customers' usage of products.

Actually, the diffusion of this type of contracts and relationships will be one of the main consequences of the capillarity of the technologies of the Fourth Industrial Revolution, not just limited to autonomous driving, as for example in the automotive sector.

In this chapter, will be firstly exposed the main technologies of Industry 4.0, especially the ones that will impact more on the potential providing of services, namely Big Data, Industrial Internet of Things (IIoT) and Cloud.

Afterwards, the topic if the business model transformation and innovation will be analysed, exposing also the potential new business models that could be adopted by manufacturing firms.

2.1 The Fourth Industrial Revolution

"*The more we think about how to harness the technology revolution, the more we will examine ourselves and the underlying social models that these technologies embody and enable, and the more we will have an opportunity to shape the revolution in a manner that improves the state of the world.*"
Klaus Schwab, *The Fourth Industrial Revolution*

In the millennial history of humanity, twain have been the crucial momentums in which the men had an irreversible and crucial turnaround, which radically transformed their societies, their aspirations and their economies.
The first has been the so-called Neolithic Revolution, the introduction of agriculture and animal husbandry, which permitted to harness a new source of energy, animal labour, which permitted an even greater development of agriculture, through the use of natural fertilizers and more effective ploughs.
The second has been the beginning of the Industrial Era, in which we are still living.
This era has never been homogenous, technological advancement does not occur gradually, but in waves, that are usually defined as Industrial Revolutions.
Conventionally, academics and practitioners define four Industrial Revolutions (Kemper, et al., 2014) (Brettel, et al., 2014).

2.1.1 The First Industrial Revolution

The First Industrial Revolution was the most radical, which turned the world into a new era. Until that moment, the only sources of energy that could be used were human and animal labour, and, rarely, some natural sources like waterfalls or the wind (which were available only in limited places and moments, though).
The introduction of the steam engine permitted a huge change, since it permitted the use of a new source of energy, coal; this promoted a development never seen before.
This was strictly link to a great development in mechanics, with the invention of the first machine tools. These included the screw cutting lathe, cylinder boring machine and the milling machine. Machine tools made the economical manufacture of precision metal parts possible, although it took several decades to develop effective techniques.
The first sector to be involved by the introduction of new techniques and machines was agriculture, together with new ways of organizing agriculture (especially the so called Norfolk

[or four-field] System); these factors permitted a decrease in agriculture workforce from 70% to 37% during the 18th century, with a rise in productivity of 90%[4].

But the main sector to be affected was the Second Sector, with the great development of textile and iron industries.

In the first one, inventions of the flying shuttle and the spinning frame permitted a great increase in productivity, making the English textile sector very competitive abroad.

The great improvements in the production of iron permitted a revolution in transports, through the creation of the railway and the construction of bridges in cast iron.

Important innovations had also occurred in the glass, chemical and paper industry.

If steam power engines can be seen as the great technological development of that period, its greatest innovation from the organizational point of view was the Factory System, characterised by division of labour and heavy usage of machinery.

This was one of the causes of one sociological phenomenon, Urbanization; actually the workforce of agriculture and old professions, because of the lack of work caused by the increase in productivity, moved to the industrialised cities to work. This caused a huge enlargement of those cities, an enlargement that was not planned, so that most of their new inhabitants suffered terrible living conditions. Inside the factories the situation was no better, and especially women and children have been exploited for a very long time before limits to working hours per day and safety working standards were ruled by law.

2.1.2 The Second Industrial revolution

The First Industrial Revolution has happened only in the UK, in Belgium, little areas of Germany and France; it lasted more or less a century.

In 1870 ca. it widespread also to other countries, especially France, Germany, north of Italy, US, Austro-Hungarian Empire and Japan. Since this development was not just an enlargement of the Industrial Revolution, but was characterised also by new technological improvements, was called Second Industrial Revolution.

These technological improvements caused a great development in those sectors who have been affected also by the previous Industrial Revolution, but not only.

A first great difference was that coal, still being very important, was accompanied by a new source of energy: hydroelectric power.

As harnessing coal was made possible by the invention of the steam power engine, harnessing hydroelectric power was made possible by the process of electrification of the economy, the main feature of the Second Industrial Revolution.

[4] https://ourworldindata.org/employment-in-agriculture

The effect of electrification had been gigantic: the factory system was revolutionised, dealing to a great increase in productivity and in the working conditions of the workers.
But not only. Electrification permitted a revolution in the exchange of informations, through the telegraph; for the first time in history was possible sending signals to the other part of the world istantenously; telecommunications began their important role in history.
Also transports have seen a great development, as the inventions of new explosives (like dynamite) permitted the constructions of roads and railways in before inaccessible areas.
That period also saw the phenomenon of Industrial Giantism, with a great increase in the dimensions of the factories, a far more efficient and precise division of labour, together with (similarly to what happens also nowadays) to the creation of very big trusts and groups of firms, enhanced by the diffusion of the corporation as a governance structure and of stock markets. Became very diffused also groups made of industries and banks, that could then finance the economic activities inside the same governance, giving birth to the so called financial capitalism.
If the First Industrial Revolution was characterised by a situation of free markets and economic liberalism, the Second Industrial Revolution was characterised by protectionism, since the newly industrialise countries wanted to protect their productions from the goods coming frim the already industrialised nations.
For this reason, the Second Industrial Revolution, though the UK continued to play a great role, saw the rising of Germany (in Europe) and United States (in the world) as new economic powers.
But the role of the state was not just reduced to this; the Belle Epoque was also the age of Imperialism, since every nation tried to gain new markets for its products and new lands as source of raw materials.

2.1.3 The Third Industrial Revolution

The Second World War and, subsequently, the Cold War, forced the military forces of the United States to make a series of investments whose innovations grounded the basis of what would have been the beginning of a new era, the Digital Age.
The process of introductions and development of these technologies in the industrial world has been named Third Industrial Revolution (or Digital Revolution).
As the name suggests, the main innovation had been the conversion from analogic to digital signals, through a process of quantization; this permitted a more efficient transfer of informations and, especially, a far more easy and efficient way of storing those data, since

digitalised quantities can be better described through numbers, and so it is easier to make computations on them.

The process of digitalization had been made possible through the enormous development of the technology of processors, which give births to the first microprocessors, which permitted, in the 70s, to introduce the first personal computers, giving public access to a technology firstly developed by the American Army during the Cold War: Internet.

If the processors permitted to convert information in digital formats and computers to work on it, Internet permitted to exchange it all over the world.

Born as a secret project of the Defence Department of the US, later had a lot of epigonies around the world, each with a different protocol. A first important step was the construction of unique protocols, the Transmission Control Protocol (TCP) and the Internet Protocol (IP), which created what is now known as Internet. But still was not so easy for common people to freely access information on this platform. Another great step happened in 1991, when Tim Berners-Lee defined the HTTP protocol, which permitted to access the Internet as a huge hypertext, making it really accessible to everyone; the World Wide Web was created.

Digitalization, computers and the internet marked the beginning of the Information Age, that is marked by the free deliverability of information and the immediate accessibility of it. Actually, the real means of change has not really been physical, but immaterial and related to data and its conversion in meaningful information.

The era of digitalization is strictly linked to the phenomenon of Globalization, expecially after the fall of the Soviet Union in 1991; the United States, the only remained superpower, promoted capitalism and free markets all over the world, including even the only communist superpower which had survived: China. This permitted to the biggest western firms to establish global value chains, giving birth to the phenomena of Off-Shoring and Delocalization.

The establishment of global value chain, apart from these geopolitical reasons, was mainly permitted to what Porter called the Second Wave of IT (Porter & Heppelmann, 2014) in which the advent of an ubiquitous connectivity permitted to multinational firms to coordinate global value chains.

That globalisation of value chains permitted to a lot of developing countries to grow, with some extraordinary success, like the one of China.

The process of Digitalisation, begun in the 60s, continued at a more and more accelerated pace; first were digitalised the computers, then, through time, also the vinyl discs, VHS etc.

The pace of this development has often been described through the Moore's Law, according to which every 18 months the number of transistors inside a microprocessor would double.

2.1.4 The Fourth Industrial Revolution

2.1.4.1 Concept and definition

The main source of innovation, this time, will be the fact that machines will be able, thanks to the new processors and connectivity, to communicate directly to one another, without the human medium, as happened up to now.

In reality, this is not something new. As said by (Jeschke, et al., 2017), in manufacturing, the first attempts to create a network of "things" date back to the 1970s and were summarized with the term "Computer-Integrated Manufacturing" (CIM).

However, in the 1990s (with the rise of Lean Production) excessive IT solutions were increasingly regarded as inefficient and many CIM projects as a failure. In retrospective, the early disappointments can be traced back to the reason that technology and people were not ready to successfully implement the ideas.

Subsequently, Product Data Management (PDM) has been established as a new approach to design networks within engineering departments connecting product data and people. With Product Lifecycle Management (PLM) the network idea is taken further, considering consistent data management as an objective for the whole lifecycle.

Now we are living the innovation brought by the fourth industrial revolution, in which, in the digital (or smart) factory, the aim is to integrate data, models, processes, and software tools.

Another term that is often used together with the Fourth Industrial Revolution is the so called Industry 4.0.

"Industry 4.0" is not an invention of academics, but the name of a series of policies carried out by the German Federal Government in order to improve the process of digitalization of German Firms; it then became so notorious, even among entrepreneurs and practitioners, that then its use became widespread also in academic research. Whence the variety of studies made on this topic.

Among the experts, though, there is no agreement on defining precisely what Industry 4.0 is. Henceforth some examples:

- according to the Industrial Internet Consortium™ "*the integration of complex physical machinery and devices with networked sensors and software, used to predict, control and plan for better business and societal outcomes*."
- in the opinion of (Kagermann, et al., 2013)"*a new level of value chain organization and management across the lifecycle of products*";
- according to (Hermann, et al., 2016) "*a collective term for technologies and concepts of value chain organization*"

Among the literature debate, very frequently the terms Fourth Industrial Revolution and Industry 4.0 are considered as synonyms (Lu, 2017) (Liao, et al., 2017).

According to the global consulting firm McKinsey, instead, Industry 4.0 should be more related to the innovation now occurring in manufacturing, so Fourth Industrial Revolution should be seen as a phrase for giving a more extended and global view of the phenomenon. According to their view, this is the "*fourth major upheaval in modern manufacturing*", coming after the lean revolution of the 1970s, the outsourcing phenomenon of the 1990s to countries with increasingly inexpensive labor costs, and the automation that took off in the 2000s (Baur & Wee, 2015).

In the discussion about Industry 4.0 were highlighted six design principles, conceived for supporting companies in identifying and implementing Industry 4.0 scenarios. According to (Schlick, et al., 2014) they are: interoperability, virtualization, decentralization, real-time capability, service orientation and modularity.

1. *Interoperability*. According to (Lu, 2017), it is the main advantage of Industry 4.0. According to (Vernadat, et al., 2008), who was trying to dealing with Enterprise Architecture, interoperability is "*the ability of two systems to understand each other and to use functionality of one* (Lu, 2017)*another*". It represents the capability of two systems exchanging data and sharing information and knowledge (Lu, 2017).
2. *Virtualization*. Virtualization is the monitoring of physical processes through CPSs. A virtual copy of the Industry 4.0 factory is then created, by linking sensor data (monitoring physical processes) with virtual plant models and simulation models.
3. *Decentralization*. The rising demand for individual products makes it increasingly difficult to control systems centrally. Decentralization means the ability of CPSs within Industry 4.0 factories to make decisions on their own, always in a context of general coordination. The availability of new and big quantities of data and the subsequent capability by lots of devices of applying algorithms, or even learning from their past activities, pose new efforts and innovation in decision making.
4. *Real time capability*. The capability to collect and analyse data and provide the derived insights immediately. Thus, the plant can react to the failure of a machine and reroute products to another machine. This is made possible by the diffusion and capillarity of processors and algorithms, which can be embedded in a lot of devices.
5. *Service Orientation*. The services of companies, CPS, and humans are available over the Internet of Service (which permits to vendors to sell their services through the internet) and can be utilized by other participants. They can be offered both internally and across company borders.

6. *Modularity*. Flexible adaptation of Industry 4.0 factories to changing requirements by replacing or expanding individual modules as well as changing requirements by replacing or expanding individual modules. Modular systems can be easily adjusted in case of seasonal fluctuations or changed product characteristics.

2.1.4.2 The technologies of Industry 4.0

This introduces us to the main technologies which are taken into consideration once the discussion on Industry 4.0 is initiated. There are several taxonomies regarding this matter, one of the most diffused is the one made by Boston Consulting Group (Scalabre, 2016).

Following this classification, the nine enabling technologies of Industry 4.0 are (Figure 2.1): Big Data and Analytics, Autonomous Robots, Simulation, System Integration (both Horizontal and Vertical), Industrial Internet of Things, Cybersecurity, Cloud, Additive Manufacturing (3D printing) and Augmented Reality.

It is important to underline that, although will be treated separately, in reality it is impossible to harness the full potential of the fourth industrial revolution using only some of the listed technologies.

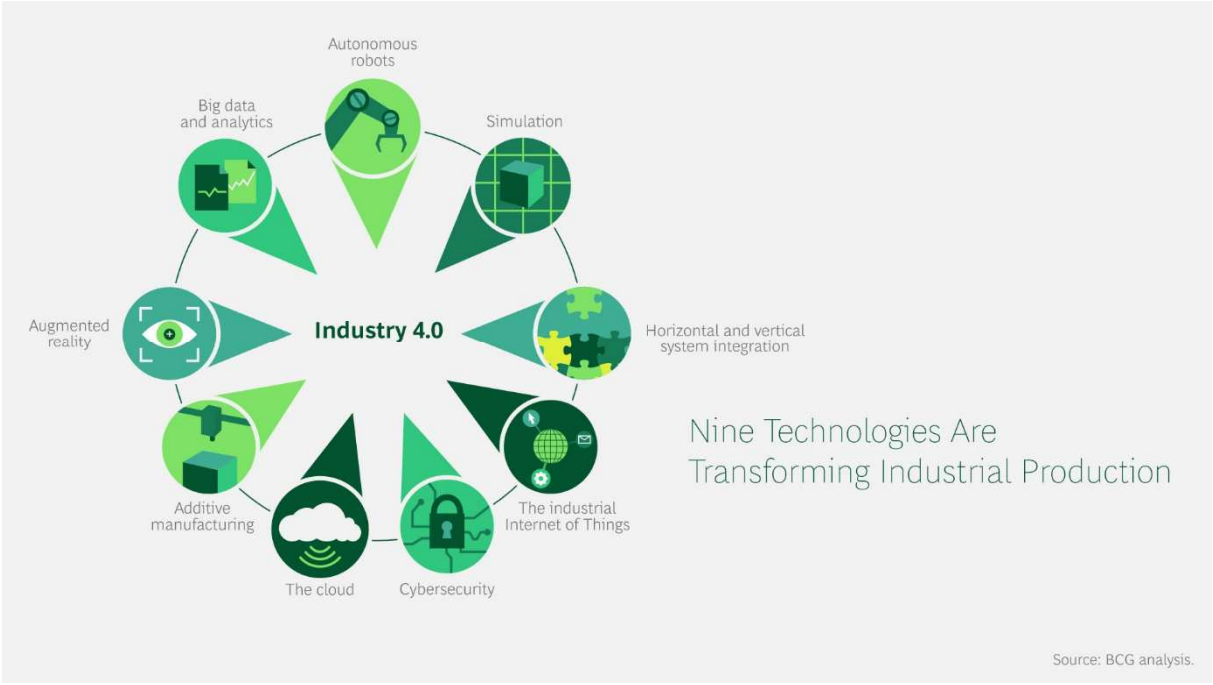

Figure 2.1 Enabling technologies of Industry 4.0 (Scalabre, 2016)

1. Big Data and Analytics

Now we have a lot of data, not just from consumer, but in almost any industry, even B2B, from a lot of sources (production equipment and systems as well as enterprise); this explains

the importance of their collection and comprehensive evaluation. For sure they will become the standard in decision making.

2. Autonomous robots

Robots are not new, but we will see more and more them able not just to interact with one another, but also with humans, and capable of learning from humans and from their own activity.

3. Simulation

The creation of models is not something new. What is new, instead, is the capability of building models that not only are comprehensive of machines, products and humans, but the possibility to test them virtually in advance, so that once the machine has to be built, or to be setup, the probability that an inconvenient occurs is far lower. Now it is really possible to build a virtual version of the real world in its almost complete likeness.

These possibilities offered by simulation could not have been possible without what in literature are called Cyber-Physical Systems and Internet of Things.

4. Enterprise Integration

Because of the availability and of the immediate exchange of data inside the firm and between the firm and the rest of the economy, the barriers between the different functions of the firm and between the firm and the value chain, will progressively blur.

For this reason, the concepts of vertical and horizontal integration come into action.

Vertical integration is the internal integration, between the different functions of the firm in order to make more efficient the value chain of the firm (Stock & Seliger, 2016).

Horizontal integration, instead, is the external integration, it deals with collaborations of partners along a supply chain (Stock & Seliger, 2016). Big Data and Industrial Internet of Things will permit a strong degree of collaboration among the firms of a value chain, leading to the concept of value network.

5. Industrial Internet of Things (IIoT)

Industrial Internet of Things is the fact that sensors and machines of a manufacture are networked and make use of embedded computing. This is not something of completely new, as a concept; but the new possibilities given by modern processors and connectivity will permit a generalised use of them, even in unfinished products.

IIoT will permit to decentralise decision-making, making it an instantaneous process.

6. Cybersecurity

This enormous propagation of connected devices, data, and processing capabilities, will lead also to unprecedented threads regarding security.

So it is important to invest heavily in krypting the data when are transmitted, protect them while are stored in servers (maybe physically present in the buildings of the firm), have high-level identification systems, have an enterprise policy on the information that employees can show to the outside, or through social networks.

7. Additive manufacturing

3D printing is not a new technology. It was first invented by Hideo Kodama, in 1981, and three years later an American, Charles Hull, invented the so called “Stereolithography”. These technologies, though, had a lot of imperfection, so they did not success.

With the beginning of the new millennium, a lot of progress have been made, even in biological 3D printing, to create human organs ex novo.

But was only in the beginning of the decade after 2010 that this machines became affordable.

Actually now they are widespread, and used especially for prototyping.

However, in a not so distant future they will become the means through which entire components of final products will be made. In the aerospace industry, actually, the deployment of this technology, now possible, has already lead to considerable decrease in costs, in complexity and lead time.

In the future, where, conceivably, almost everything will be 3D-printable, additive manufacturing, through the elaboration of huge quantities of big data, will permit mass customization, that now sounds like an oxymoron, but not for long.

8. Augmented reality

Augmented reality id strictly linked to the technology of simulation.

It will permit to completely merge the real and the digital world, creating representations of digital data and analytics over the real world.

This will permit to provide real data information for decision making, working procedures and virtual training.

9. The Cloud

The term cloud is a vivid expression for a network of servers that provides layered services in the form of Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a

Service (SaaS). The great improvements in technology, connectivity and capacity storage will permit an increased deployment of this technology in smart production systems.

2.1.4.3 Big Data and Analytics

Concept and Definition

There is no standard definition of Big Data. It can potentially be anything anyone might be interested to know that can be subjected to computer analysis. Big Data can be defined as datasets whose size is beyond the ability of typical database software tools to capture, store, manage and analyse.

Therefore, the term is usually used to indicate vast, rapidly growing, diverse and often unstructured sets of digitized data (i.e. data lakes) that are difficult to preserve using traditional databases. It can range from anything floating around the ether, the proprietary information of companies and official government records, to name a few.

Even though the expression is relatively new, the tendency to group and store huge amounts of information for future analysis goes way back. The label however, became popular in the early 2000s when the sector analyst Doug Laney formulated the well-known 3Vs model, which has been since then used as a common framework to describe Big data challenges and opportunities. According to him Big Data can be analysed through three different dimensions:

1) *Volume:* that is, the quantity of data collected. Organizations collect data from different sets of sources, financial transactions, social media, sensors, machine-to-machine etc. In the past, storing and analyzing this much data wouldn't have been possible, but today new technologies facilitate these tasks;
2) *Velocity:* refers to the speed at which data is generated and processed. It flows at unprecedented speed and therefore needs to be managed timely, sometimes even in realtime with technologies like RFID tags and smart metering;
3) *Variety:* data comes in different formats and types (numerical, structured, unstructured, email, video, audio etc.)

The leader in analytics SAS[5], added another two dimensions to Laney's list:

4) *Variability:* information flows can be very inconsistent and come with periodical peaks, managing daily, seasonal or event-related peaks could be challenging especially if these are represented by unstructured data;

[5] https://www.sas.com/en_us/insights/big-data/what-is-big-data.html

5) *Complexity:* the multiple origin of data makes it hard to connect, pair, arrange and transform transversal information despite the relevance of finding correlations and hierarchical relations between collected data.

Others added as further dimensions Veracity (which refers to the level of data that is useful for the firm's needs, hence the need to keep data cleaned) and Value (the capacity of the firm to generate economic value).

Considering these dimensions, (De Mauro, et al., 2015) propose a more precise definition. According to them, Big Data "*represents the Information assets characterized by such a High Volume, Velocity and Variety to require specific Technology and Analytical Methods for its transformation into Value*".

Potential For Value Creation

Big data can enable companies to create new products and services, enhance existing ones, as well as invent entirely new business models. According to (Elgendy & Elragal, 2014) such benefits can be gained by applying big data analytics in different areas, such as customer intelligence, supply chain intelligence, performance, quality and risk management and fraud detection.

1) Customer Intelligence

As for customer intelligence, the potential of Big Data is huge, and can highly benefit industries such as retail, banking, and telecommunications. Big Data can create transparency, and make relevant data more easily accessible to stakeholders in a timely manner. Apart from that, Big Data analytics can provide organizations with the ability to profile and segment customers based on different socioeconomic characteristics, as well as increase levels of customer satisfaction and retention. This can allow them to make more informed marketing decisions, and market to different segments based on their preferences and to properly recognise sales and marketing opportunities. It is also possible to inform companies about what their customers like (as well as what they don't like) by performing sentiment analysis on data provided by social media, so that firms can be alerted beforehand when customers are turning against them or shifting to different products, permitting them to take action accordingly.

Additionally, Big Data opens new possibilities for direct marketing, by monitoring customer sentiments towards brands, and identifying influential individuals. Big data analytics can also enable the construction of predictive models for customer behaviour and purchase patterns, therefore raising overall profitability. Also in segmentation of market Big Data open new

possibilities, since it is possible to deploy more sophisticated big data techniques, such as real-time micro-segmentation of customers, in order to target promotions and advertising.

2) Supply Chain and Performance Management

As for supply management, Big Data can be used for forecasting demand changes, and accordingly adapt the needed supply. This can increasingly benefit the manufacturing, retail, as well as transport and logistics industries. It is also possible to automate replenishment decisions, by analysing stock utilization and geospatial data on deliveries. This will reduce lead times and minimize costs and delays, as well as process interruptions. Additionally, Big Data simplify the decision of changing supplier, according to quality or price competitiveness. Furthermore, alternate pricing scenarios can be run instantly, which can enable a reduction in inventories and an increase in profit margins. Finally, big data can lead to the identification of the root causes of cost, and provide for better planning and forecasting.

Great possibilities can also be seen in performance management, and this will especially benefit government and healthcare industries. Actually, the usage of analytic tools permit to link their strategic objectives with the service or user outcomes. Also monitoring become more efficient, through the use of predictive KPIs, balanced scorecards and dashboards.

3) Quality Management and Improvement

Especially for the manufacturing, energy and utilities, and telecommunications industries, big data can be used for quality management, in order to increase profitability and reduce costs by improving the quality of goods and services provided. For example, in the manufacturing process, predictive analytics on big data can be used to minimize the performance variability, as well as prevent quality issues by providing early warning alerts. This can reduce scrap rates, and decrease the time to market, since identifying any disruptions to the production process before they occur can save significant expenditures. Furthermore, managers can make swifter decisions for quality management using real-time data analyses and monitoring of machine logs. Also, big data analytics can allow for the real-time monitoring of network demand, in addition to the forecasting of bandwidth in response to customer behaviour.

4) Risk Management and Fraud Detection

A problem in organizations, as far as regards risk-management, is that risk profiles are managed in isolation across separate departments. High performance analytics can help to gather these information into enterprise wide risk profiles. This can aid decision makers in risk mitigation, since they are provided with a comprehensive view of the different risk types and their interrelations.

Furthermore, new big data tools and technologies can provide for managing the exponential growth in network produced data, as well reduce database performance problems by increasing the ability to scale and capture the required data.

Along with the enhancement in cyber analytics and data intensive computing solutions, organizations can incorporate multiple streams of data and automated analyses to protect themselves against cyber and network attacks.

In addition, customer intelligence can be used to model normal customer behaviour, and detect suspicious or divergent activities through the accurate flagging of outlier occurrences. Furthermore, providing systems with big data about prevailing fraud patterns can allow these systems to learn the new types of frauds and act accordingly, as the fraudsters adapt to the old systems designed to detect them. Thus, big data tools, techniques, and governance processes can increase the prevention and recovery of fraudulent transactions by dramatically increasing the speed of identification and detection of compliance patterns within all available data sets.

Issues and Challenges

Apart from the previously examined potentialities, according to (Wamba, et al., 2015) Big Data also can bring to certain challenges:

- *Data policies Privacy*. Concerns with security are justified especially with personal data such as health and financial records. Also questions about intellectual property and liability are not fully answered and regulated by law, and this constitutes a great limit to the deployment of Big Data.
- *Technology and techniques*. Technologies encompass: storage, computing, and analytical software, while techniques are more related to new types of analyses of big data. Both are needed to help individuals and organizations to integrate, analyze, visualize, and consume the growing torrent of big data.
- *Organizational change and talent*. Currently, organizational leaders often lack the understanding of the value in big data as well as how to unlock this value. In addition, many organizations do not have the talent in place to derive insights from big data. Furthermore, many organizations today do not structure workflows and incentives in ways that optimize the use of big data to make better decisions and take more informed action.
- *Access to data*. The access and integrate information from various data sources is the key for the realization of “big data”- enabled firm transformative opportunities.
- *Industry structure*. The full business capture and realization from “big data” will be function of the industry structure (e.g., industry with a relative lack of competitive

intensity and performance transparency, high competition vs. low competition, high performance transparency vs. low performance transparency, high concentrate profit pools vs. low concentrate profit pools). " For example, in the public sector, there tends to be a lack of competitive pressure that limits efficiency and productivity; as a result, the sector faces more difficult barriers than other sectors in the way of capturing the potential value from using big data"

Big Data and Decision Making

From the decision maker's perspective, the significance of big data lies in the possibility to make proper decisions using information and knowledge coming from the data. Actually, Big Data is becoming an increasingly important asset for decision makers. Large volumes of highly detailed data from various sources such as scanners, mobile phones, loyalty cards, the web, and social media platforms provide the opportunity to deliver significant benefits to organizations. However, data can really be useful only if they are properly analyzed to reveal valuable insights, allowing for decision makers to capitalize upon the resulting opportunities from the wealth of historic and real-time data generated through supply chains, production processes, customer behaviors, etc.

Not by chance, organizations are more and more accustomed to analyzing internal data, such as sales, shipments, and inventory. This is not sufficient, though. External data (such as customer markets and supply chains) are becoming more and more important to be analysed, and the use of big data can provide cumulative value and knowledge.

With the increasing sizes and types of unstructured data on hand, it becomes necessary to make more informed decisions based on drawing meaningful inferences from the data.

A lot of frameworks are available for trying to conceptualise the possibilities offered by data for making decisions. An example is the so-called B-DAD framework, given by (Elgendy & Elragal, 2016).

The name B-DAD framework come from Big-Data, Analytics and Decisions, and it was developed to map the tools, architectures and techniques for making decisions using data. The "Big" is hyphenated because it refers to the following three aspects as being big, not only the data, and additionally maps the incorporation of these aspects together.

They divide the decision making process in four phases: Intelligence, design, choice and implementation (Figure 2.2)

The first phase is intelligence phase, where the useful data are collected from external and internal sources. In this phase the sources of the data need to be identified, and the data need to be gathered from the different sources, processed, stored and then migrated to the end user.

Such big data needs to be treated accordingly, so after the data sources and types of data required for the analysis are defined, the chosen data is acquired. After the big data is acquired and stored, it is then organized, prepared, and processed, This is achieved across a high-speed network using Extract, Transform, Load (ETL), or Extract, Load, Transform (ELT) or big data processing tools.

The next phase in the decision making process is the design phase, where possible courses of action are developed and analyzed through a conceptualization (or a representative model) of the problem. The framework divides this phase into three steps, model planning, data analytics, and analyzing. In the model planning step, a model for data analytics is selected and planned. In this step, basing on the types of data available and the intended outputs and analyses, are selected and planned for the models and algorithms which are found to be most appropriate. Traditional data mining and advanced analytic tecniques, such as classification, clustering, regression and association rules, can be chosen, along with machine learning and AI tecniques such as neural networks, decision trees, and pattern based analytics. In addition to this, time series analysis can be used for analysing sequences of data points which represent values at successive times. Furthermore, if the big data is in the form of text, or we are dealing with social media data, it is possible to choose between text analysis (from documents or social media) social network analysis and sentiment analysis. Additionally, graph analysis can be used for representing complex networks, and path analysis can be used for describing direct dependencies among variables. Moreover, density based or spatial analyses can be applied for clustering dense areas or dealing with special or geographical data, and clickstream analyses can be used for web data and analysing mouse clicks.

Subsequently, in the analytics step, the selected model is applied. It can be accompanied by predictive analytics, in order to analyse current and historical data as well as make predictions about the future.

In the analysing step, the output of the previous step and the result of the analytics are analysed. Accordingly, the possible courses of action are defined, which leads us to the next phase.

So, the following phase in the decision making process is the choice phase, where the impacts of the proposed solutions (or courses of action) from the design phase are evaluated using specific methods. In the framework, this phase is divided into two more steps, evaluate and decide. In the evaluate step, different options are analysed, using methods and instruments like dashboards, simulations of the solutions, what-if scenarios, cognitive maps, heuristics, KPIs, as well as advanced or interactive data visualizations. Then, in the decide step, the best option is taken according to the previously decided criteria.

Finally, the last phase in the decision making process is the implementation phase, where the proposed solution from the previous phase is implemented. Consequently, the big data tools and technologies can be used in monitoring the result of the decision, as well as in providing real-time or periodical feedback on the outcomes of the implementation.

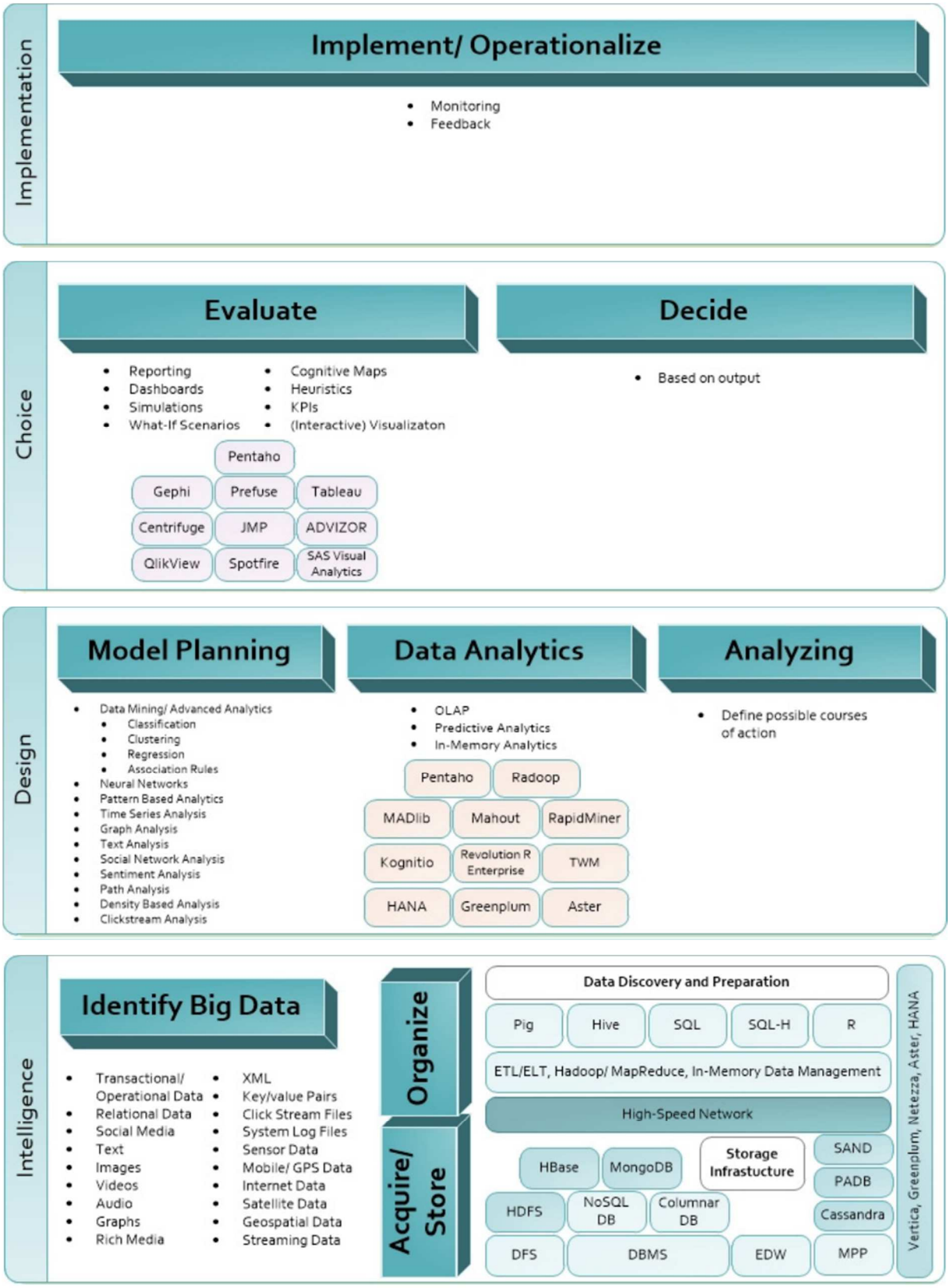

Figure 2.2 B-DAD framework, by (Elgendy & Elragal, 2016)

2.1.4.4 Industrial Internet of Things (IIoT)

The Internet of Things (IoT) is an information network of physical objects (sensors, machines, cars, buildings, and other items) that allows interaction and cooperation of these objects to reach common goals. Sometimes, when it is needed to speak about Internet of Things, it is underlined the fact that it enables not just the interconnection of Thing to Thing (T2T), but also between physical objects and people (Human to Thing [H2T]) and even facilitates Human to Human (H2H) connections.

The collection and combination of data from various IoT devices and the usage of Big Data analytics permit to decision-makers to take appropriate actions with important economic, social, and environmental implications.

According to (Abdmeziem, et al., 2016) the IoT can be divided from an architectural point of view into three layers: perception (or sensing) layer, middleware layer and application layer:

1) The *perception (or sensing) layer* is the layer in which the required data are gathered.

   The main task of the perception layer is to perceive the physical properties of things around us that are part of the IoT. This process of perception is based on several sensing technologies (e.g.RFID,WSN,GPS,NFC,etc.).

   In addition, this layer is in charge of converting the information to digital signals, which are more convenient for network transmission.

   However, some information may not be so easy to collect. Thus, also microchips can be a part of this layer in order to give to the objects sensing and even processing capabilities. Indeed, nanotechnologies and embedded intelligence will play a key role in the perception layer. The first one will make chips small enough to be implanted into the objects used in our every day life. The second one will enhance them with processing capabilities that are required by any future applications.

2) The *network layer* is responsible for two main tasks: to process the received data from the Perception Layer and then, also to transmit the data to the application layer through various network technologies, such as wireless/wired

   networks and Local Area Networks (LAN). The main media for transmission include 3G/4G, Wifi, Bluetooth, infrared technology, and so on. Since huge quantities of data will be carried by the network, it is crucial to provide a sound *middleware*[6] to store and process this massive amount of data. To reach this goal,

[6] The *middleware* is a software interface that provides the required abstraction to hide the heterogeneity and the complexity of the underlying technology involved in the lower layers.

cloud computing is the primary technology in this layer. This technology offers a reliable and dynamic interface through which data could be stored and processed.

3) The *application layer* uses the processed data by the previous Layer. In fact, this layer constitutes the front end of the whole IoT architecture through which IoT potential will be exploited. Moreover, this layer provides the required tools (e.g. actuating devices) for developers to realize the IoT vision. In this vision, the range of possible applications is impressive.

Applications include among others transportation, healthcare, smart homes and industrial environments. For the latter, the term Industrial Internet of Things (IIoT) or just Industrial Internet is typically used.

Sometimes, these terms are used as synonyms of "Industry 4.0". The differences between the terms or initiatives mainly concern stakeholders, geographical focus and representation according to (Wang, et al., 2015). Further, IIoT semantically describes a technology movement, while Industry 4.0 is associated with the expected economic impact.

Like IoT, the Industrial IoT covers many industries and applications. It opens plenty of opportunities in automation, optimization and chemical industry, but especially in manufacturing and transportation.

- Manufacturing: This is the largest IIoT market. It is also the largest industry from an IoT spending perspective. Manufacturing is among the industrial sectors that will be directly impacted by the disruption springing from IIoT. A smart production unit may consist of a large connected industrial system of materials, parts, machines, tools, inventory, and logistics that can relay data and communicate with each other. IIoT connectivity drives the convergence of operational technology (robots, conveyor belt, smart meters, generator, etc.) and information technology.
- Transportation: This represents the second largest IIoT market from an Internet of Things spending perspective. Today's transportation infrastructure is stressed to the breaking point. Airlines, rail companies, and public transit agencies can aggregate huge quantities of data to optimize operations.

So, it is possible to say that IoT is the most general concept, whilst IIoT is the same concept applied in the manufacturing context.

Another concept that comes closed to the one of IoT is that of Cyber-Physical System. Sometimes they are considered as synonyms, depending on the context in which the terms are used. According to (Wang, et al., 2015) IoT mainly refers to technology and information (adopting a bottom up perspective), whilst CPS emphasises interactions between physical and cyber parts, including humans. In this sense, both the terms rely strongly on networked

software-intensive systems, while emphasising different aspects of the corresponding systems.

The term Cyber-Physical System was coined in the US in 2006 (Lee, 2006) and since then has gained lots of interest.

According to (Wang, et al., 2015) it is possible to say that CPS are integrations of computation and physical processes. Embedded computers (and networks) monitor and control the physical processes, usually with feedback loops where physical processes computations and vice versa. In other words, CPS use computations and communication deeply embedded in (and interacting with) physical processes in order to add new capabilities to physical systems. A CPS may range from minuscule (a pacemaker) to large scale (a national power grid).

2.1.4.5 Cloud Computing

The great progress made in the cloud technology (with reaction times of just some milliseconds) will permit the diffusion of more and more services based on this technology, since it permits a far greater efficiency in managing and sharing data. This will lead to a great flow of data inside the firm and between the firms and its closed environment.

There have been multiple definitions of Cloud Computing, also because some experts argue that, in itself, was something already present from many years.

The most diffused definition is the one by the National Institute of Standards and Technology (NIST). The NIST defines Cloud computing as "*a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models*" (fig. 2.3)

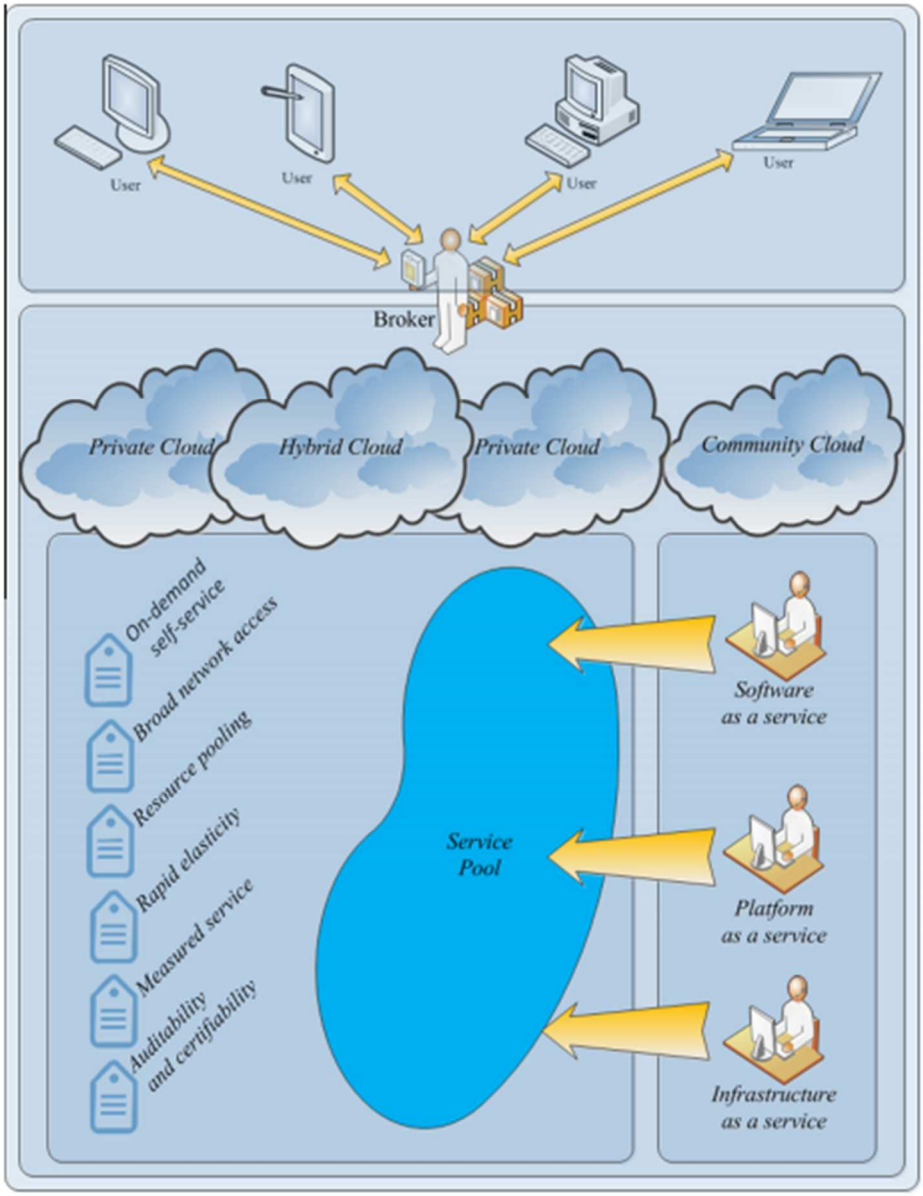

Figure 2.3 - Cloud computing, characteristics, deployment models, service pool, and types of services and users (Jula, et al., 2014)

So, ideally, the Cloud should have all of the following five characteristics:

1. *On-demand self-service*. A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically and can use a ‘‘pay-and-go’’ method (without having to interact with humans) through an online control panel.
2. *Broad network access*. Resources and services that are located in different vendor areas in the cloud can be available from an extensive range of locations and can be provisioned through standard mechanisms. The terms ‘‘*easy-to-access standardized mechanisms*’’ and ‘‘*global reach capability*’’ are also used to refer to this characteristic.

3. *Resource pooling*. The provider's computing resources are pooled to serve multiple consumers using a multitenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. Examples of resources include storage, processing, memory, network bandwidth, and virtual machines. Stated differently, the user does not have knowledge and does not need to know about the location of the provided resources.
4. *Rapid elasticity*. Fundamentally, elasticity is another name for scalability; elasticity means the ability to scale up (or scale down) resources whenever required. Users can request different services and resources at any time according to their needs. This characteristic is so admirable that Amazon, as a well-known cloud service vendor, has named one of its most popular and commonly used services the Elastic Compute Cloud (EC2).
5. *Measured service*. Different aspects of the cloud should automatically be controlled, monitored, optimized, and reported at several abstract levels for the resources of both the vendors and consumers.

According to (Jula, et al., 2014) another two characteristics should be added:

6. *Multy-tenacity*. Multi-tenacity means that it is essential to have models for policy-driven enforcement, segmentation, isolation, governance, service levels, and chargeback/billing for different consumer categories.
7. *Auditability and certifiability*. That is the importance for services to prepare logs and trails to make possible to evaluate the degree to which regulations and policies are observed.

In addition to the characteristics of Cloud Computing, also the relationship between provider and consumer can be categorised. The cloud can then assume the following four "Cloud computing deployment models".

1. *Public Cloud*. This is the most diffused approach, in which the cloud owner provides public services on the Internet based on predefined rules, policies, and a pricing model. Since the providers possess a large number of widespread world resources, they can offer to the consumer different choices in order to permit to her to select the appropriate resources.
2. *Private Cloud*. This type of cloud is designed in order to prepare most of the benefits of a public cloud exclusively for an organization or institute. Usually a cloud like that is set up because in facts it constitutes a corporate firewalls, that can lead to decreased security concerns. The organization faces abundant costs, since it is responsible for all of the affairs of the system.

3. *Community Cloud*. In this case, a number of organizations can establish a community and share cloud computing based on their common requirements, concerns and policies. The main advantage of a community cloud is that it permits on one end to reduce costs (compared to the private cloud) and increased security (compared to public cloud).
4. *Hybrid Cloud*. It is a combination of two or more types of clouds (private, community, or public). For example, an organisation may bridge its internally operated private cloud with other public clouds by standardised or proprietary technology.

Another topic related to Cloud Computing are the so-called Cloud Computing Service Models. They refer to the degree of depth with which services are provided through Cloud Computing; the most basic one is the "Infrastructure as a Service" model, then the "Platform as a Service" model, and at last the "Software as a Service" model.

1. *Infrastructure as a Service* (IaaS). IaaS provides the raw materials of cloud computing, such as processing, storage and other forms of lower level network and hardware resources in a virtual, on demand manner via the Internet. It differs from traditional hosting services (with which physical servers or parts thereof are rented on a monthly or yearly basis) since the cloud infrastructure is rented as a virtual machines and can scale in and out dynamically, according to the customer needs. Such on-demand scalability is enabled by the recent advancements in virtualisation and network management. IaaS users do not need to manage or control the underlying cloud infrastructure but have control over operating systems, storage, deployed applications, and in some cases limited control of select networking components.
2. *Platform as a Service* (PaaS): PaaS moves one step further than IaaS by providing programming and execution environments to the user. The PaaS user can create applications using programming languages and APIs (Application Programming Interfaces) supported by the provider, and then directly deploy the applications onto the provider's cloud infrastructure within a few clicks. The PaaS user does not manage or control the underlying cloud infrastructure (including network, servers, operating systems, or storage), but has control over the deployed applications and possibly application hosting environment configurations. Such an approach can reduce most of the system administration burden (e.g. setting up and switching among development environment, test environment, and production environment) traditionally carried by the developers who can then concentrate on more productive problems.
3. *Software as a Service* (SaaS): SaaS provides users with complete turnkey applications through the Internet, even complex systems such as those for CRM or ERP. Software

or applications are hosted as services in the cloud and delivered via browsers once subscribed to by the user. This approach can eliminate the need to install, run, and maintain the application on local computers. SaaS is known for its multi-tenant architecture in which all the users share the same single code base maintained by the provider. Authentication and authorisation security policies are used to ensure the separation of user data. Such a sharing mechanism enables the cost and price of SaaS to stay competitive compared to traditional off-the-shelf and bespoke software. SaaS is expected to alleviate the user's burden of software maintenance, and reduce the expense of software purchases by on-demand pricing.

2.2 New Possibilities for Servitization

According to (Wise & Baumgartner, 1999) what have been the traditional ways for competing are no longer available for those firms that nowadays want to achieve a sustainable competitive advantage. Actually, according to the authors, three used to be the foundations through which winning competition: vertical integration of supply and production (to control the cost), disciplined research for creating a product with superior value and, finally, by achieving a dominant market position (in order to benefit from economies of scale). All these factors would have permitted to maintain a durable cost advantage, to garner steady revenue growth and to build up substantial barriers to competition.

Nowadays, it is different. Cost can very difficultly be a differentiating factor in itself, and even technological primacy, per se, does not guarantee economic success and a sustainable competitive advantage.

Consequently, according to (Wise & Baumgartner, 1999), nowadays firms must "*move downstream*", towards the final customers, offering them proper services. This will permit to them to acquire the new foundations for a sustainable competitive advantage, i.e. expanding their definition of value chain, rethinking the meaning of vertical integration (looking at distribution) and, especially, shifting their focus to building a strong customer allegiance.

The Fourth Industrial Revolution, through the new technologies and systems it provides, can help these firms a lot. Actually, the advent of so called "Smart, Connected Products" has provided new possibilities for firms, permitting them to build stronger relationships with their clients, a very important thing nowadays in order to acquire customer allegiance.

2.2.1 Smart, Connected Products

The complexity (i.e., functions and features) and proliferation of customization options of technical products starting from consumer goods (such as cell phones) all the way up to cars and airplanes is constantly increasing; the amount of product-related data that needs to be managed is growing massively. This is one of the main reasons for making the products smart and connected, so that their users will be properly guided during the whole lifecycle.

There is also to add that nowadays some technological conditions are finally making this possible, like increased performance, efficiency and miniaturization of components, and especially a new IPv6 internet registration system that will permit to offer $340*10^{36}$ potentially new internet addresses (in order to identify new connected devices).

At their inception, smart products were just able to identify via RFID. Today smart products not only provide their identity but also describe their properties, status and history. Not only, nowadays they are able to communicate information on their lifecycle. They know not only

about the process steps already passed through (like the production steps still to be performed on the unfinished product), but are also able to define future steps (like upcoming maintenance operations). This capability of doing computations and store data permits to them also to communicate and interact with their environment; for this last characteristic, (Porter & Heppelmann, 2014) specify they should be called "*smart, connected products*"; "smart products", according to them, should be the initial types of products with embedded processing capabilities but still unable to connect and exchange data automatically.

According to them, a smart, connected product is made from physical, smart and connectivity components.

Physical components comprise the mechanical and electrical parts of a product.

Smart components comprise the sensors, microprocessors, data storage, controls, software and, usually, an embedded operating system and and enhanced user interface.

Connectivity components comprise the ports, antennae and protocols enabling the wired or wireless connection with the product. Connectivity can take three forms:

- *One-to-one*. An individual product connects to the user, the manufacturer, or another product through a port or other interface;
- *One-to-many*. A central system is continuously or intermittently connected to many products simultaneously;
- *Many-to-many*. Where multiple products are connected to many other types of products and often also to other external data resources.

Connectivity is particularly important, apart for permitting to the product to exchange information, in order to enable some functions of the product to exist outside of the physical device, in what can be called "*product cloud*". (Porter & Heppelmann, 2014) state that, in order to fully reap the benefits of smart, connected products, the firm has to invest in reinventing the technological infrastructure of the firm, creating what they call the "*Technology Stack*"(fig. 2.4).

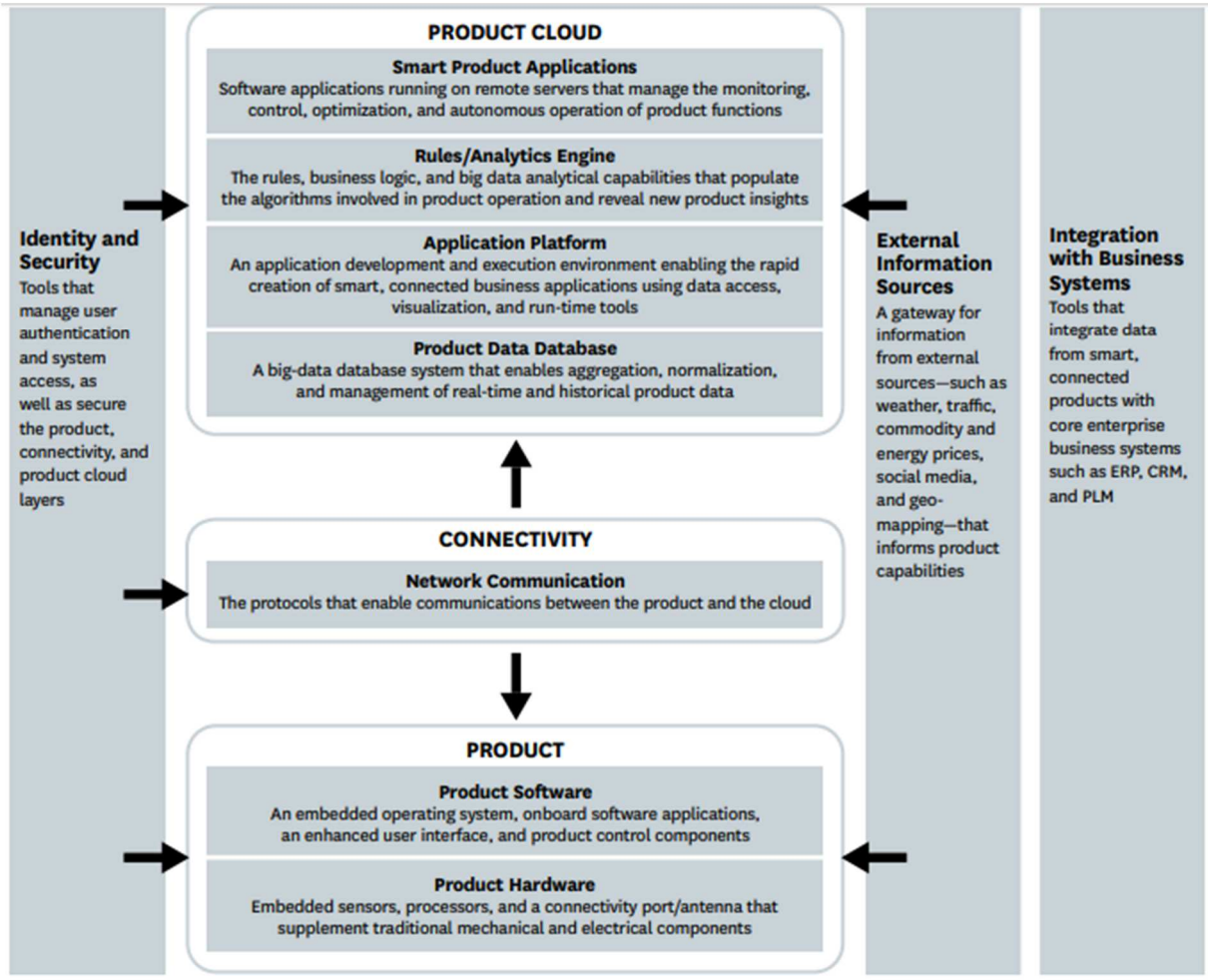

Figure 2.4 - The Technology Stack, from (Porter & Heppelmann, 2014)

Apart from the dimensions of the product, the connectivity and the product cloud (already discussed) the Stack also includes three longitudinal dimensions: an identity and security structure, a gateway for accessing external data, and tools that connect the data from smart, connected products to other business systems (for example, ERP and CRM systems).

(Porter & Heppelmann, 2014) categorise the capabilities of smart, connected products into four types:

- *monitoring* (alerting if changes in the environment or in the product occur),
- *control* (affecting the behaviour of the product through embedded or cloud algorithm),
- *optimization* (through the gathered data and remote control it is now possible to adjust and personalise the algorithms and the product as never before)
- *autonomy* (not just related to self-diagnosis and reaction, but also interaction with other systems and products).

Recognising the potential of the data coming from smart products (Porter & Heppelmann, 2015), groups them into four types of analytics:

- *Descriptive analytics*: analytics that have the function to describe the characteristics of the products and of the environment in which it is inserted;
- *Diagnostic analytics*: describe the causes that have brought a decrease in the product performance of even an its failure;
- *Predictive analytics*: analytics that collect patterns in order to predict impending events;
- *Prescriptive analytics*: prescribe which actions to do in order to fix the problems or enhance the performance of the smart, connected product.

2.2.2 Remote Monitoring Technology

Smart, connected products are a key feature of the innovation given by new digital technologies in business; it is then worth it, to deepen the understanding of this topic.

First of all, it is necessary to highlight that, although the work by (Porter & Heppelmann, 2014) remains seminal, this concept was also investigated through other names.

For example, (Wise & Baumgartner, 1999) call it simply new digital technologies; (Allmendinger & Lombreglia, 2005) prefers to call it smart services. According to (Grubic & Jennions, 2017) smart connected products, remote diagnostics, remote services, smart technology, smart services, digitised products and digitalisation can all be considered different names through which the literature analyses the same phenomenon.

In any case, the underlying principle, in any case, is the fact that, according to (Grubic, 2014), this technology is "*a combination of software and hardware technologies which enables remote collection of data about the performance and usage of a product in the field to determine its current and predicted condition and health*". From now onward, will be used the name finally adopted by Tonci Grubic, that is Remote Monitoring Technology (RMT).

Remote Monitoring Technology is not always economically convenient and able to fulfil truly desired needs of the customer, so it is applicable only to certain types of products.

Actually, according to (Grubic & Jennions, 2018) it becomes useful to be applied if the product:

- is capital-intensive;
- comes from complex engineering;
- has a long life cycle;
- requires considerable effort to maintain;
- in case of breakdown, gives rise to consequences that are severe and may bring high-impact disruptions to the customers.

According to (Grubic, 2014) Remote Controlling Technology gives a lot of advantages both for the customer and the manufacturer.

For the customer, the application of this technology offers a variety of benefits, starting from the minimization of downtime, together with a reduction of time devoted to error diagnosis and repair. Actually, the errors and faults can be detected remotely in real time, and all the necessary activities (like bringing the right spare parts and tools) can be prepared in advance. Secondly, using Remote Monitoring Technology the manufacturer benefits from getting direct access to operational data instead of receiving potentially erroneous and/or misleading incident descriptions by the customer. The customer then can benefit from a more accurate and precise understanding of the problem from the manufacturer, even without the need to investigate the issue, which again diminishes downtime.

The minimization of downtime is just a reactive approach of problems by the manufacturers. The real potential of RMT relies in the development of proactive approach, in which the provider is able to understand and forecast breakdowns. The potential to act proactively in stopping or preventing breakdowns, means manufacturers are able to deliver more attractive value propositions to their customers. So the customer can see a great reduction of risk, usually exemplified by non-availability of the product and its suboptimal performance. This value proposition of removing unpleasant surprise implies a transfer of risk to the provider.

Assuming the point of view of the provider, there are many benefits as well.

For example, Remote Monitoring Control permits to improve performance of their products and their availability, to improve maintenance efficiency and effectiveness and differentiate from competitors' offers. It provides also a reduction in costs. Actually, analysing data on status, use and health of products, not only helps to create new services centred on the analysis of this data, but to reduce the cost of service as well. Nevertheless, it is important to stress that this technology does not (and has not) replaced traditional field service. In addition of this, RMT permits to have a great insight into the customers' needs, and so give appropriate feedback to the R&D department. Also, this technology represents a driver for internationalisation, since SMEs can more easily assist their products wherever in the world they are located, with a significant reduction of cost for them.

Apart from these benefits, there are also some challenges related to Remote Monitoring Technology.

First of all, there are the limits of this technology. Actually, very often there is a lack of standardisation, since manufacturers use proprietary standards and make sensors which are not compatible; this is a problem, since there would be greater sharing and integration of sensor data among different manufacturers. But RMT is also limited for itself. Actually, the

Remote Monitoring Technology can only detect what the technology is designed to detect and there will always be faults that are beyond its reach. Also, the technology itself is a potential source of error. Therefore, there is an element of contextual information that cannot be acquired via sensors and which plays a very important role in delivering services promised by remote monitoring technology. It becomes then fundamental to maintain a type of relation with the customer that is not purely based on the data remotely collected. Actually, the service provider using the RMT cannot collect the same data as the customer and the customer cannot collect the same detailed data as the service provider. Services enabled by RMT should not be perceived as replacing the involvement of a local maintenance team, either this team being the customer or the service provider. Both sides need to be involved and should cooperate together. These ideas are very similar to the proposition of the customer as co-creator or co-producer of value as formulated in service-dominant logic.

Another set of challenges is related to the perceived value of this technology in the eyes of the customer. Actually, getting the customer to participate as a co-producer of value from RMT depends initially on his view about the benefits of this technology for his business. In literature, these benefits are mainly in the areas of minimization of downtime and transfer of risks to the manufacturer. However, the literature reveals that customers are still not convinced of the benefits of remote monitoring technology enabled services and manufacturers have not been very successful in fully monetarily exploit the potential of RMT.

A further challenge relates to the changing of mindset. As exposed before, to reap the benefits of RMT the relation between customer and provider must be perceived as a value co-creating project. This suggests needed changes in the mindset and the way that the involved parties work together. Actually, often senior management do not perceive the value of services for the enterprise, and the projects of application of RMT may be implemented only by technical staff, that has not the commercial capabilities to apply it.

One last set of challenges is more related to surveillance and ethics. Actually, by embedding RMT into the products, the provider has the possibility to indirectly monitor the user. Besides monitoring the health and condition of a product the technology also provides insights into how the product is used. (Jonsson, 2006) sums up this issues with the concept of Embedded Panopticon. This framework brings further three main issues. First, since the technology is embedded in the product, users, if not informed, may not be aware of the fact that they are controlled. Second, even if the customer knows that he is being monitored, he may not know what is monitored about him. Thirdly, the aim and purpose of monitoring may also be hidden to the user. These issues are very important for both supplier and customer. The embedded

monitoring possibility may challenge their business ethics and impact the business relationship so they should address the ethical questions from the start.

2.2.2 From value chains to value networks and digital ecosystems

The introduction of smart, connected products challenges the very important concept of value chain, still followed by a lot of firms.

The concept of value chain is an important framework made by Michael Porter many decades ago. It defines it as the collection of activities relate to the product, from the design phase to the support phase. This collection of activities is a direct reflection of the firm's strategy and of its implementation; they are, then, the inner and substantial source of competitive advantage.

This framework assumes the value creation process as a linear process, where the customer has a role only at the end of it. At every stage of the chain, value is added to the product by making it, processing it, adding to it, or polishing it.

The problem with this way of viewing the value creation process is that it is not enough customer centric. And this fact, in a dynamic and globalised world where customers want brands to be more engaging, honest, ethical, and transparent, is no more attainable.

Here come the so-called "value constellations", where the focus does not lie on the company or the industry (as before) but on the value-creating system itself, within which different economic actors (suppliers, business partners, allies, customers) work together to co-produce value.

The term value constellation was coined by (Normann & Ramírez, 1993), and described a wide tendency of the literature of the time to overcome the value chain paradigm set by Michael Porter. According to (van Middendorp, 2009) value constellations, strategic alliances, value webs and strategic networks are all synonims through which the literature had analysed what is now commonly referred to as value networks.

One of the main features of so-called value networks, is that each actor contributes an incremental value to the network, but concentrates only on their core competencies; in this way, the competitive advantage does not come simply from the firm itself, but from the overall network (Riasanow, et al., 2017).

An example of a service provided through a Value Constellation is Paris' *Autolib'* scheme. Autolib' consists of a number of self-service electric cars parked across the city. It is surprising to know how many players were involved in such a project:

- about 26 municipalities first agreed to take part in this movement;
- companies Bolloré and Pininfarina provided the cars;

- city planners, engineering consulting firms and mobility experts defined the numbers and size of the stations;
- water companies helped identify where the sewers/water pipes were located and if they should/could be moved;
- electrical and gas companies located the pipes and the cables;
- a geological study was conducted to check the quality of the ground;
- the Prefecture of Police was consulted to assess the level of security of the zone;
- firemen assessed accessibility in case of accidents;
- architects from the Bâtiments de France, endorsed the choice of location in order to validate the compliance of planned infrastructure with the architecture of Paris.

All this was done just to locate the parking spots. Citizen could enjoy of the service by subscribing to it and paying a fee related to the period of desired usage of the automobiles and, in case of accident, also an additional amount of money depending on the number of car strikes.

It is evident that a service like this could very difficultly be understood through the value chain logic.

The value network presents functions and activities, which are performed simultaneously. The advantage of a value network is an adequate display of cooperation relationships and alliances.

According to (Clarysse, et al., 2014) the members of a value network (or business ecosystem) deliver value to end customers as an interrelated system of interdependent companies rather than as individual companies. Business ecosystems are nested commercial systems where each player contributes a specific component of an overarching solution. In a business ecosystem, inter-organizational networks consist of both collaborative and competitive relationships which results in a "coopetition" structure. As a result, it is the competition among ecosystems, not individual companies, that largely fuels innovation.

According to (Clarysse, et al., 2014), through collaboration in a value network, firms exploit their interdependencies and have a competitive advantage over isolated companies which internalize all components of a value chain. For start-ups it is therefore important to participate in such a business ecosystem. Companies in a business ecosystem co-evolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies.

The new digital technologies involved in the so called "third wave of IT" (Porter & Heppelmann, 2014) are transforming the supply chain, giving rise to the so-called "Digital ecosystems". According to (Li, et al., 2012), a digital ecosystem can be defined as "*a self-*

organizing, scalable and sustainable system composed of heterogeneous digital entities and their interrelations focusing on interactions among entities to increase system utility, gain benefits, and promote information sharing, inner and inter cooperation and system innovation".

According to (Li, et al., 2012) Digital Ecosystems are characterised by three characteristics: self-organization (the spontaneous emergence of global structure out of local interactions), scalability (the ability of a system, network, or process to handle growing amounts of work in a graceful manner or its ability to be enlarged to accommodate that growth) and dynamism (the profiles of digital entities constantly change as the time is going on).

2.2.4 Digital Servitization: Business Disruption and Downstream Movement

The general drivers of servitization have already been exposed in the first chapter, together with the service paradox, which constitutes a threat for firms which decide to servitize.

According to (Vendrell-Herrero, et al., 2017), firms are really able to capture the value coming from services only "*when disruptive shocks arise and digital technology disrupts the way product firms compete and offer services*". So, digitisation (as named by the authors) gives a gamut of possibilities that firms can exploit to compete.

Digitisation (or the third wave of IT, or Industry 4.0 or whatever way is preferred to call it) is a different phenomenon with respect to servitization: a firm could introduce new services in its offering without introducing new digital technologies and vice versa a firm could introduce these technologies without servicizing. It is anyway largely recognised that nowadays the two phenomena are largely intertwined.

Not by chance, (Holmström & Partanen , 2014), investigating how new technologies could impact supply chain management and equipment, posits that "digital servitization" is one of the possible outcome, leading to a firm strategy directed to the constant renovation and refurbishment of the product. More precisely, "*digital servitization*", that can then be defined as "*the provision of IT-enabled services relying on digital components embedded in physical products*" (Vendrell-Herrero, et al., 2017). This is a very recent topic, that differ from the traditional concept of servitization.

Actually, according to (Vendrell-Herrero, et al., 2017), the main differences are that:

1) the marginal cost of digital services is near zero. This is clearly an opportunity for the provider, and a way to solve the servitization paradox, since one of the main problems which were underlined was the fact that, because services are labour-intensive, an increase in services would mean also an increase in human workforce costs. However,

this could also present a problem if the customer cannot understand the value that comes from these services, and consequently be eager to adequately pay for them.

2) whilst services are usually complementary to a product offering, digital services are often substitutes for traditional products. This possibility was noted, in the digital servitization literature, especially in the context of B2C markets. In particular, (Greenstein, 2010) noted this fact with relation to the development of internet connection in households for retailing services.
3) digital technologies, as with other disruptive technology, open new business opportunities that can be executed by new entrants, especially hardware and software developers or retailers. This was also underlined by (Porter & Heppelmann, 2014), stating that smart, connected products will blur the industry's boundaries.

A very important topic in digital servitization is the relationship between the firm and the other entities of its supply chain, especially the ones located "downstream", that permit to get to the final customers, a concept anticipated also by (Wise & Baumgartner, 1999)

The importance of knowing the needs and habits of the final customer introduces us to the concept of link channel, that is, in the context of co-creation, the place where the customer are engaged in the process of creation of value. According to (Rymaszewska, et al., 2017), digital servitization can be seen as similar to link channels, though different, since it is aimed at providing best possible level of services to end users.

(Vendrell-Herrero, et al., 2017) say that link channels (or, generally, getting in touch with customers) enables greater understanding of consumer needs as they are an important element in creating and capturing value. For this reason, firms closed to the customer have a strong bargaining power compared to the upstream ones.

When moving downstream, it is then fundamental for firms to think a strategy in order to enhance their bargaining power or their gains. Since for upatream firms may be difficult to establish a direct connection with customers, (Vendrell-Herrero, et al., 2017) propose they should sustain their strategy identifying, managing and deploying their unique resources. These unique resources can assume various forms, they can be patents, intellectual property rights or copyrights, tacit knowledge, organizational culture and flexibility et cetera.

2.2.5 Digital Servitization in Manufacturing

It is important to underline that the topic of digital servitization is very recent, and so the specific literature is at its inception (differently from traditional servitization). Up to now,

scholars have been mostly focused on the music, software industry and manufacturing (Vendrell-Herrero, et al., 2017).

A first study that tries to investigate the topic of digital servitization in manufacturing is (Coreynen, et al., 2017). In this study, the possibilities offered by digitisation may be viewed from two operational perspectives, which lead to three different pathways of servitization.

The first perspective to be considered is the one that leads to see the firm “in back-end”, the industrial view. It is the perspective through which the providers are able to create solutions. Emerging technologies in a company's back-end operations enhance operational performance, for instance through automation, and increase transparency for better-informed decision-making such as the allocation of resources. Such digital methods may disrupt certain general assumptions on manufacturing costs and may eventually break the effectiveness-efficiency trade-off to such an extent that they can even reverse off-shoring trends. Manufacturers can leverage this knowledge to improve not only their own processes but also their customers' processes, by providing advice or training services, for example

Secondly, the “front-end” view, or commercial perspective. Here, providers aim to better understand the customer's value creating process, helping them to reach their own goals. Nonetheless, the providers may gather information about the customers and better understand their needs. Front-end digitization allows for new types of customer interaction, such as through the creation of self-service touch points like personal digital assistants.

For the both perspective insofar, a different servitization pathway may be followed.

In addition to these, though, firms can follow a different pathway, that combines the two previous perspectives, so that the provider is able to radically change the customer’s process and at the same time have a disruptive impact on provider-customer relation. This is the pathway that for example is possible achieve through smart, connected products.

A study that tries to apply the concept of digital servitization to SME in the manufacturing sector is the one by (Opresnik & Taisch, 2015), in which it is stated that simply adding services to the offering nowadays does not constitute a real competitive advantage, and so firms must tackle on new technologies in order to differentiate from competitors. More specifically, they should focus on Big Data. Big Data (and the information that can be extracted from them) according to the view of (Vendrell-Herrero, et al., 2017) can constitute a specific resource over which a firm can build a sustainable competitive advantage.

Actually, the ICT available nowadays, together with IoT and Smart Products, permits to collect a sheer amount of data, that is related not only on the production of the product but also on its usage and even in the ideation and design phase. In addition to this, data permit to create what are defined as Manufacturing Service Ecosystems (MSE), exchanging data in a

way that permit to obtain others' resources and information and develop its own ones by combining them with those of others.

They provide in this sense a framework of what they call a "Big Data Servitization Strategy". (Fig. 2.5). The framework is developed along two dimensions: one related to the procedures done on the data (on the data architecture and process) and the other on the servitization process.

This last servitization process is seen as divided in four steps. The first is the setup of a Manufacturing Service Ecosystem (MSE) before starting with the actual composition of a Product-Service System (or, as they call it, Product-Services, P-S). Actually, it is necessary to access the data of the partners cooperating in servitization, then identify the data relating to the most relevant assets in each manufacturing enterprise, and finally load them. This is related to the logic of value constellations previously described.

The second servitization phase is the ideation of a new PSS based on the previously loaded data coming from the firm and its partners; following that, a certain PSS composition is tested and approved and, finally, the PSS is deployed on the market. The fact that the data are available also to other partners permits their partial or full reuse in some later servitization scenarios.

The third servitization phase the PSS is on the market and in use by consumers. In this step the process of informatization is introduced into servitization. Data are now collected by the manufacturer from the usage of each PSS on the market.

In the fourth servitization phase, the PSS in question is being improved, relying on continuous innovation. This step sees the beginning of the Big Data exploitation, in which the data are first analysed and then used to innovate existing PSS and ideate new ones. This permits to the manufacturers to stay in contact with their consumers and to very quickly sense changes in the latters' behaviour. This option, though, is just one among the available. The other option, actually, is to sell the generated and collected data on the market to other business entities (e.g. marketing agencies, manufacturers and service providers). This last option has to be carefully pondered, since data can nowadays constitute a unique resource for building a sustainable competitive advantage.

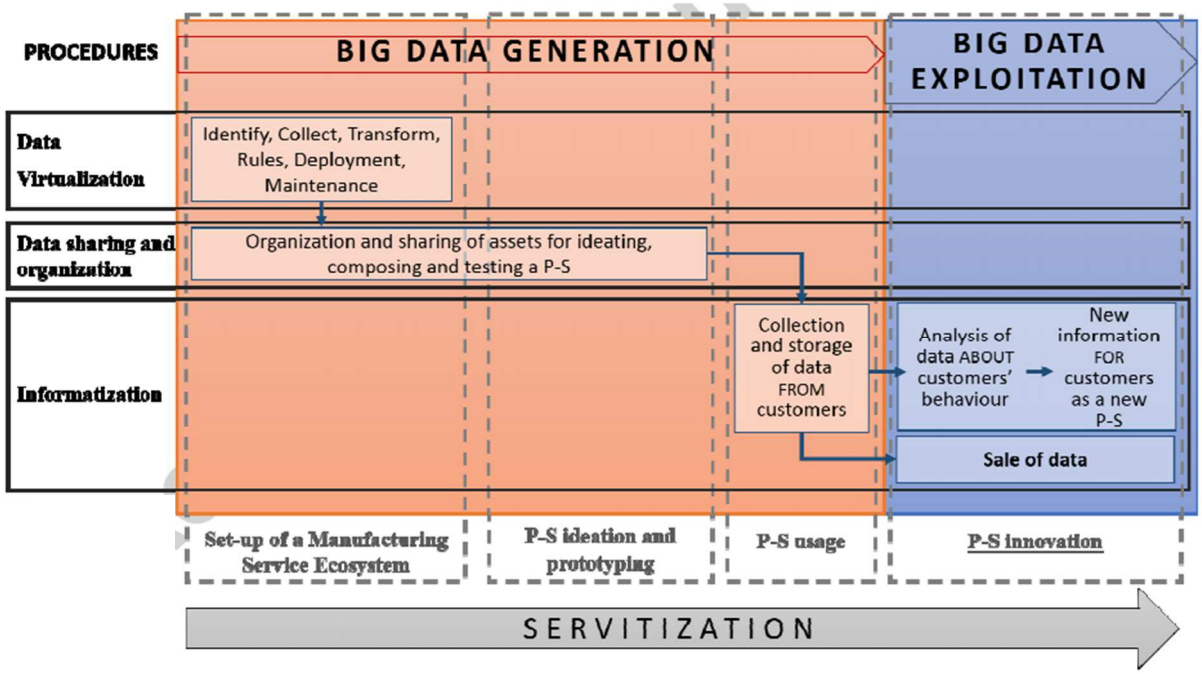

Figure 2.5 Big Data Servitization Framework (Opresnik & Taisch, 2015) *(P-S stands for PSS)*

The other dimension explored in the framework is that of the Big Data procedures, that are divided in three groups: Data virtualization, data sharing and organization and, at last, informatization.

Data virtualization is that set of procedures whose objective is to extract and comprehend the value of assets through the measurement of their characteristics and record the data in a database. The virtualization method provides a systematic approach to do that. It is framed within software processes that facilitate the population of the data warehouse and are commonly known as "Extract-Transform-Load" processes. It has five main steps: identification of key assets, population of the PSS ontologies, definition of rules, deployment, and maintenance. Data virtualization is one of the two ways through which data are generated, in this framework focused on servitization.

Then the second set of procedures is constituted by the one on data sharing and organization. As each partner should have the right to ideate and deploy PSS, the previously virtualized data must be shareable across the entire MSE.

The last set of procedures is the second important source of data, from the development of PSS, in this framework. It consists in the gathering of data during the usage of the PSS and their analysis through analytics.

Thus, informatization starts by collecting and storing data during a PSS usage. One possibility is to do this through smart-products. Secondly, the data can be used in two ways. On the one

hand, they can be analysed using business intelligence techniques (where the newly generated information serve as an input for a new innovative PSS or to incrementally innovate the existing one). On the other hand, those information, or simply raw data, can be resold to other entities; for instance to marketing agencies in need of longitudinally accurate behavioural data, that are extremely hard to obtain, or to other manufacturing enterprises with complementary products, or to independent service providers wanting to design a new service. However, the data exploitation phase would be much more efficient if organized within an ecosystem of partners interested in data exploitation (the information ecosystem). Thus, the transactions could be closely managed, ensuring privacy policies and enhancing trust.

A way to test and analyse this framework is to see it through the five Vs of Big Data (Volume, Velocity, Variety, Verification and Value). As for Volume, its increasing is guaranteed by the virtualization phase and from the automatic generation and collection of data from smart products during PSS usage. As for Velocity, since the greatest number of transactions and their frequencies are in the ideation, composition and testing phase of PSS, their exchange and combination in a Manufacturing Service Ecosystem permit to make them easily accessible to all partners involved so that they can perform the required service engineering operations. As for Variety, the types of data are increasing more and more depending on the advancement of the servitization process and on the partners involved. As for Verification, it represents a challenge because it is hard to control and ensure the required level of data quality in all aspects. As for the last "V", Value, it is given by the adoption of servitization, with all its potentialities and challenges previously highlighted.

2.2.6 Entering the Installed Base Market

One of the main differences and developments characterising digital servitization and making it different from "traditional" servitization, is the strong importance that has the installed base. Actually, new digital technologies offer a lot of opportunities for contemporary manufacturers, that have been in the business for a sufficiently long time. Actually, even if the equipment and machineries part of the installed base may not be recent (and so not conceived taking into account modern technologies), it is possible to revamp them, making those machineries able to generate and collect data and so to potentially provide new services, in order to add new revenue streams, different from just providing spare parts and reactive maintenance.

According to (Oliva & Kallenberg, 2003) the firm should not just thinking about its own installed base, but should enter inside the overall installed base market. Entering this market

introduces some peculiar characteristics to the process of servitization and of the market in which it is done.

First of all, services are no longer comprised in a certain bundle, in a PSS. Installed Base (IB) services encompass all the needs of the customer after the selling, but they should be open also to competitors' products. Secondly, can be suppliers of these services not just product manufacturers but also components manufacturers, system integrators, end-users' maintenance units.

For the previous reasons, the IB market is very big but also very competitive. However, manufacturers competing in the selling of new products have some advantages compared to the other competitors. First of all, they have more information about the new equipment joining the installed base, and can prepare then more easily the appropriate services. Then they are facilitated in the acquisition of knowledge about the product and its technology, and so also on what the equipment needs over its life cycle. Finally, they have lower capital requirements, since they already possess most of the technology needed to offer IB services.

(Oliva & Kallenberg, 2003) offer also a road map for entering the installed base market.

First, since usually the firm already offers services related to the product, but in a fragmented way (from an organizational point of view), the firm should consolidate this offering, gathering it into a single organizational unit. This consolidation should also be accompanied by the development of a monitoring system, to assess the effectiveness and efficiency of the service delivery.

The second phase is entering the installed base market, identifying the profit opportunities and setting the structures and processes to exploit it. There are two major challenges, though. The first is the necessity of a cultural change, in order to make the firm service-oriented. It is difficult, actually, for equipment maker to get excited about smaller services of repair and maintenance. It is then fundamental that the manufacturer learns how to value and how to sell services. (Oliva & Kallenberg, 2003) suggest to create a separate organization to handle the service offering. The second major challenge is the creation of a global service infrastructure that is able to respond locally at the requirements of the IB. This challenge encompass three different difficulties. First, the firm must invest to build an infrastructure, that will not generate revenues immediately. Second, the firm must learn how to diffuse knowledge across the network (f. e. certifying the service centers) and to manage large organization of service personnel. Third, the firm must decide about the degree of standardization of the service offer.

The third phase regard the expansion of the IB offering. Once the core functionalities of the service organization had been established, this expansion occurs through two distinct transformations. The first is changing the customer relation from transactional to relational;

moving along this dimension changes the pricing method, from a markup for labour and components to a fixed price covering all services over an agreed period. Moving to relational contracting, the provider assumes the risk of equipment failure, but is able to reduce the variability of demand. The second transformation regards the focus of value proposition from product efficacy to product efficiency and effectiveness within the end-user's process. Through this shift the manufacturer becomes then a solution provider.

The final step should be the "pure service organization", in which the provider completely assumes operating risks and takes entire responsibility of the end-user's process.

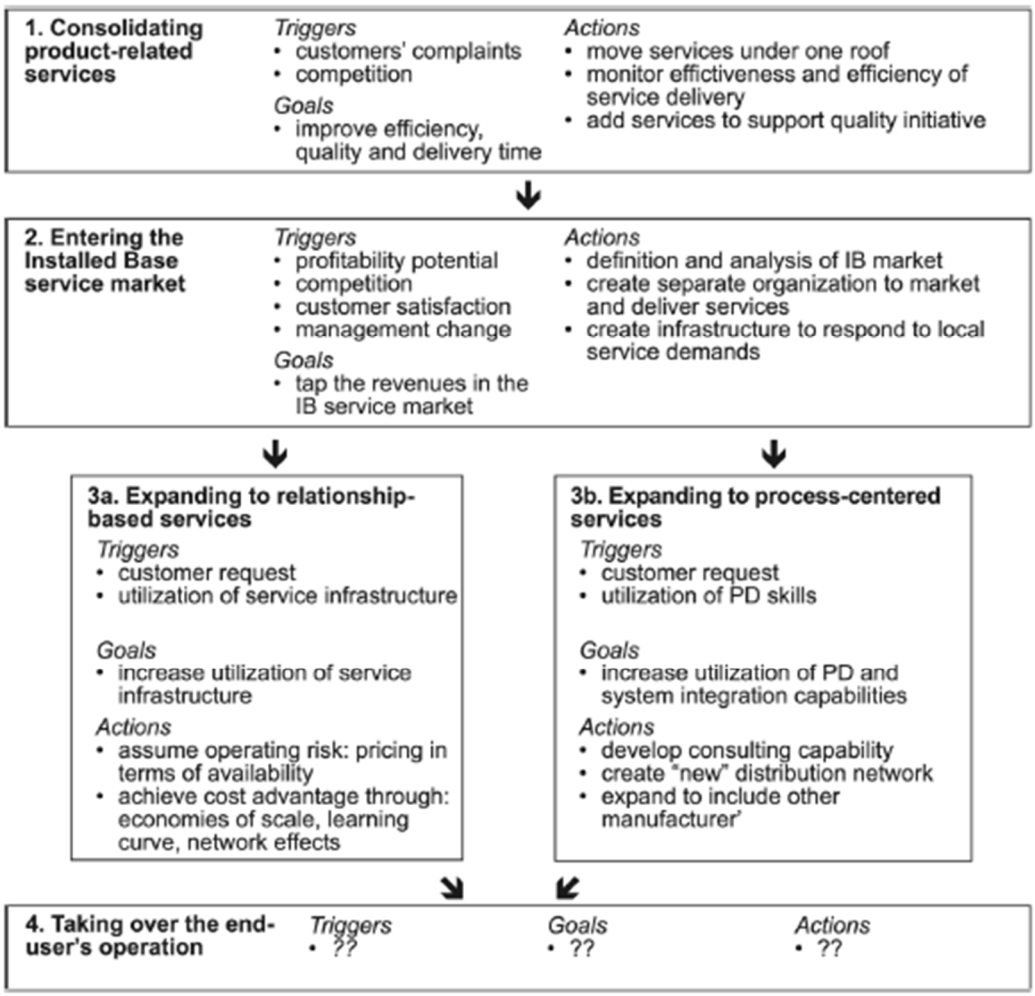

Figure 2.6 Process model for entering the Installed Base market (Oliva & Kallenberg, 2003)

2.3 New business models and value propositions

One of the often cited consequences of the introduction of new technologies is the development of new revenue streams coming from the application of new business models. Actually, the possibilities offered by digital servitization are numerous.

Servitization, though, is not a simple choice of different alternatives; it is also a process of continuous improvement and tendency to an higher, if possible, level of service-intensity.

The "servitization journey", that a firm can potentially follow starting from an initial situation of absence of services, can be illustrated through the next Service Evolution Model by (Burckart & Rustema, 2015), in Figure 2.7.

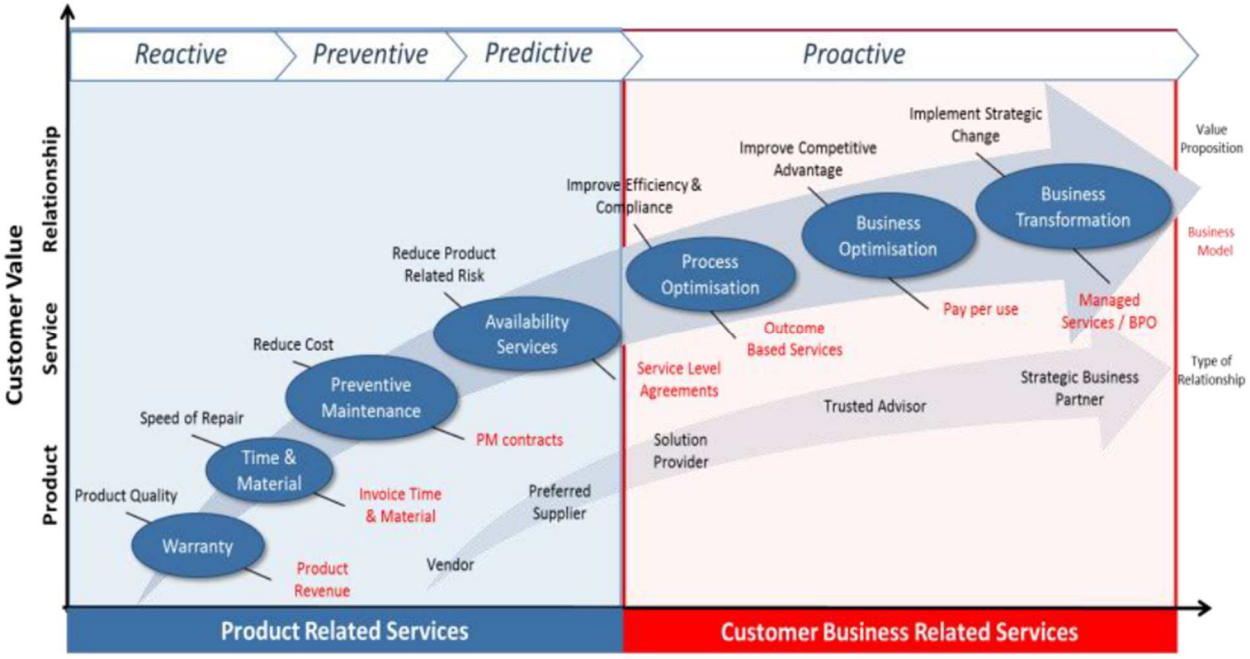

Figure 2.7 - Service Evolution Model by (Burckart & Rustema, 2015)

On the top of the model it is depicted the type of offering that can be given, showing the different potentialities coming from smart, connected products. The services given can be located in a continuum, from

- reactive (solving problems once they have appeared);
- to preventive (anticipating possible problems according to R&D recommendations);
- to predictive (anticipating the problems according to specific forecasting method, usually analytics);
- to proactive (not simply looking at the problems but at the changes that should be done by the customer in order to optimize its business or even change it according to its strategy or values).

On the bottom of the model is highlighted the fact that, if the services given are linked to a proactive role of the provider, they then are linked to the business of the customer; they are linked instead to the product of the customer in all the other cases.

In the middle, the greater arrow groups the different services that are given in a process of increasing servitization. Under this row are depicted the corresponding business models, on

the top of that instead the corresponding value propositions. Just a note, in this chart, when they speak about Outcome-Based Contracts, they mean aOBCs, namely focused on availability of the equipment. The next phase is constituted by the contract in which the customer pays not just for how much time he can potentially use to produce, but for how much it factually produces (pay-per-use contracts). Finally, the step is of those contracts in which the customer outsource the management of its operations (through what are sometimes called eOBCs, Outcome-Based Contracts based on economic results).
The lesser arrow instead depicts the type of relationship established between the provider and the customer. At the beginning the customer is just a vendor. With predictive maintenance the provider could become a preferred supplier. With availability services it could already become a solution provider, for example by increasing the uptime of the technology it provides. Once it starts to sell process and optimization services, it becomes a trusted advisor, where the customer seeks the knowledge and the expertise that the provider is able to offer. Offering business transformation services the firm becomes a strategic business partner.

In the following part of the chapter, after general considerations of the strategy and business model innovation that a firm may follow, will be analysed some advanced, since they are the ones most able to provide a competitive advantage to the firm and also the one whose usage is most enabled by new technological innovation.

2.3.1 Strategic decisions and Business Model Innovation

In order to choose the right business model (or business models' combination) the firm must take ten main decisions, according to (Porter & Heppelmann, 2014).
First, the firm must decide which set of smart capabilities should it pursue. In order to do that, it should decide which, among the potential features, will really deliver value to the customers, compared to their cost. This choice depends also from the market segment the firm decides to serve, and on their capability of reinforcing their positioning in it.
A second choice is related to the embeddedness of the capabilities previously chosen, to which one embed in the product and which one, instead, in the cloud. In order to understand this, some factors have to be taken into consideration. First of all, if the response time needed in a certain functionality must be quick, then it should be embedded in the product; the same if an high degree of automation is needed or if the data collected are confidential and need to be transferred the least possible. On the contrary, embedding functionalities in the cloud can be particularly important in the case of remote or hazardous locations of the products, in the

case in which the user interface is complex and needs to be changed frequently, and also when the product needs frequent upgrades.

A third important choice the firm must make is between a closed and an open system. If it decide to sell the smart, connected product as a closed system, it means that every its part is provided by the firm. This permit to control technology and data, and to better direct the development of the product. It has the disadvantage that product development may be longer with this approach. In the other case, instead, of selling an open system, the firm decide to assemble part of the solution from different companies. In order to permit to external subjects to contribute, the interface and the architecture must be more standardized. An open system guarantees a faster application development, but less control on data and product innovation. Sometimes, in case of value constellations whose products can be seen as systems of systems (as in smart homes), the firm is obliged to choose an open system approach, since it becomes extremely difficult to have the full control on all the products that make that system. A lot of firms are now trying to apply, in some sector, an hybrid approach, in which the system is open but the firm has control on some important features of the product.

Another choice, strictly related to the previous one, is deciding which parts of the product build internally and which ones externally, outsourcing them. Outsourcing permit to speed the process and access resources probably unavailable, but can be problematic because can be costly and requires a major exchange of information (that are then less likely to constitute a strategic resource). Nowadays, this outsourcing is most of the times necessary for manufacturers, since they do not possess the digital capabilities now required by competition.

A further choice regards the data that the company decide to collect. Actually they have to be chosen properly, in line with the strategy chosen by the firm. If the firm advantage relies on optimising the performance of the machine, then must be collected massive data able to be immediately used. If the focus instead is on giving complete solutions, the data must be collected from all the devices. This attention is necessary also because collecting data adds cost to the product, considering the sensors, the connectivity, the storage, the analysis and the security of the data collected.

Moreover, a different choice regards the ownership and the access of data. Actually, the owner of the data coming from the usage of the product should be in theory be just the customer, but obviously the provider has a strong incentive to retain them. Nowadays appropriate standards have not been established, so the firm must decide its policy on this topic and the legal form through which enforcing it.

Smart, connected products provide a great means through which dis-intermediatize the supply chain, maintaining a direct relation with the customer. However, doing this is not a good idea if the firm necessitates of distribution partners critical in delivering training and service.

Besides of that, the firm must also decide if changing its business model, if deciding to maintain the ownership of the product after the agreement with the customer, or if gaining most of the revenues from advanced services offered to the customer.

In addition to that, again with reference to the data, the firm must decide if monetising its data product through selling them to third parties or not.

Finally, the firm should decide if expanding its scope. One of the main effects of the introduction of smart, connected products will actually be the fact that traditional boundaries of industries will be blurred. So the firm must decide if provide or not a proprietary platform where to connect all the devices, or if expanding its business also to related products.

A particular challenge involved in planning these type of strategies is understanding where may be the opportunities to long for. (Allmendinger & Lombreglia, 2005) suggest two ways through which the firm may look for new opportunities regarding the implementation of remote monitoring technologies.

First of all, the firm should look at the life cycle of the product, to understand the activities the customer is involved before, during and after the purchase of the product. Actually, for the customer, the final cost of owning an industrial product is far larger than the purchase price; (Wise & Baumgartner, 1999) found that the buyer of a locomotive engine spends 21 times its purchase price to support its use of the product. It is then important that the manufacturer engage in a series of activities involving the different phases of the life cycle of a product, providing for example services of maintenance, but also installation, training of the personnel and so on. (Allmendinger & Lombreglia, 2005) suggest, based on their research, that, as a rule of thumb, the product overall cost for the customer should be at least ten times the purchase price in order to be a good candidate for the implementation of advanced services.

Secondly, the manufacturer should look at adjacencies, that is, to all the activities that are not related to the product sold by the manufacturer, but are important for the customer in order to properly use it. In this sense it is fundamental for the customers to establish partnerships with other firms in order to simplify these adjacent activities for the customer.

Following these sources of opportunities, (Allmendinger & Lombreglia, 2005) proposes four types of business model that a manufacturer may follow to innovate its product-centric business model: the models of the embedded innovator, of the solutionist, of the aggregator and of the synergist.

The first is that of the *embedded innovator*. In this case the firm follows a path that still is strongly related to the technological innovation of its own product, building inside of it computational intelligence and providing connectivity, do that the product become a "silent partner" of the manufacturer, since make easier and more efficient for it to deliver the services included in the contract. If the product, maintaining its centrality, become though also a gateway to a broader range of activities that tries to encompass all the life cycle of the product, assuming the eyes of the customer, it is the case of the *solutionist*.

However, the manufacturer may also want to establish partnerships, trying to leverage on the adjacencies of the customer activity, since data and information coming from the single product are not valuable per se. A first way to do that is following the model of the *aggregator*. In this case the product is the cornerstone of all a series of devices used by the customers, and the manufacturer exercises a central control and gathering of all the data. In doing so, it makes full use of its business relationship establishing partnerships with all the producers of the devices connected with its main products; it also permits to strengthen very much its customer relationship. It is also possible, anyway, to follow a different path, in which the firm does not offer the central part of a system, but a device that can be very well integrated in that system; this is the case of the *synergist* model.

In any case, as pointed out by (Kowalkowski, et al., 2015) the process of servitization is multifaceted and does not necessarily imply a unidirectional development towards the provision of more extensive services as schematised by (Tukker, 2004). Instead, they may occupy multiple positions along the service transformation continuum to satisfy different customers' needs.

According to (Kowalkowski, et al., 2015) the movement of servitization is described, in the literature, as following three prevalent and interrelated dimensions:

1) from product towards process-oriented services;
2) from standardized towards customized services;
3) from transactional towards relational services.

It is also recommended that the transition should be gradual and sequential, due to the complexity associated with distinct changes of parallel dimensions in the business of the enterprise.

(Kowalkowski, et al., 2015) propose three system-supplier roles that the manufacturer can assume: equipment supplier, availability provider (a term preferred by the authors to "solution provider"), and performance provider; these roles correspond to the three systems model remarked by (Tukker, 2004) (product-oriented, use-oriented, and result-oriented).

An *equipment supplier* provides services that are directly related to its equipment, and its customers have a strategy that remains fairly independent of suppliers. The services are product-oriented, transactional, standardized, and input-based.

An *availability provider* tend to offer services along the whole life cycle of the product, making them a differentiating factor for the competitors. The strategy of its customers usually aims at sharing capability development with the supplier. The offering is use-oriented, relational, customized, and output-based (such as a promise to achieve availability).

A *performance provider* extends extend their activities even further in the direction of system co-development, process management, and continuous optimization; its customers have a strategy which relies mostly on supplier expertise and capability development. Often, the customers pay only for actual, achieved results and value-in-use (i.e., performance).

In their empirical analysis, (Kowalkowski, et al., 2015) noted also another trajectory, different from the abovementioned ones, which they define as the role of the *industrialiser*. This is a trajectory that a firm may follow after having employed for many years an offering characterised by customized solutions and a relational type of relationship, typically to large key-account customers. The firm can capitalize on the knowledge and experience gathered in these more complex and relationship-intensive offerings, by downsizing them and standardising many of their elements.

(Ardolino, et al., 2017) analysed the relations between the technologies of Industry 4.0 (in particular, Remote Monitoring Technology, Cloud Computing and Analytics) and the servitization paths that a firm may follow.

As regards the availability provider profile, Remote Monitoring Technology enables efficient data collection from widespread fleets. Also Cloud Computing plays a big role; in particular, IaaS is extremely efficient for storing field data captured by connected machines and SaaS for having applications that process the cloud's raw data and generate and share information across the organisation.

In the case of a performance provider, Remote Monitoring Technologies, Cloud Computing and Analytics are all combined to extract knowledge from field data and make significant predictions on products' faults and customer behaviour.

According to (Ardolino, et al., 2017) the use of IaaS and SaaS is not a prerequisite for moving along the two abovementioned paths since data can be collected and processed in traditional ways, such as stored in a local database where applications embedding prediction algorithms run. It becomes instead very useful in the case of the industrialiser profile, which pushes companies to standardise and industrialise what they had previously developed, tested and successfully sold in big, particular, customized contracts to reach larger customer bases. Once

economies of scale and standardisation are achieved, the use of a PaaS system offers technology able to integrate the building blocks of a modular service offering.

2.3.2 Service Level Agreements

Service level agreements are a fundamental concept in the service management discussion, which relates to exploitation and operation of IT industries (Bouman, et al., 1999). In this sense, they provide a framework for specifying the main aspects and objectives that, in a relationship between an IT supplier and a customer, involve availability, level of performance and specific functionalities. Service Level Agreements are based on guaranteeing availability of the product, on guaranteeing that it will not have period of downtime, or at least a certain minimum level of it. The main value proposition coming from these contracts is the fact that the product will work as intended, and be potentially able to deliver what it was designed for, so reducing, for the customer, the risk coming from the product per se. For this reason, they can be called also Output-Based Contracts (Higgins & Sykes, 2009).

In a SLA is indicated not just the service provided, but also the metrics that measure its effectiveness and eventual penalties that the provider has to pay in the case the service does not respect the agreed metrics.

According to (Larson, 1998) the basis of Service Level Agreements is the output of one or more processes or interfaces designed to meet the customer's expectations (or a defined set of expectations). The purpose of an SLA should be to provide the user of the service with the information necessary to understand and use the contracted services.

Each Service Level Agreements after a service description, should contain a description of its service elements, that are defined a single service units that could be described in terms of what it is and where and when it can be delivered. Apart from a description of them, each service element should be described also in terms of:

- constraints, which define the rules and regulations within which the service will be delivered and achieved, the level of activity beyond which the defined performance will not be assured, and any requirements which, if not fulfilled, will mean the service provider may not achieve the agreed service levels;
- performance measures (typically measured as time of service delivery duration or completion) which define the extent to which deviation from the service definition, or even perfection, will be tolerated by the customer;
- pricing, which defines the cost or charge to the customer for use of the service.

According to (Larson, 1998), the service provision could be measured in terms of:

- Availability, that usually is identified as the proportion (percentage) of the time in which the contracted service scheduled is actually accessible and useable over a defined measurement period (e.g. weekly or monthly).
- Reliability defines the frequency with which the scheduled service is withdrawn or fails over a defined measurement period (e.g. not more than three failures per week).
- Serviceability is an extension of reliability, and measures the duration of available time lost between the point of service failure and service reinstatement (e.g. 95 percent of network failures in any working week will be restored within 30 minutes of the failure being reported).

In a SLA can be present also an indemnification clause (Overby, et al., 2017). It is a provision in which the service provider agrees to indemnify the customer company for any breaches of its warranties. Indemnification means that the provider will have to pay the customer for any third-party litigation costs resulting from its breach of the warranties.

According to (Trienekens, et al., 2004) a shortcoming very frequent in defining a SLA is specifying the effort done by the provider in case of damage (with all the information on time and place) instead of the results that the provider may help the customer to achieve. In addition to that, the specification of the service measures may be unclear; for example, in case of availability, which is factually the difference from a 98% level or a 99% level of availability? And, on a yearly basis, a guaranteed availability of 98% could be understood as the possibility of not guaranteeing availability for the last week?

Other challenges relate to pricing, since may be difficult to understand the proper pricing and the proper penalties in case of breach of the conditions, and that, because a SLA may be very technically complex, it can be understood only by a small group of technology oriented specialists, so that evaluation and improvement does not take place on a regular basis.

2.3.3 Outcome-Based Contracts

As famously put by Theodore Levitt "*People don't want to buy a quarter-inch drill, they want a quarter-inch hole*" (Levitt, 1972). This, in short, is the rationale behind the concept of Outcome-Based Contracts (OBCs).

OBCs are a very discussed topic when it comes to speak about servitization. They are known by many names; as a concept, they are similar to Result-Oriented PSSs, to functional products, to solutions offerings, to Performance-Based Contracts (PBCs), to Performance Based Logistics and advanced services (Grubic & Jennions, 2018).

In common to all there is an idea that the customer is purchasing a performance, a result, an output, and/or an outcome. However, what these terms mean is not clear in the literature.

They are usually described by a series of vague terms. Some authors, a bit more specifically, talk about the purchase of a functional result, even though a formal and commonly accepted definition of what a functional result truly is still lacks.

Adopting the definition by (Hou & Neely, 2018), an OBC can be defined as "*an agreement between the provider and the customer in which the provider provides total solutions and is paid based on the outcomes of the solutions or the outcomes of customer value in a continual use situation*".

Three main characteristics can be highlighted. First, in OBCs are delivered total solutions instead of individual components, and the contract specify outcomes instead of inputs, processes or outputs. Secondly, the payments the provider receives depend on the outcomes of the total solutions, or the outcomes of customer value. Thirdly, the agreement should be in a continuous use situation, referring on the relational instead of the transactional nature of the relationship.

The literature recognises different typologies of OBCs. These typologies can be summarised in the one by (Böhm, et al., 2016) which divides OBCs into OBCs based on availability (aOBCs) and OBCs based on economic results (eOBCs). The first type of contracts relates to guaranteeing the operational readiness of a system; a classical example of this is the contract "Power-by-the-hour" by Rolls Royce. Actually, rather than charging its customers for the jet engine and the time and material needed for service and repair, Rolls Royce is being paid for the number of hours that its jet engines are operating in the air; it does not guarantee, for example, an increase in performance results or economic measures like profits. This is usually done in eOBCs, where the provider has a deeper involvement in the customer operations, so that it becomes possible to guarantee an improvement. Outside of the manufacturing context, an example could be that of a marketing consultancy firm that implements a new pricing scheme at a customer firm and shares the incremental profits with them.

OBCs permit to the customers and the providers to have many benefits. First of all, an efficiency improvement for the customers, because they no longer directly manage or even own inventory. Other advantages include improved spending accountability, innovation, budget flexibility, value for money and inclusion of social and environmental objectives into specified outcomes, sometimes without linking them to additional rewards. OBCs can also achieve a more efficient allocation of resources and customer–supplier matching than fixed-price contracts.

A key characteristic of OBCs is the transfer of risk from the customer to the provider, as regards the delivery of output, performance or outcomes. This is indeed considered the main part of the value proposition coming from this type of contracts. However, what these risks

involve is not definitely clear, since there is not a formal and commonly accepted definition of performance, result, output, outcome and also risk in the literature. It is mostly recognised, however, that eOBCs carry more risk for the provider compared to aOBCs.

A possible definition of risk is the one chosen by (Hou & Neely, 2018), according to which risk is "*an event with the ability to directly inhibit the mission, strategy, projects, routine operations, objectives, core processes, key dependencies and/or the delivery of stakeholders' expectations*".

The authors provide a framework to describe and analyse the risks of an Outcome-Based Contract, that, as previously said, are mainly borne by the provider (Figure 2.8).

In building an OBC there may be two main categories of risk; first, commercial risks, regarding contract's negotiation and decisions; second, operational risks, related to the contract implementation and delivery.

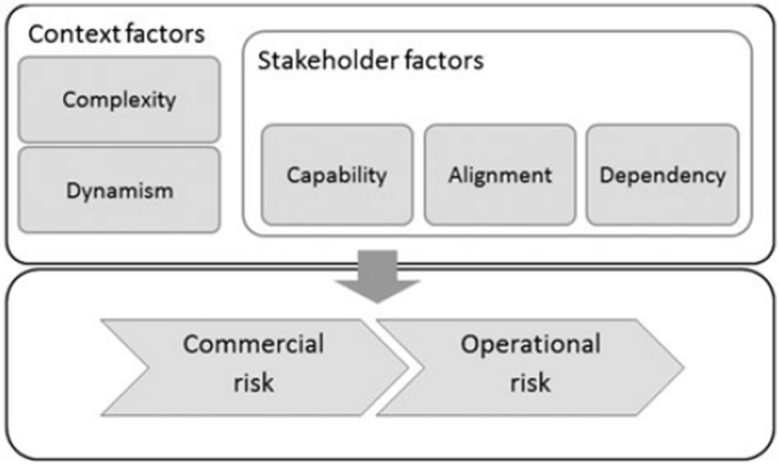

Figure 2.8 OBC's Risk Framework (Hou & Neely, 2018)

These risks may come from along five dimensions.

The first two are related to the context where OBCs are delivered: complexity and dynamism.

Complexity deals with the abundance of variables and uncertainty that are involved in the context in which the firms operate. Complexity is due to various factors, like the involvement of multiple stakeholders (that makes negotiation very difficult and risk greater), diversified customer demands (because of regional and cultural differences) and unclear customer demands (often, OBCs are new to the customer, so they are not able to clearly define their needs, making negotiation more complex). Ina addition, also complex contracts (because the variables involved are far more than usual contracts, and represents a situation usually not ruled by law) and complex environment (the role of the environment is fundamental) represent a source of risk.

Dynamism is instead related to the changes in time of the context, and is influenced by a demand by the customers which is dynamic (since the drivers of the customers are fluid and tend to change over time). OBCs are characterised also by a dynamic environment (it is a source of risk because the provider has to set the variables and the parameters at the beginning of the relationship, but they may change over time) and by the fact that they are long-term contracts (because of their lasting duration, it is very difficult to forecast and usually there is no possibility for re-negotiation).

The others are instead related to the stakeholders involved in the contract. Capability relates to the lack of capabilities and expertise of the people involved in the firm. Actually, the provider may not have the capabilities to contract OBCs, because of the lack of previous experience and knowledge and they do not have best practices to follow. The provider may also lack of capabilities to deliver OBC, because competencies like project management, supply chain management, data management and service delivery are needed. The provider may also have internal inconsistency, so that may happen that the provider over-promise, since the personnel involved in the negotiation phase is not the same of the personnel who must implement the contract. Also providers' internal resistance may be an issue, because not all the people in the organization may want to change and focusing on services. From the point of view of the customer, it may not be able to consume the delivery and to play its roles; actually, some tasks may remain in any case competence of the customer, and it may fail to understand them and to properly do them in accordance with the provider. The same lack of capabilities may involve also the other stakeholders.

Alignment relates to the potential mismatching between provider and customer; it is then necessary that they both align. First, they must align in goals, both short-term and long-term; providers would like to have flexibility in the long run, whilst customers instead would prefer stability. They should align also in their visions, since customers may perceive OBCs as a loss of control over their equipment, especially if they have always done like that. The same difficulties may arise because of the practices adopted, of the lack of mutual understandings and of different culture (like different communication style or leadership). One last possible mismatching is due to bargaining power, due to the lack of experience, that may not permit to the provider to understand if the customer is taking advantage of him.

Dependency encompasses three directions. First, the extent to which the provider depends on customers (because the provider needs their inputs in different ways, like information, infrastructure or skilled labour) and other stakeholders for the delivery of the services and solutions. Second, the extent to which the provider can control or influence the performances and behaviours of customers and other stakeholders; and third, the severity of consequences

and impacts the provider has to bear due to the failure of customers and other stakeholders. Another factor that increases provider's dependency is the up-front investment, which is necessarily present in an OBC; this may cause consistent financial loss if the outcome is not delivered.

Table 2.1 summarises the main risks involved in an Outcome-Based Contract.

Regarding the context	Complexity	Involvement of **multiple stakeholders**, at different stages of the contract, both external and internal to the firm
		Diversified customer demands, depending on the country and on the region; some cultures may prefer a more detailed contracting, others a contract more general
		Unclear customer demands, since an OBC may be new to the customer
		Complex contracts, because of the many variables and external factors involved
		Complex environment, since economic, industrial and societal factors determine the possibilities of having and retain economies of scales and durations of contracting
	Dynamism	**Dynamic customer demands**, since the drivers of the customers are fluid and they frequently change
		Dynamic environment; most of the variables agreed on the contract may change due to economic dynamics, and the provider may not have the possibility to renegotiate it
		Long-term contracts; many events may happen, making the variables and factors considered at the beginning not suitable anymore or no more meaningful.
Regarding the stakeholders	Capability	**Providers' lack of capabilities to contract OBC**, due to the lack of sufficient experience, knowledge and capabilities for contracting Outcomes.
		Providers' lack of capabilities to deliver OBC, since it may not have project management capability, the expertise and resource capability, the supply chain management, the service and products design, data management, service delivery and technological capability
		Providers' internal inconsistency, between the negotiation and the implementation teams, between the senior leadership and the project levels, among different departments within the provider's organisation
		Providers' internal resistance, because many people in the organization may not be willing to do the transition to services or may not agree internally for political fighting among functions
		Customers' lack of capabilities to consume the delivery and to **play their roles**, that lead the customer to continually change its request leading to
		Other stakeholders' lack of capabilities to perform; because of the great number of subjects involved this lack may be very likely

	Alignment (as regards…)	**Goals**, both in the short and long term; for example the provider may tend to prefer flexibility, whilst for the provider the main goal is stability
		Visions; for some providers, the importance of OBCs is to set practical ground rules for implementations and to build a collaborative relationship, whilst some customers still think in a traditional way, considering the contract as rigid agreements without flexibility.
		Practices; at the negotiation stage, the customer may want to use their own financial modelling and indexes and practices. These may be different from the provider in some cases. At the implementation stage, the customer may want to be involved in the micromanagement, whilst the provider needs freedom for decision-making with least interventions
		Understandings; the parties, if not experienced, may be not negotiate with agility and be not fully aware of the consequences of the sign of the contract
		Culture, as regards communication styles, working styles and leaderships; for example between firms belonging to the private and public sector
		Bargaining power; one of the parties may have less bargaining power because of less experience or less market power
	Dependency	How much the provider depends on customers and other stakeholders for the delivery of the services and solutions
		the extent to which the provider can control or influence the performances and behaviours of customers and other stakeholders
		the severity of consequences and impacts the provider has to bear due to the failure of customers and other stakeholders
		Upfront investments, which is an important characteristic of OBCs, can also increase the provider's dependency, especially when the investments are contract specific.

Table 2.1 Risk typology and characteristics of an OBC, by (Hou & Neely, 2018)

2.3.4 Pay-per use contracts

Another important advanced service is constituted by the so called pay-per use contract. It is a contracting similar to the concept of use-focused PSS type (Adrodegari, et al., 2015), and to the business model called by (Tukker, 2004) "pay per service unit".

It is different from Outcome-Based contracts because here the firm does not guarantee a functional outcome or performance, but that the actual payments will be corresponded to the factual usage.

As regards the value proposition, in pay-per-use contracts the risk related to production and outcomes is not carried by the provider, but the customer still see a reduction of the risk, for two main reasons.

First, the risk of seeing the investment as a sunk cost is almost annulled. It is possible for the customer to try the equipment for a certain period of time, to see if it really needs it. This is useful in very turbulent environments, where a lot of innovation is involved and where standardisation of procedure and standards is not based on commonly accepted best practices.
Secondly, it permits to the customer to have a more flexible cost structure, without the pressure to fully exploit the capacity of the products bought under this scheme.
For these reasons, a pay-per-use scheme could be very useful when a firm wants to penetrate a market; this was the main reason why Xerox was able to penetrate the copy market being just at the early development stages.
For providers, the implementation of pay-per-use contracts is challenging, since it takes longer until revenues are able to create profits. Actually, traditional sales are substituted by usage fees; costs include research and development, equipment, operation and maintenance costs; operation and maintenance costs capture all the activities for ensuring product usage, like inspection, repair, spare parts (they increase with the usage of the product and decrease vice versa). Profits then depend on the ability of companies to predict customer product usage.
Every service intervention is costly, so the provider has a strong incentive to minimize it and to focus on predictive maintenance.
It is difficult that a firm is able to apply this type of contract and relation with its clients. (Gebauer, et al., 2017) tries to analyse which these capabilities should be, and propose three main areas: financing pay-per-use services, aligning costs with equipment usage and collaborating with customers.
As already said, *financing the implementation of a pay-per-use contract* is challenging and difficult. In order to be able to do it, the firm must first of all deeply consider the customer needs, understanding why they should prefer a pay-per-use contract and not instead a leasing or a rent. Secondly, the firm must carefully be able to predict the financial consequences of a complete or partial offering given under these contractual agreements. Thirdly, it should be able to actively collaborate with banks, for example making an agreement through which the property of the equipment and usage fees go to the bank, that then transfer the payments to the provider. However, the bank may prefer different schemes, like renting or leasing, so it is important also to consider other financing channels, like impact investors[7] (if the product is related to a social or environmental wellbeing).

[7] *Impact investing* refers to investments made into companies, organizations, and funds with the intention to generate a measurable, beneficial social or environmental impact alongside a financial return.

Also modularization of pay-per-use packages becomes important, since every investor could, for example, invest in the pay-per-use contracts with a certain level of risk, or environmental impact. Very important are also capabilities of service innovation and risk management, so that the firm is able to give a draft for financing schemes and correctly assess and mitigate possible risks. Finally, it is important that the provider is able to coordinate all these investors and their chosen pay-per-use services.

A second organizational capability needed for implementing pay-per-use services is *aligning costs with equipment usage*. Actually, it is relatively easy to understand the costs for the provider looking at its ERP. Completely different is allocating that cost to the actual usage of the customer through an appropriate conversion. In doing this, it is then fundamental the transfer and collection of data, as highlighted by (Opresnik & Taisch, 2015). Following their Data-driven Servitization Framework, a great importance is then assumed by virtualization, and it is fundamental to collect data from suppliers of components and having under full control the cost structure. Also the phase of informatization, through gathering data from the usage of the product, is very important, since the manufacturer can then check if the previous forecasts were correct and eventually correct them. This can be done first of all by experimenting with component costs. It is also important to be able to remotely monitor the equipment condition. After having monitored the equipment, it is necessary to consider also the great variability of usages, and to properly include it in the cost function. Then it is also essential to include the suppliers into the pay-per-use approach, to align the costs to equipment usage; for this reason, it may be useful to establish a Service Manufacturing Ecosystem (Opresnik & Taisch, 2015). Finally, it is also necessary to increase cost transparency through a reduction in vertical integration, relying more on external suppliers, if they also accept a pay-per-use scheme.

At last, is fundamental to have the capability to *collaborate with the customers*. In order to develop it, the provider should engage in dialogue with direct and end-users, in order to forecast the production levels of the equipment, and introducing softer or harder penalties if those levels are not reached. Secondly, the provider should offer complete solutions, in order to have as many variables as possible under its control. Lastly, it is very important that maintenance is integrated into the operations, for example through remote assistance. The collection of data after the selling is fundamental for guaranteeing such advanced services, together with proper actions to ameliorate their veracity, going beyond their great variety coming from the involvement of different stakeholders, suppliers and customers. This permits to recognise the patterns of the customer's behaviour, and so to elaborate appropriate pricing policies.

2.3.5 Examples and applications of advanced services

When it comes to think about advanced services implementation, the first example that is made is the service "Power-by-the-Hour" by Rolls Royce. More specifically, the initial reference is to the contract signed in September 2003 between the US Navy and Rolls Royce for the provision of maintenance and logistical support for the Rolls-Royce Turbomeca F405 Adour engines that powered the navy's 200-strong fleet of Boeing/BAE Systems T-45 Goshawk advanced naval jet trainer aircraft (Smith, 2013).

Under the terms of the contract, Rolls-Royce was to be the sole provider of logistics support, receiving a fixed price for each hour the engines were in the air. The full package of Rolls Royce comprised engine maintenance, support, trouble-shooting, parts supply and logistics support for the aircraft at three naval air stations in Mississippi, Texas and Maryland. From this point of view, it could be seen as a pay-per-use scheme.

However, even more importantly, Rolls Royce also guaranteed a certain level of improvement of performance. Performance was measured, at a fleet level, in Ready-for-Issue (RfI) engine availability; previously, this RfI level had averaged 70%, so for almost one third of the time the aircrafts were out of action. Rolls Royce, through its "Power-by-the-Hour" contract, promised to increase this RfI level to 80%, and this is the reason why the agreement is usually considered an Outcome-Based Contract, focused on availability (Grubic & Jennions, 2018).

The contract had an option, that it could be renewed after one year for other four years. Having considered the success of the first year, the US Navy decided to prolong the contract. Two years into the contract in 2005, RFI engine availability had risen above the target rate of 80% in the initial year reaching 85%, while the average time between engine removals had increased from 700 hours to over 900 hours and the expected engine removal rate had fallen by 15%. In addition to that, the "Power-by-the-Hour" contract permitted to be beneficial to the US Navy also from a financial point of view, with a saving over the five years of 17% (Smith, 2013).

Then Rolls Royce expanded this contract also to civil aviation, where these services are offered with TotalCare®, comprising a range of packages that allow airlines to select from a menu of services on an agreed scale of costs per flight hour.

TotalCare by Rolls Royce had also been considered, in some literature, as an eOBC (Grubic & Jennions, 2018). According to (Grubic & Jennions, 2018), though, this is not correct, since Rolls Royce does not link the payments to some economic result of the customer. In the opinion of the authors, this type of contracts is not even feasible from a technological point of

view in manufacturing, because of the limits involved in actual Remote Controlling Technology.

If the existence of eOBCs in manufacturing may be discussed, in other sectors are instead present, like in the pharmaceutical industry. In the US some big multinational have undertaken drug provision contracts with certain private insurers, which provided upfront discounts or further additional rebates in relation to certain measurable outcomes, like for example the reduction of the level of hospitalization. A recent well-publicized example (Seeley & Kesselheim, 2017) involved a drug called Entresto. One key clinical trial showed a 20 percent relative risk reduction in death or hospitalization. In 2016, Novartis disclosed that it had established separate deals with multiple private insurers to provide additional rebates if a higher level of hospitalizations occurred. In return, the drug Entresto was given preferred formulary status, meaning that patients were responsible for lower co-payments and overall prescribing of the drug would be expected to rise.

As for pay-per-use contracts, the most famous is the model adopted by Xerox, in the 60s, in which customers pay just for papier usage. This permitted to Xerox, although at its beginning, to dominate the market.

A more interesting example is found in (Lay, 2014), in the plant engineering industry[8].

The company involved is the ALD Vacuum Technologies, in Hanau, Germany (now owned by AMG Advanced Metallurgical Group N. V. in the Netherlands). ALD has developed innovative vacuum furnaces and vacuum processes (that solve the problem of oxidation of the metals involved) and regards itself as one of the leading suppliers of this technology. When this new technology was first introduced, ALD realised that the processes were not easily accepted because they were significantly different from established heat treatment processes using atmosphere and oil quenches. To improve understanding of the new technology by the global manufacturing community, ALD established their ‘‘Own and Operate Division”. This division installed several vacuum heat treatment facilities and operates them currently for various customers. One of these customers is General Motors Powertrain. The operation arrangement made with GM Powertrain comprises the following aspects: ALD built the facility ‘‘fence-to-fence’’ to the customer’s plant and remained owner of all equipment. The capital for this investment was financed by bank loans. The employees for running the facility were hired by ALD. GM pays for the vacuum heat treatment of the transmission gears according to the number of manufactured parts. The contract with GM includes no fixed

[8] Plant engineering companies design and construct power plants, petrochemical plants, steelmaking plants, drinking or wastewater plants, assembly plants, and production facilities for various other industries.

number of parts to be delivered, which implies that the market risk of GM is partly transferred to ALD. ALD has accepted this risk to provide a showcase for the ALD brand equipment technology as well as the new process techniques. Furthermore, ALD acquires additional know-how from running the innovative equipment, which enables this plant engineering company to improve the equipment's performance and to gain an increased competitive lead.

This agreement permits to see some of the advantages shown for a pay-per-use contract. For the customer, it is possible to avoid start-up problems and start-up costs possibly generated by an investment in innovative and unproven plant technology, transforming a cost that is usually fixed in one that is instead variable. Also, for ALD it was possible to learn from the usage of the plants by GE Powertrain, and present it to other customers as already proven. In addition to that, the collaboration established with banks, without which this agreement would not have been possible.

CHAPTER 3 EMPIRICAL CASES

Introduction

As it was possible to notice, the interest of literature and academics on the topic of servitization and on its revamping due to the Fourth Industrial Revolution has been huge. Not by chance, a lot of firms have introduced various gamuts of services in their offerings. Not always these enlargements have been successful, as shown through the empirical analysis of the servitization paradox.

Empirical research on digital servitization is still scarce, due to the newness of the topic and to the fact that a lot of firms are usually just approaching these themes. The approach that is usually followed is doing interviews to people responsible for the implementation of these policies, trying then to make assumptions and generalisations based upon the findings.

This is also the approach followed here. Three firms belonging to the capital equipment industry have been contacted and three knowledgeable respondents have been interviewed.

The interviews have shown that there is a general awareness of the importance of services and of the possibilities offered by the new technologies coming from Industry 4.0. There is a lot of experimentation in the industry, as regards the manufacturers. As regards their clients, instead, they are not attracted by some types of services that should involve the gathering of their data. Convincing the customers of the validity of the advanced services seems to be the main issues, nowadays, related to the implementation of digital servitization.

In this chapter, after a description of the methodology used, the empirical cases will be presented; a discussion of the empirical evidence and conclusive remarks will follow.

3.1 Methodology of investigation

As anticipated, a cross section analysis of multiple cases is the methodology adopted in the study.

As stated by (Yin, 2014) case study research is one of the form of social science investigation. It should be used when: 1) there is the need to answer to a "how" or "why" question; 2) a researcher has little or no control over behavioral events, 3) the focus of study is a contemporary phenomenon.

(Yin, 2014) suggests that it is proper to use the case analysis method if it is commonly used in the investigation of a certain phenomenon; it is then appropriate apply this methodology in the field of digital servitization, since this has been, up to now, the mostly used investigation method (Baines, et al., 2009).

A case study permits to focus on a "case" and retain a holistic and real-world perspective, permitting to understand complex social phenomena (Yin, 2014). Particularly, it is appropriate to apply it if the phenomenon is new and it necessitates of investigations trying to highlight potential opportunities and challenges. The possibilities of discovery and exploration of new phenomena make qualitative analysis, according to (Miles, et al., 2014), one of the best method for investigating new phenomena.

Another reason that lead to the use of case study methodology is when the phenomenon analysed is likely to involve important contextual conditions pertinent to the case (Yin, 2014). As also stated by (Miles, et al., 2014), qualitative analysis does not exclude the context, on the contrary it is taken into account, an this permit to understand latent, underlying, or nonobvious issues. This seems particularly legit as regards this analysis, because of the peculiarities introduced by new digital technologies as regards value networks and the organizational structure of enterprises.

Case study method is also characterised by criticisms. According to (Yin, 2014) one of the main concerns is related to the fact that it is not possible to derive general conclusions from the studies; the author, though, argues that also with a single physical experiment it is not possible to demonstrate a certain physical law. What is important, in using case study analysis, is using the data to make theories, through so-called analytic generalizations, being aware that, since case study are not a statistical sample, they do not constitute statistical generalization.

Multiple case study permits to slightly increase the possibility of making generalisations, since more material is available; in addition to that, they also permit to make comparisons, to

see if theory seems able to predict what happens into reality, taking into consideration different conditions.

Here will be analysed how three firms in the equipment industry have dealt with a process of digital transformation and the enrichment of their offerings through new services.

The collection of data has been done through a series of face-to-face interviews, preceded by the study of companies' websites, blogs and all the secondary information available on the internet and on the AIDA database[9]. Every interview was transcribed, coded and analysed.

Capital equipment manufacturers (as an industry) were chosen because their products satisfy all the characteristics highlighted by (Grubic & Jennions, 2018); they are capital intensive; they come from a very long and complex engineering; they usually have a very long life cycle; they require a considerable effort to maintain; in case of breakdown, they give rise to severe consequences for the customer.

3.2 Presentation of the cases

All the chosen firms are located in the Veneto region. They are not homogenous as regards turnover and headcount. Their heterogeneity was a choice made in order to confront the dynamics of digital innovation, to see which impact have the dimensions of the firm in making strategic and organizational choices. In addition to that, there was also the intention of exploring opportunities and challenges of digital servitization with regards to small and medium enterprises.

All the firms are inside the global market and have to face global competitors.

In particular, Alpha and Gamma are two family businesses, now facing a generational change.

In table 3.1 are collected the main data about the three firms.

Company	Headcount in 2017	Turnover in 2017 (in thousands €)	Installed Base	Role of the Interviewee	Duration of the Interview
Alpha	29	8.692.651	300 ca.	General Manager	70 minutes
Beta	84	20.286.246	600 ca.	Product Development Manager	60 minutes
Gamma	652	202.658.562	700 ca.	Innovation Manager	70 minutes

Table 3.1 Characteristics of analysed companies

[9] AIDA ("Analisi Informatizzata Delle Aziende Italiane") is a digital database with financial and accounting data of more than 700.000 Italian capital firms, elaborated by the society Bureau Van Dijk.

All the companies have a strong awareness of the importance of new technologies and of the impact that they will have on their business, and they are trying, with caution, to enlarge their offering with advanced services. In doing so they all have a lasting experience of collaboration with universities and other centres of research and innovation.

3.2.1 Company Alpha

Company Alpha is a small enterprise, specialized in providing tailored solutions in grinding equipment to a large variety of sectors, in aerospace, automotive, marine, railways, earth moving, energy, oil & gas and capital goods. Particularly important is the automotive sector, especially the off-road, responsible for one third of its revenues.

In spite of its dimensions, it is a global company, with customers all around the world, also because many of them are big multinational companies; some of its main markets outside of Europe include America and Turkey.

The competitive advantage of the firm is based on building tailored solutions, with a very rapid response, in having direct responsibility on each stage of production process, so that delivery times are short and the assistance is rapid and efficient. Constant innovation is also an important characteristic that they tend to emphasize.

The person interviewed was the general manager of the firm. According to her, the strategy of the firm consists in a Blue Ocean strategy[10], in which they are searching for and maintaining a specific niche in the market. For this reason, they claim to not have direct competitors, but just some firms with which they tend to make comparisons; these firms tend to be or large multinationals or other small enterprises like them.

The firm is a family business. They are currently engaged in an important generational change. This generational change marks also a change in the strategy and business model of the firm. Actually, during the previous generation, services were given for free, whilst now, apart from enlarging the range of services, there is also the will to value them and make the customers pay for them.

The academic and working experience of the general manager have helped a lot in making this generational change possible. After a degree in management engineering, she spent three years in an important IT firm, where she could deep her knowledge about the culture of service, in particular as regards SLAs. Then she moved to the family business. Recently, she directed the renovation of the internal information system.

[10] Blue ocean strategy generally refers to the creation by a company of a new, uncontested market space that makes competitors irrelevant and that creates new consumer value often while decreasing costs. It was introduced by W. Chan Kim and Renée Mauborgne in their best-selling book of the same name (Kim & Mauborgne, 2014)

As anticipated, the firm has always been very keen to innovation, most of the times anticipating what would have then become the trends of the sector. For example, they had already introduced the Ethernet hub and the collection of data in cloud already 7-8 years ago. This usage of the data has been fundamental in the growth of the company, since, according to the ownership, it permitted to enter the global market. According to the general manager, the application of what now in known as Industry 4.0 is not something new, it exists from at least twenty years. Nowadays the real challenge is to build centralised systems with intelligible analytics and alarms.

As regards human resources, in the last ten years the firm has doubled the workforce. Nowadays, a problem that they have about workforce is that they are not able to find certain competences, especially regarding the integration of information systems and numeric control. At a conference on the technical high schools of the area, they said that what they need are not persons able to do app coding, but the type of coding involved in production and making.

From the technological point of view, one of their main challenges is the deployment of Virtual Reality (VR). VR would permit to them to reduce the costs of a centralised management of services, but its implementation is very difficult, since would require to double the work of the technical office, now composed by seven people. The difficulty of the implementation of VR is related to what has been in the past their competitive advantage, namely the fact of having short delivery time. In order to achieve this, the phase of design of the equipment had been simplified, leaving the less important particulars (like screws) to fiduciary installers, who actually are both assemblers and installers. This way of designing the equipment permitted to enhance delivery time, but with the problem of dependence on installers and a reduction of full control on the final equipment.

Up to now, the usage of Virtual Reality is related to watch the equipment before its assembling, but they do not possess a digital twin, they are not able to make simulations about numerical control or the production of final pieces. Since they considered strategic to have a digital twins on which make simulations, they asked to a consulting firm to make those models and simulations for them. Unfortunately the consulting firm couldn’t satisfy their requests, since they were not able to provide sufficient data to build a digital twin of the equipment enough accurate to make simulations and predictions (especially about the different weights involved in production).

From the point of view of IT, their biggest trouble is related to the middleware, on how to integrate and dialogue different systems and programming languages. Recently, to make this task easier, they turned into a their own, customized proprietary ERP.

It becomes very difficult for their customers to deal with the middleware, and so also for them. They made an example of one of their clients that had to revamp their equipment, and one of the main challenges was to harmonise their software, the ERP of their customers and also the software of the robot involved in the process (already owned by the customer).

From the point of view of software and components, the firm decided to rely on an important German multinational. They considered also the possibility of doing middleware management in house, but that would have meant to distance too much them from the core business.

Interestingly, the general managers asserted that their sector (of machine tool) is no more characterised by disruptive innovation related to the production process per se (the general principles of mechanics applied are still the same from fifty years); innovation comes from new sensors and from increased speed of production (so it is more an incremental type of innovation). Sensors, especially, have an extremely high degree of innovation, the general manager told that a new sensor is available in the market almost every month.

Sensors are important not just for remote monitoring and control, but especially for production. Actually, they permit to provide closed-loop processes, so that the equipment is able to refine its processing once it has been initiated using appropriate feedback information. Actually, the precision required by their customers is ca. of 2-3 microns, and that precision is attainable only through electronics. This is why sensors constitute a so big share of the final price of the capital equipment (about 15%); not only for their cost per se, but also for the cost of their installation.

Another challenge that they are facing now is related to valuation of the service for the customer. As a matter of fact, once they used to present to the customers a price list; nowadays, instead, all the products are tailored. In particular, has changed a lot the job in the sales function, since nowadays is extremely important also the period following the sale, not just the moment of the sale.

At the moment, the firm is using a network of agents and dealers. As for the agents, they usually have the problem that they do not have an appropriate preparation, and they always need to contact the firm; if Alpha has the necessity to enlarge the network of agents, now it always requires that new agents possess a technical background.

Another problem that has company Alpha is related to the customers. As a matter of fact, they not always know really about new technologies, especially if they are small enterprises less accustomed to innovation; sometimes they have been asked for an equipment “with the 4.0”, just for fiscal reasons. Indeed, the “Industria 4.0” plan by the former economic development minister Calenda has been a huge driver for their business.

Their main concern, anyway, is that their customers do not understand the value of their services, since they give more value to their privacy. Actually, Alpha is already able to offer to their customers a service of preventive maintenance able to guarantee level zero of downtime; they are able to analyse the data coming from the equipment forecasting a certain problem, sending then an alert, even with, attached, the preventive check for maintenance. In order to enjoy this service, though, the customer needs to keep the equipment connected to the internet all the time, and none of the customer is willing to do so. They prefer to keep the machine disconnected, and connect it to the internet just for maintenance, once the problem has shown.

They believe the data coming from the equipment may be stolen and that their competitors may know their industrial secrets, most of the times they are not even interested in knowing the costs of the zero-downtime service.

In addition to privacy concerns they believe there is also a problem of opportunistic behaviour from the workforce of the customers. Actually, it is very likely that company Alpha, with the information that can gather (most of the equipment has even videocameras) can understand which workers has made a mistake in doing their job and refer it to its foreman. The underlings then have an incentive to keep the equipment disconnected and connect it only if a problem arise.

Company Alpha was anyway able to renovate its installed base through the selling of a black box, a hub that permits to collect all the information coming from the machine and to exchange it through the internet. This was also used for permitting to their customer to enjoy of the fiscal incentive coming from the Calenda Plan.

The main themes emerged from the case of company Gamma are schematised in Table 3.2.

Competitive advantage of the company	• The offering of tailored solutions • Short delivery time • Continual innovation • Relation with the client
Reasons for the adoption of Remote Monitoring Technologies	• Entering the global market • Monitor and increase efficiency of the equipment • Centralise the management of services
Main technologies adopted (in relation to Industry 4.0)	• Simulation (for reducing product development time) • Big Data and Analytics (for machine optimization in use)
Workforce	Difficulty to find competences in relation to integration of systems and numerical control
Devoted team	Absent, reduced dimensions of the firm make it unnecessary
Collaboration with external entities	With consulting firms, for exploiting simulation

	expertise With a German multinational for software components
Sale force	Network of agents and dealers. The firm aims at finding personnel with adequate technical background
Customers	They are not very informed or interested about new digital technologies They don't want to keep the equipment connected to the internet because they value more the privacy of their data than the services that Alpha could offer to them
Installed Base	The company implemented a black box that permits to digitalise old analogic equipment

Table 3.2 Main themes emerged from the case of company Alpha

3.2.2 Company Beta

Company Beta is a medium enterprise, specialised in the production of gable-top filler machines. The person interviewed was a product development manager, with the objective of managing the innovation of the product based on new digital technologies.

More precisely, the main product of the firm is producing machines capable to shape pieces of pre-formed paper (called "blanks"), to sterilize them (when necessary), to fill them and, eventually, to put the cap. The gable-top so produced are mainly destined to dairy products industry, but are also destined (outside of Italy) to soups, yoghurts and even dry food (mainly spices).

The main customers of Beta belong to the dairy products industry; these enterprise do not work only on milk and cheese, but also on fruit juice (since the necessary equipment is usually the same). Then Beta is also involved in niches, like that of liquid eggs; in particular, egg-white processing is developing, because of its abundant vitamins and proteins. Other niches involve non-cow's milk, like soy milk, coconut milk and so on. Ninety per cent of the customers of Beta produces for the cold chain of distribution, in supermarkets.

From a geographic point of view, the main markets are Europe and the former Soviet Union. Then North and South Africa, and, recently, also in the Far East.

As a commercial strategy, Beta tries always to use direct sales, but, given the limited size of the firm, it is not possible for them to be present everywhere in the world. To solve this issue, they refer to distributors, to agents and also to signallers, that is firms that are not subjected to formal agreements with Beta, and informally signal to other firms the products of Beta.

Another very important category of Beta's customers is that of the so-called "carton-suppliers". These firms are mostly system-suppliers, so they provide an entire system from

the factory to the packaging, and in that case they buy the equipment from Beta in order to manufacture these systems.

One interesting fact is that those carton-suppliers - apart from being the main customers of Beta - are also its main competitors. This happens because these carton-suppliers produce their own equipment or they buy it also from Beta's competitors (when they need it more customized).

The competitive advantage of Beta comes from its reduced dimensions, and from the consequent flexibility in meeting customers' needs with personalized solutions; Beta, according to its management, is able to satisfy a lot of requests, producing equipment able to do a large variety of tasks. Another point of difference with respect to its competitors is also the high speed of delivery.

Beta considers itself a solution provider, and considers this the main part of its value proposition. Its customers have the possibility of explaining a certain problem and expecting that Beta will find a solution for them; so, they do not simply work on order, most of the times the customer does not know exactly what it needs. This is also another point of difference with big carton suppliers, which can offer a closed (even if large) list of options and personalisation.

From the technological point of view, the main innovation that they have recently introduced was related to a remote assistance service obtained through the usage of augmented reality.

At first the idea was to use 3D eyeglasses, but it was technologically unfeasible for the customers, because most of their factories are in fact Faraday cages, so there is almost no field inside of them, if the customer decide to not install a Wi-Fi. It is then extremely difficult, for a worker, to use 3D eyeglasses for remote assistance. The solution provided by Beta uses instead smartphones, or tablet. This way, it is not necessary to be always connected to the internet, and so the customer can use engage in this service without the need to install in the workshop Wi-FI or other equivalent technologies. The service works in the following way: the worker can take a picture of the area of the equipment where the problem has arisen, and then send it to Beta's helpdesk, where the assistant can attach objects and information on the photo sent to Beta. This picture, anyway, is of a dynamic type, so that, once the worker has come back to the workshop, where there is no field, the tablet (or smartphone) is automatically capable of providing the information and attachments made by the assistant once the worker has framed again the equipment with the tablet's camera.

This technology was not developed in-house, but by an external IT consulting firm, from Israel.

Another project on which Beta is currently working to reinforce the after-sale is a platform able to collect data from the machines and provide measurements and specific KPI -, related to performance, equipment, efficiency and specific problems - to the customers. This part, more related to Big Data and analytics, has been developed internally as regards the back-end part, whilst the front-end was designed by an external consulting firm.

Maintenance is provided following an advanced contractual scheme of the type "bonus-malus", that is: if the efficiency of the equipment is higher than previously agreed, the customer will pay more, if instead it is lower than previously agreed, the customer will pay less.

Beta is also working on preventive maintenance, starting from a service of condition-based maintenance and diagnostic. Since the equipment is made from thousands of pieces, a great part of the job now is to decide which pieces to monitor, since it is very costly and difficult from a technological point of view to install sensors to control every components.

Other technologies are used less frequently. For example, 3D printing is used just for prototypes or to accelerating the testing phase.

Another field involved in the innovation process of Beta is relative to simulation. To develop this technology they are also collaborating with the department of engineering of the University of Padova. The type of simulation that are mostly doing now is related to Finite Elements Method (FEM-Simulation); so, for example, they are able to test if the machine is able to support the weight, of itself and also of the raw materials and final products. Other simulations regard thermo- and fluid-dynamics. The most advanced simulations are done by an external firm, but they are trying to bring these competences in house.

All these projects are being done with a very clear strategy in mind: to be competitive with regards to the carton-suppliers, that are multinational companies. These companies can be present all around the world, whilst Beta can't do that for its small dimensions. The technologies related to remote maintenance, that is augmented reality and big data and analytics, were chosen to be implemented for this reason.

Simulation instead had the role of accelerating product development. As a matter of fact, the most difficult process in product development is product validation, since everything needs to be tested, physically or (more conveniently) virtually. For example, because of hygienic reasons, air fluxes inside the equipment have to respect certain characteristics, and fluid-dynamic simulations permit to check these fluxes before materially constructing the equipment.

Beta, from the point of view of the customers, finds very little interest in the application of remote controlling technologies and the services that come after them. It is very rare that the

customers asks spontaneously for these type of technologies and services. According to the interviewed product innovation manager, there is still little interest on these themes in the industry. After exposing the services and the benefits that they can give, though, most of their customers show to be interested, and accept to enjoy these services, especially the new service on remote maintenance through augmented reality.

As regards the people involved in the implementation process, Beta has prepared a special team made by two persons. One of them was an internal resource of Beta, whilst the other was a research fellow paid by the Veneto region, who worked one year on predictive maintenance. As regards the part on IoT, the automation team was involved, but its members were not devoted full time to the project.

Beta is also involved in the project "*Reti Innovative Regionali*" of the Veneto region. Beta contributed to found one of these networks, playing an active role in it. These networks permit to Beta to interact with different firms of different sectors and positions in the value chain, permitting to freely exchange information without the fear of losing their competitive advantage, in addition to the enjoyment of specific financing from the region.

The major challenges that Beta is now tackling are related to the workforce, to the customers and to bureaucratic requisites.

As for the workforce, they have a lot of difficulties in finding the right competences. None of the people currently working in the devoted innovation team has remained there for more than one year.

As for the customers, the problem is that they are not interested to these new technologies and to the related services; and even after having being told of the benefits, most of them still are very worried about the protection of their privacy, especially as regards the new services based on big data analytics.

Beta is currently devoting a great effort in forming the sales function, for making the customer understand the value of their services. For example, when there is an important fair, they make comparisons between the situation in which the equipment is not monitored through their services and the situation in which it is not.

Another challenging topic was related to the requirements needed for the access to projects like "*Reti Innovative Regionali*". Bureaucracy made Beta lose a lot of time in preparation. Also, it was fundamental to use the right words to present the projects: some years ago Beta asks for financing another project related to Industry 4.0, but, since the topic was not so publicised as nowadays, the financing was rejected.

The main themes emerged from the case of company Beta are schematised in Table 3.3.

Competitive advantage of the company	• Offering of tailored solutions • Ample flexibility in output capacities and configurations • Short delivery time
Reasons for the adoption of Remote Monitoring Technologies	For being able to compete globally with multi-national carton-supplier
Technologies adopted (in relation to Industry 4.0)	• Augmented reality (for remote assistance) • Big Data (for the new analytics platform) • 3D printers (for product development) • Simulation
Workforce	Struggle to find the right competences and profile High turnover of roles related to new digital technologies
Devoted team	Two persons full time, one internal and the other a research fellow from the university of Padova
Collaboration with external entities	Participation in "*Reti innovative d'impresa*" for exchange of best practices with the University of Padova for research and innovation with Israeli consulting firm for the development of the remote assistance software through augmented reality
Sale force	Preferably internal, but because of the reduced dimensions of the firms it also employ a network of agents, dealers and signallers
Customers	• Their main customers (the carton-suppliers) are also their main competitors • In general, not interested to new digital technologies • Too worried to lose their privacy
Installed Base	Beta offers the possibility of revamping of old equipment, in order to install remote monitoring technologies on it

Table 3.3 Main themes emerged from the case of company Beta

3.2.3 Company Gamma

Gamma is a big enterprise, global leader in the production of stone processing plants.

More specifically, it is structured in three divisions: natural stone processing machines, compound stone processing plants and machine tools.

Historically, Gamma has begun its activity working with machines processing natural stone, so equipment able to work on stone directly coming from the quarry. Then it has diversified into machines and plants processing compound stone (or technological stone as is sometimes called); these are huge plants that are actually making artificial stone from sand, with particular additives and other raw materials. Finally, because of technological commonalities, Gamma expanded in the machine tools sector. Nowadays the greatest part of the turnover

comes from the compound division, then from the natural stone division and finally from the machine tools division.

The person interviewed was the head of the Industry 4.0 applications in the compound stone division, now he is in charge to extend the novelties of Industry 4.0 also to the other divisions of the firm. More specifically, he is in charge of deciding how these new technologies can bring value to the customers of Gamma, enhancing their satisfaction.

Before the establishment of those teams now devoted to the implementation of the technologies of Industry 4.0, Gamma has achieved an important project related to Business Intelligence. In this project, through a process of datamining, the data coming from the ERP and the Manufacturing Execution System (MES) of the customers were analysed in order to present them in real time on a dashboard and, through time-series analysis, also doing business intelligence activities. This software is customizable by the customer, easing for him the extraction of information. In addition to this, it permits also to extract the data through an Excel sheet.

Gamma is now in a very important phase of innovation, with its Industrial Plan 2018-2020 having smart products and smart services as cornerstones. More specifically, Gamma is analysing the deployment of I4.0 technologies with two main objectives: firstly reducing the lead time, since these technologies permit to reduce bottlenecks in the process (especially in the compound division); secondly, to improve the quality of the final product, thanks to the traceability of the product and of the batches (tried without the usage of RFID, since they cost a lot, and 1/300 is usually damaged).

The main aim, anyway, is to build a solid and lasting relationship with the customer, a relationship in which Gamma could offer its own personnel for the assistance and the customer pay for the increased productivity.

This strict and personal relationship is still deemed very important to retain, even if a lot of services would be supplied remotely. One of the main reasons is due to the fact that it is very costly to put sensors able to collect data on every aspect of the equipment; so the choice of which parts to monitor is fundamental. But even if collecting data was cheap, it is not possible to predict all the possible variables involved in the production process. In relation to this, the example made by the innovation manager was enlightening.

Gamma has a very important customer in Portugal, where they have a plant processing compound stone. These plants are very big, they are long from one to two kilometres in their overall length. In Gamma they have been then the first type of plant to be innovated trough sensors and remote collection of data. The plant in Portugal, once, had a problem. On certain days, the stone was not of good quality. The helpdesk and assistance in Gamma tried to look

at the sensors and the data provided by the plant, but they couldn't find anything of wrong. It was necessary, then, to go physically in Portugal to check the plant. The plant was checked, and again nothing of problematic was found. It was just by chance that the manager, touching the sand that constitutes the main raw material of the plant, noted that it was too hot; and that turned out to be the real cause of the problem. As it was later discovered, in that place of Portugal, on certain days there is the market in the villages around the plant, so the trucks transporting sand were forced to follow a route that was more sunny that the habitual one, and that heated the sand, giving in the end bad quality stone as a result. In hindsight it was easy to put another sensor with the objective of measuring the temperature of the sand in entrance, but in advance no one could expect the importance of a similar variable.

A strict relationship with customers is also very desired by the customers themselves. Gamma has received requests to send its own personnel even for 1, 2 or 4 years

The building of this type of relationship will require a radically new approach by the people in the sales function, since they need not to focus only on the preliminary phases, until the sign of the contract, but also to the post-sales phases, in order to cultivate Gamma-customers relations. The enterprise policy, in this sense, is to internalize as much as possible the sales function, in order to have a deeper control on sales and customers' relations.

When the innovation manager began its actual job in Gamma, the analysis of data in Gamma was just limited to SQL, collection in databases and data structuring. After the positive application of I4.0 technologies to the production functions, then their application was extended also to enhance customer relationship, starting from the compound stone division and now expanding to all the others. When the manager was given the task of innovating the machine tool division, he discovered that they were not collecting data deemed important.

An important point, often stressed by the manager, is the fact that collecting data from the equipment is difficult not just from a purely technological point of view, but also in deciding how much sensors put on it, which data collect with the actual knowledge of the variables that have an influence on the production phase, in which process or process phase collect the data. Putting sensors and collecting data is actually very costly, for the costs of the sensors per se, but also for the connections, that need to be done in a certain way, with a high labour cost. In addition to this, Gamma is most of the times not able to find the right sensors in the market; for this reasons is now preparing a project through which it will be able to produce its own sensors, or at least to provide the right specifications to its suppliers.

Another challenge is constituted by the fact that the equipment produced by Gamma is most of the times one-off, every piece of equipment has its own design and production, so it is difficult to harness the knowledge coming from previous products and experiences.

Gamma has also introduced retrofitting services in some old plants. This is considered another opportunity by Gamma, but it represents also a challenge because the retrofitted equipment needs different people with different competences than the new equipment, that has these technologies already incorporated.

Gamma has recently introduced a black box that permits to collect data and give some basilar information. Unfortunately, Gamma claims to not have enough experience in making these boxes interesting for their customers. These boxes provide two main indicators: the OEE (Overall Equipment Effectiveness) and the TEEP (Total Effective Equipment Performance). These indicators are becoming more and more important, since in certain markets it is possible to sell the compound stone plants only if they have a certain guaranteed level of OEE (the manager said that in France for example they require an OEE of 65%). These required indicators give rise to various problems. In the case of machine tools, for example, Gamma has strong collaborations with certain suppliers of tools. When Gamma does experimentations and predictions on OEE, it uses the tools offered by its partners, and suggests to its customers to use those specific tools. However, the transparency given by Big Data may reveal to the customers that the tools suggested by Gamma are not the best in the market, and may then change them with others coming from suppliers that are not partners of Gamma. This for Gamma is a big problem, since it is no more able to make good predictions on the effectiveness of the equipment and because it conflicts with the business of tools and spare parts. For this reasons Gamma is cautious in implementing analysis of data that would give rise to full transparency.

Another important innovation that Gamma is introducing is prediction based on machine learning technologies; the division in which this innovation has being applied is the one of the compound stone processing plants. Predictive analytics are being applied following three main objectives. First, it is being applied to the process, so that it is able of doing “self-control” on its activity. Secondly, a change in perspective; up to know, it was possible to regulate the plant, in consideration of certain trade-offs, so that its defected production would be of a certain percentage; now Gamma wants to produce an equipment that is able to self-regulate in order to achieve a 0% level of defects in the product. Thirdly, in alarms management; in a compound stone plant there are thousands of different alarms, so even understanding which is the right alarm may be complicated.

In this processes of innovation, Gamma has followed different routes to acquire the right competences. First of all, through internal training on the existent workforce. Secondly, through external partners, like data scientists and firmware specialists; apart from harnessing competences that Gamma does not have, collaboration with external partners is important

especially for not doing time-consuming activities. At last, through targeted recruitments; the innovation engineer on this topic said that the main problem that they usually find in recent graduates is that they are not very willing to do things that deviates from their route of studies, even if they would be formed for; on contrast, they find more mental openness in persons that have studied certain subjects on their own. The general policy of Gamma, anyway, is to internalize as much as possible the competences it needs.

The team in charge of introducing and developing I4.0 technologies is made of six persons, three newly hired resources and three external ones; depending on the needs, also other external resources are sometimes contacted.

Gamma also collaborates with other firms in different industries in order to exchange information without eroding their competitive advantage.

The main themes emerged from the case of company Gamma are schematised in Table 3.4.

Competitive advantage of the company	• High quality level (proved by multiple quality certifications) • Research and innovation • Relation with the client
Reasons for the adoption of Remote Monitoring Technologies	For building a strong and lasting relationship with the client. More specifically: - for reducing the lead time - to improve the quality of the final product
Technologies adopted (in relation to Industry 4.0)	• Big Data and Analytics • IIoT and Remote Monitoring Technologies
Workforce	Difficulty in finding the right competences and, in case of recent graduates, enough mental flexibility
Devoted team	Seven persons, of which three newly hired graduates and three external consultant
Collaboration with external entities	Consulting firms for business intelligence activities
Sale force	Under a process of internalization and training
Customers	Even though Gamma tries to provide remotely its services, a physical contact with the customers is still deemed important
Installed Base	Gamma developed a black box for retrofitting. Management of old equipment is problematic since it needs a dedicated workforce

Table 3.4 Main themes emerged from the case of company Gamma

3.3 Discussion

All the three firms believe that their competitive advantage relies on the possibility of giving tailored equipment that constitutes the solution of a specific problem of the customer, and, especially in the companies Alpha and Beta, in doing so in a short time; Alpha and Beta in particular consider their reduced dimensions essential to achieve this goal. Firms of reduced dimensions have less the possibility of proposing complete pack solutions able to fulfil an operational need of the customer; it is possible to see this especially in the opposition between Beta and its carton-supplier competitors. They are also less able to achieve economies of scale, compared to larger firms, like Gamma, in this analysis. These findings agree with the theoretical model by (Moen, 1999), through which SMEs, in order to compete and export globally should focus on product uniqueness and technologically sophisticated niche products, since they have limited resources for building a distribution system of their own and leverage bargaining power on their distributors.

Their business environment is very competitive, global (Beta for example makes 90% of its revenues from outside of Italy) and under great processes of innovation, especially regarding the manufacturer-customer relationship.

Following the strategic framework of (Allmendinger & Lombreglia, 2005), all the firms have decided to focus on the life cycle of their product, without considering very much possible adjacencies; so they can all be classified as solutionists, and actually they all describe themselves as solution providers in their websites.

Following the typology of (Kowalkowski, et al., 2015) they can be classified as availability provider, since they tend to offer services along the whole life cycle of the product, with the aim of making them a differentiating factor from the competitors.

A challenge that all the firm are now tackling is relative to the mistrust of the customers in engaging in advanced services, in which they should exchange data with the firm. They believe their data will not be safe, and so they prefer to keep them private and exchange them the least possible; in all the analysed cases are the manufacturers who have the initiative for proposing new services, they are never asked for them by their customers.

From this point of view we can see a situation that is the exact opposite of the “service obligation” highlighted by (Copani, 2014), in which machine tool providers have a passive attitude towards service innovation and they move to develop a new service offering just because they are asked by their customers.

This challenge was also recognised by some explorative analysis, like in (Klein, et al., 2018); the firms interviewed used a series of instruments to ameliorate this, from third-party certifications of security protocols to legal assurances that data belong to the customer, is kept confidential with non-disclosure agreements and is never shared with third parties.

Other studies, like (Grubic & Peppard, 2016), highlight the fact that the customers are worried about the fact of not fully understand the ways in which the manufacturer can detect the errors, seeing smart services "as a black art", and that they have excessive expectations on the real capabilities offered by smart services.

This seems not be the case of the company interviewed in this study, their customers are usually not very interested in remote controlling technologies, or too worried about privacy, since they instinctively value more their privacy than the full effectiveness of their equipment. (Klein, et al., 2018) seems to suggest that the key feature that permit to the customer to feel that their data are in good hands is the building of a long and trusted relationship with the customer, and the creation of an enterprise branding focused on trust and reliability, in which the manufacturer appear as a strategic partner.

As suggested by the manager of company Alpha, the problem of keeping the machines always connected may be the presence of an opportunistic behaviour in the underlings of the customers. Actually, the manufacturer, analysing the data, could permit to the foreman in the customer to understand which among its underlings has made an error, and to punish him. The underlings then have an incentive to keep the machine as much dis-connected as possible. If this really is part of the problem, it may be delicate for the manufacturer to suggest the connection of the machine to the internet. There may be the necessity to introduce incentives for the workers of the customer to always keep the machine connected to the internet, through new special contractual agreements.

Another difficulty that they are facing is the necessity of valuing these new services, without giving them for free as it was common practice until some years ago; this is particularly considered in company Alpha, because of its small dimensions and for its very high level of tailoring complex solutions. It is not possible to make a price list, as it was in the past, nowadays each contract have to be valued separately.

The difficulty of pricing services in servitized firms was also highlighted by (Lerch & Gotsch, 2014) which remark the importance of avoiding the "Overhead Cost Trap", i.e. the fact that costs for service delivery are invoiced not directly but indirectly by the product price, which leads to an overpriced product on the one hand and inferior service delivery on the other. The authors suggest that a firm should follow a life cycle analysis of costs and benefits, considering both the cost drivers of the customer (acquisition costs, operating and maintenance costs and disposal costs) and of the manufacturer (planning and development costs, construction and production costs, operating and maintenance costs, and disposal costs). These measures, though, are reductive, because, according to (Lerch & Gotsch, 2014) simple accounting of costs and benefits provides no explanation, for example, of the

productivity or the quality of the services and holds no possibility for service business accounting on a company level. Consequently, the service delivery process is still mainly "a black box", which hinders the management and accounting of service structures and processes.

The privacy concerns make out of discussion the possibility indicated by (Porter & Heppelmann, 2014) and (Opresnik & Taisch, 2015) of selling the data to third parties for obtaining a new revenue stream; value must be created internally.

In any case, all the firm believe that services will be what in the end would permit to differentiate them from their competitors, and so they are working to increase their share in the revenues, even though, at the moment, the bulk of the sales still comes from traditional selling of equipment.

(Vandermerwe & Rada, 1988) thirty years ago, forecasted that the new industry dynamics will lead to the formation of new types of competitors for manufacturers; for example, they would compete with their suppliers, with other industries completely different and also with their customers. Similarly, also (Porter & Heppelmann, 2014) stated that, because of smart connected products, industries will tend to offer more and more solutions, selling not just products, but systems of products.

In the last decades, carton-supplier firms have undertaken a profound change in their offering and business model. Now they are not simply selling carton packages, but complete solutions, providing the blanks and the equipment to work on them to produce carton packages. This fact was challenging for companies like Beta, since on the one hand it opened new possibilities for them, having new potential customers, but on the other hand it makes contracting more difficult, since these new customers have a far greater contractual power and less switching costs, since they have a global network of suppliers, and Beta is just one of them.

In order to continue to have these important customers without being overwhelmed by them, Beta had also grown globally, as much as it was permitted by its small dimensions. This, in the case of Beta, is the main rationale behind the usage of new digital technologies. In addition to this, Beta has reacted focusing its value proposition on customization and speedy in the delivery time. This is in their opinion the only ways through which they can compete with those multinationals.

Another theme that emerged from the interviews is the necessity of being as closed as possible to the customers; actually, all the firms are trying to internalize as much as possible the sales workforce and network, in order to have a deeper control on customer relationship

management. This trend can be seen as similar to the "moving downstream" imperative (Wise & Baumgartner, 1999), in which the firms must move as closed as possible to the customers in order to give to them advanced services through the long life cycle of the equipment.

(Baines & Lightfoot, 2013) suggests that this movement to downstream should lead also to a diffusion of operations facilities and front offices around the world, bringing the example of Rolls Royce, that, after the implementation of its power-by-the-hour contracts, expanded its facilities from the one in the UK also to USA, Hong Kong and Singapore, all locations closed to one of their important customers. That marked a difference with the so called "second wave of IT" (Porter & Heppelmann, 2014) , in which such big multinationals had instead the incentive to concentrate and delocalize.

The enterprises interviewed in this study have not such dimensions so that they will follow a route of expansion like that followed by Rolls Royce. On the contrary, especially for SMEs, new digital technologies seems an opportunity to centralize and better control the relationship with the customers, relying less on an external network of agents or dealers. In the case of Gamma, assistance and technical support were also strongly requested by their customers, with personnel directly depending from Gamma; Gamma, in that case, is sufficiently big to satisfy these requests.

In the case of Alpha, internalization involved also a stricter control on the design phase, that was in the past partially reserved to the installers, for reducing the delivery time. The centralization process of Alpha is also making the Italian personnel to travel a lot around the world, far more than before.

A challenge particularly important for all the interviewed firms is the necessity of establishing a service culture in the organization, in particular in the salesforce. For the sale force this is a particular moment of great change; once the sale force was directed mostly to sell products, with a great attention on the pre-sale phase, and a decrease in efforts after the sale was done. Now, instead, the crucial part comes after the sale, so the sale force has to retain and reinforce the relationship with the customers, offering new services and tailoring them on the necessities of the customer, whence the importance of a basic technical preparation of sales people. This explains also another challenge highlighted by the interviewed firms, that is the lack of enough technical skills, especially in the case in which they were using external networks of agents; only with these technical skills, actually, the agent can understand autonomously the needs of the customers and providing the correct insights to the management of the company.

Not only the sales function and networks are changing as regards their organization and competences, but the overall firm organization is under great processes of reform.

According to (Porter & Heppelmann, 2015), smart connected products introduce a tendency in organization towards a greater integration among the functions, in order to coordinate more properly all the phases of the life cycle of a product and to react more easily to the needs and problems of the customers.

In SMEs this integration is guaranteed by small dimensions, that make interactions between people of different functions more simple. In larger organization, like the one in Gamma, this is not possible. For this reason, Gamma adopted a reformed organization based on processes and on the Japanese concept of *obeya*, which permits to group the persons belonging to different functions -but working for a certain category of product- in a single place (*obeya* in Japanese actually means "big room"). An *obeya* is not a synonym of division, since it regards more spatial and physical organization, with less attention on power relationships and hierarchy. For example, Gamma possesses an *obeya* devoted to supply chain, that is transversal to all the three divisions of the enterprise.

(Porter & Heppelmann, 2015) suggests that a firm, in order to build the right competences in innovation and data management, should build a specific group in the organization, headed by a Chief Data Officer. In addition to this, (Porter & Heppelmann, 2015) suggest that other groups should be established, focused on product innovation and service provision, especially in the after-sale; it is called by the authors "dev-ops unit", because it should include persons from product-development (the "dev") and from the operations (the "ops").

Among the three firms, Beta and Gamma both decided to introduce focused groups for the implementation of these new technologies; Alpha did not need it because of its reduced dimensions.

Beta decided to establish a small group of two people totally devoted to this, and other people internal to the firm, involved just when necessary. Of the two persons one was a researcher of the university of Padova, paid with financing from the Veneto Region. Even though it does not fully respect the definition given by (Porter & Heppelmann, 2015), for its focus on product development can be considered similar to a dev-ops unit.

Gamma decided to have a group of seven people devoted to this, of which three were specifically hired for this reason and three are external consultants (the seventh person is the interviewed manager). This focused group by Gamma is very similar to a "unified data organization", and the interviewed manager, among the persons interviewed, can be considered the closest to the role of a Chief Data Officer, even though his unit is still in a experimental phase.

None of the firms has decided to introduce a separate sales force for the provision of services. This seems to contradict the findings by (Oliva & Kallenberg, 2003), according to which the

service organization should have also to be equipped with a separate sale force. The interviewed enterprises found more compelling to train the overall sale force, instead of building a new, separate one. This was especially true for the smaller firms, because of their reduced dimensions.

According to (Ardolino, et al., 2017) the principal technologies involved in service transformation are Cloud Computing, Industrial Internet of Things and Big Data Analytics (predictive analytics, in particular).

All the company believe in the fundamental role of innovation and also research (in particular, Gamma has even an its own centre of base research) and they have introduced new digital technologies in order to reinforce what they believe has been their competitive advantage and positioning. All the firms have introduced IIoT technologies, in order to sell smart products and using remote monitoring technologies in order to provide them with services. Also Big Data and analytics have a big role in permitting these firms to provide these advanced services and at the same time centralise and internalise the management of the services.

Another technology very important was simulation, especially for firms like Alpha or Beta that base their competitive advantage on fast delivery time.

Other technologies used were 3D printers (by Beta for prototyping), augmented reality (by Beta for its service of remote maintenance) and cybersecurity (by all the firms).

A question highlighted by all the firms is the cost of gathering data, due to the cost of the sensors, their installation and connection. So the difficulty of choosing the right data to collect and the right parts of the equipment to control.

All the firms have opted for a closed system, not permitting to the customers to assemble autonomously the parts of the solutions from different companies. Having an open system would have meant also to standardise more, and so to have less possibilities of customization (and that would have been a damage for Alpha and Beta). There are though different levels depending on the size of the firm. Gamma, the biggest, had the possibility to develop full solutions, developing internally also the software components and of interface with the ERP of the customers. Alpha, instead, in relation to the system interface aspect, has decided not to do it internally, because it would have not permitted to focus on their core business. So, at the moment, for facilitating the interface with the ERP of the customers, it is basing its software components on the solutions offered by a German multinational firm; from this point of view, Alpha believes it's a problem the lack of IT systems integrators in their customers.

As regards the choice of what to put in cloud or out of the cloud, the choice is made in relation to the willing of the firms to internalize, centralize and control the services given to their customers.

The offering of services per se is no more a source of competitive advantage in the manufacturing sector. As famously put by (Levitt, 1972), everybody is nowadays in the service business. For making services a truly source of differentiation of differentiation, a firm, according to (Mathieu, 2001) should focus on a more advanced type of services, defined by the author as "Services Supporting the Client" (SsSC), in opposition to the "Services Supporting the Product" (SsSP). SsSC are different, and related to more added value, from SsSP, for four orders of reasons. First, the direct recipient of the service is not the product, but the person, the client; secondly, SsSC are higly customized, whilst SsSP are standardised; thirdly, the intensity of relation is higher for SsSC, since more people are involved in the provider's organization and higher is the involvement between the parties. The last dimensions regards a service expanded marketing mix (Booms & Bitner, 1981), that adds to the classical four Ps also physical evidence, participants and process. SsSP are more related to physical evidence (e.g. materials and instruments for spare parts) and process (the process delivery should be flawless as regards standards, mechanisms and procedures; SsSC are instead related to people (including both the provider's and the customer's personnel).

(Mathieu, 2001) suggests that a firm should focus its service offering on customization, relationship management, and that SsSC should support the client in its R&D, production phase and commercial phase.

All the firms have decided to enlarge their service offering, trying to cover the overall life cycle of their products, according to (Allmendinger & Lombreglia, 2005), and this makes them classifiable as solutionists.

The adoption of technologies from Industry 4.0 is fostering the development of pre-sales services, especially in smaller firms like Alpha and Beta, where short delivery time and customization are the main source of their competitive advantage. In Alpha great is the attention on the pre-sale phase. Usually it starts directly from the workpiece (given by the customer), highlighting all the possible problems that may arise from working it and provide a solution to the customer; after the machine is designed with a continual collaboration with the client, tailoring it on his needs, both mechanically and electronically (for example, designing the right cycle time for the customers). Also in Gamma, due to the great complexity of the products they make, there is a continual relation with the client starting from the first contact through machine design and implementation. In Beta there is also this type of problem-solving attitude and idea of having a continual relation an exchange of feedbacks with the client, even though the products are more standardised, so the focus consists more on the possibility of offering a great gamut of these standards, including some niches. Services are

more focused on the pre-production phase, including installation, production start-up support and commissioning.

In delivering this result, for Alpha and Beta simulation has been an important technology to be adopted.

The main efforts, though, are now concentrated on the after sales services, and all the firms succeeded in implementing services of remote monitoring, diagnosis and assistance. This was particularly important in permitting them to expand worldwide without the need of a big service organization. Now their focus is mainly on predictive services, a quite challenging task that require the utilisation of external capabilities in order to be fully achieved, since no firm had the possibility to develop these competences, insofar.

The case of Beta demonstrates that a solution, as originally thought, may be even too advanced for certain situations, as demonstrates its remote-maintenance through the usage of augmented reality. The fact that most factories do not have field urged them to point on an app that could work (momentarily) without field, and the idea on the use of 3D glasses was then excluded.

The case of Beta was interesting also because it shows the importance of using the correct words for describing what they are doing, and the importance of bringing these phenomena in public discussion, to make the public aware of it. Actually, they tried a lot of times to receive financing for their research, but it was only thanks to the interest brought by Calenda and its plan of incentives that they were finally able to receive the regional research financing.

Firms have also to deal with the limits of remote controlling technologies, that, as also stated by (Grubic, 2014), can "*detect just what they can detect*". In this way the example made by the innovation manager in Gamma was particularly interesting, since it demonstrates the importance of maintaining a physical and personal relationship, that the new technologies can strongly reduce, but can't completely permit to avoid.

Insofar, none of the firms has begun the use of contracts in which the property of the plant remain of the provider, and revenues come only through regular fees.

There are though some interesting aspects. For example, in Gamma the fact that in certain markets it is obliged to guarantee a certain OEE in order to enter that market. Although this can be seen as a guarantee on the performance of the plant, this arrangements cannot be considered an outcome-based contract, for various reasons. First of all, it is not really a part of the value proposition of Gamma but more a pre-requisite that is needed in order to operate in those markets. Secondly, the non-respect of the guaranteed OEE does not reflect directly in a change in the maintenance-fees or equivalent payments, but in a legal claim by the customers.

Another interesting service is a type of maintenance offered by Beta, interesting because it permits to actually share the risk between the customer and the provider, with a direct reflection on the payments involved in the contract. Actually, maintenance is provided with a "bonus-malus" scheme, where the customer pays more if the efficiency is greater than previously agreed and less if it is lower than the previously agreed level of efficiency.

The need of acquiring new competences and capabilities has been another theme emerged from the analysis. (Mathieu, 2001) describes how can a firm acquire these capabilities through the so called collaboration continuum. The extremes of this continuum are internalizing and outsourcing; internalizing would be the one extreme of developing in house the necessary capabilities, whereas outsourcing would mean entrusting a partner to implement certain operations. Partnering is a solution in the middle of the continuum, in which the responsibilities are shared between the manufacturing firm and its partners.

The firms claim that schools and university lack in providing people with the right set of competences, and the newly graduates students are often not very flexible in adapting to the needs of the enterprise.

All the firms have, as a general objective, the will to have all the resources internal to the enterprise. Since they do not have all the required competences, though, they decided also to make use of external consultancy and collaborations. In particular, Alpha tried to collaborate with a IT consulting firm in order to make advanced simulations, without succeeding; Beta did that outsourcing for the remote maintenance service in which augmented reality was involved; Gamma established an equally participated new entity with an IT consulting firm in order to develop its black box that provides services of analytics (this choice was made in order to keep secret the technology involved in the plants).

New technologies are making more important the consideration of the so called value networks. In our analysis this was particularly evident in the case of Gamma. Gamma actually made use of multiple external collaborations and outsourcing, especially as regards its activities of business intelligence and machine learning. It also has strong collaborations, in the case of machine tools, with certain tools suppliers, with which exchange data and optimize its analytics (giving rise to the problems of excessive transparency previously highlighted).

All the firms understand the importance of revitalizing their installed base, so they all are offering "black box", machines that can be easily integrated with their plants, and that can permit to offer services of data collection, storage and analysis, also on time on a dashboard. These boxes were particularly interesting especially for Italian customers, because of the incentives coming from the Calenda Plan.

Alpha was able to sell 50 of these boxes, and Gamma 15 in its machine tools division.

Table 3.5 schematises the main themes coming from the literature and their views according to the cases.

SMEs need to be global, and for doing this need to focus on the level of technological innovation finding the appropriate market niche (Moen, 1999). At the same time, lower costs and technological innovation per se are no more durable strategies for a sustainable technological advantage (Wise & Baumgartner, 1999).	All the firms have a long history of continual innovation and pursue of high quality, proposing themselves as providers of tailored solutions, with short delivery time. Alpha and Beta focus more on the flexibility and velocity coming from their reduced dimensions and from the niches they occupy in the market. Gamma advantage focus more on the relationship with the client, economies of scale and the fact of serving different markets. All the firms agree on the fact that establishing a strong and durable relationship with the client will be fundamental in the future.
"Service obligation" of manufacturers (Copani, 2014) Customers are worried about privacy concerns (Klein, et al., 2018) Customers are worried about not understanding how manufacturers treat their data (Grubic & Peppard, 2016)	All the firms do not feel a "service obligation", on the contrary, they take the initiative of proposing to the customers new services and technologies, since in general customers are not interested in the technologies coming from Industry 4.0. For this reason, customers are not concerned about not understanding the way the manufacturers provide services through their data, but they are as regards the risk of losing secrecy of their data. For this reason very few customers keep their equipment always connected, even though all the firms can guarantee high levels of cyber-protection.
Firms may incur in the "Overhead Cost Trap" (Lerch & Gotsch, 2014) Pricing services is difficult for servitised firms, and pricing can't be simply based on comparing benefits and costs (Lerch & Gotsch, 2014) It is possible for a firm to extract value from the data gathered from its customers through selling them to third parties (Porter & Heppelmann, 2014) (Opresnik & Taisch, 2015)	The interviewed firms are not facing any "Overhead Cost Trap", since they are not trying to incorporate the value of services in the final price of the equipment, but to price them separately. They are all facing the challenge to correctly price services; for the smaller firms, this is even complicated by the fact that their products are more tailored on the specific needs of the customers, and so they can't do a price list. The possibility of extracting value from data selling them to third parties is out of discussion, for the above mentioned privacy concerns of customers.
Servitised firms will face unusual types of competitors, like their customers or their suppliers (Vandermerwe & Rada, 1988)	Beta is now in a situation in which its main customers are at the same time its main competitors. Beta is facing this problem expanding its market globally and focusing on the innovation, flexibility and speedy of delivery that have always constituted its competitive advantage.
"Moving downstream", being as closed as possible to the customers (Wise & Baumgartner, 1999) In moving downstream, a company may need to expand its operations facilities around the world (Baines & Lightfoot, 2013) Need to establish a service culture (Gebauer, et al., 2005)	All the firms shows a desire for being as closed as possible to the customers, in order to maintain that continual relationship that all believe will sustain their competitive advantage. None of the firms is considering the idea of offshoring their operations facilities, as made by Rolls Royce. On the contrary, they consider new digital technologies as a way to deep their internationalisation gaining at the same time an higher level of internalization and centralization of the services they can provide. This is especially true for the smaller companies, since they have less workforce to devote to the provision of services. All the firms are training their sale force in order to introduce a more aware service culture; for doing that, they all believe sales people, in order to be competitive, should have a solid technical background.
Stronger integration among the functions of a firm (Porter & Heppelmann, 2015) Creation of devoted groups for data management and product innovation (Porter & Heppelmann, 2015) Firms should establish a separate service organization for the implementation of services (Oliva & Kallenberg, 2003)	All the firms shows a need for stronger collaboration between the different functions. For Alpha and Beta this need of flexibility and integration has not caused huge changes in the organization, because these characteristics were already present because of their reduced dimensions. For Gamma this has been far more challenging; in order to cope with these new organizational needs, it has reorganised itself on processes and through the Japanese concept of *obeya*. Gamma, in addition to that, has also created a group responsible for the data management of the whole enterprise. Also Beta has created a small group, but it was more related to product innovation. Alpha had not the need to devote people full time for data management and product innovation related to services.
The principal technologies involved in a digital service transformation are IIoT, Big Data and analytics and Cloud Computing (Ardolino, et al., 2017) Firms must be aware of the limits of Remote Monitoring Technologies (Grubic, 2014)	All the firms are investing in inserting sensors and connectivity into their products, and in storing and analysing them with appropriate software technologies. Cybersecurity is another technology highly employed in all the firms. Alpha and Beta had found great improvement in their product development process through the use of simulation, permitting to them to speed up their delivery time. Beta makes use also of 3D printers for product development.

	All the firms highlight the fact that it is very difficult to balance the need to gather information through sensors and their high costs of installation. Gamma for this reason has begun an its own project for producing these sensors internally. The firms, and Gamma in particular, believe that in any case remote monitoring technologies will never completely substitute a human and personal relation with the client.
Firms should direct their service development on services supporting the client, focusing on customization, relationship management (Mathieu, 2001) Opportunities in servitization come from looking at the life cycle of the product or at its adjacencies (Allmendinger & Lombreglia, 2005) Firms should direct their offering towards advanced services in which they assume a proactive role (Burckart & Rustema, 2015)	All the firms directing their service offering through the life cycle of the product, making them solutionists. Technology is helping them in the pre-sale services, permitting to achieve an high level of customization. It is also helping them in the after-sales, with the aim of building a strong and durable relationship with the client. This is the main objective of Gamma, in particular. All the firms are struggling in providing predictive services, based on the continual exchange of data, for the above mentioned concerns of the customers. None of the firms is now applying a contract in which property is not transferred, the risk is shared, or payments are regular fees. Beta is providing a contract of maintenance with partial sharing of risk, and Gamma in certain markets must be able to guarantee a certain level of OEE.
Firms can acquire new competences and capabilities along a collaboration continuum (Mathieu, 2001)	All the firms would prefer to internalize all the competences and capabilities they need, but they can't always do that, for their reduced dimensions or because they want to learn them in a shorter time. Alpha and Beta usually have outsourced their activity of simulation, whilst Gamma has done it for its activity of Business Intelligence. Gamma has also made a partnership with an IT consulting firm for the development of its black box.
Value created through value networks and competition based among companies but among value networks (Clarysse, et al., 2014)	All the firms actively collaborate with universities, that are then a great actor of their value networks. In addition to this Gamma relies on external collaborations as regards the activities related to Business Intelligence and analytics.
Importance of harnessing the value of the Installed Base (Oliva & Kallenberg, 2003)	All the firms offers services of upgrading and revamping of old equipment. Alpha and Gamma offer in particular also a black box capable of collecting, storing and analysing the data coming from the machine.

Table 3.5 Main themes emerged in the literature and their view coming from the cases

Conclusions

Digitalisation is nowadays one of the main challenges that firms are tackling. The advent of new technologies coming from the fourth industrial revolution and their application to manufacturing is introducing a disruptive change in a lot of industries, from a technological and, especially, organizational and business point of view.

In particular, the perspective of the present analysis is that of servitization, that is, the enrichment of the offering of a firm with services. Servitization is not a new phenomenon, per se, it has been analysed in the literature and by practitioners for decades. In contemporary times, though, the presence of the new digital technologies of Industry 4.0 brings renovated and enhanced possibilities for the firms to enlarge their offerings with services, giving rise to what has been defined as digital servitization. This has given to large multinational firms the possibility of implementing new business models, in which payments are linked to performance and value in use for the customer, the economic risk of the customer is partially shared with the provider as regards its products, and gains, for the manufacturer, are distanced in time, coming from the cultivation of a committed relationship with the client. The most famous example of this is the "Power-by-the-Hour" contract by Rolls Royce.

The capital equipment sector, for the reasons highlighted by (Grubic, 2014), is among the industries in which the possibilities offered by digital servitization are greater. In addition to this, it is also one of the industrial cornerstones on Italy and of the Veneto region.

The objectives of this analysis were to understand how companies in Italy are dealing with this type of changes, which challenges they consider as more important, which technologies are now exploiting, which services are providing with these new technologies and which problems have they encountered in these implementations. Also, it was interesting to notice how other challenges like internationalisation and changes in internal organizations could influence or be influenced by these phenomena. Considering, furthermore, that the great majority of enterprises in Italy are of small and medium dimensions, it was interesting to see how the above mentioned phenomena were influenced by the variable of firm dimensions.

The method considered best suited for this type of analysis was that of multiple case studies, because of the recentness of the topic, in order to give better insights into the phenomenon and explore its opportunities and challenges.

For these reasons, three firms of different dimensions were chosen, all belonging to the capital equipment sector. In particular, both Alpha and Gamma are specialised in the machine tool sector, whilst Beta is specialised in producing gable-top filler machines.

The general insight coming from this analysis is that nowadays there is a lot of wariness in the industry as regards the adoption of Industry 4.0 technologies in the provision of new services for the customers (differently from their application in the operations, that is more advanced). These wariness, from the side of the manufacturers, is partly due to their lack of experience in the field, but is especially due to the behaviour of the customers, that, on one side, do not see the urge of this type of innovation, and, on the other, are too worried about their privacy and industrial secrecy.

This attitude by the customers is highlighted in all the firms interviewed. Usually, the customers are willing to engage in services of remote maintenance, but when it comes to more advanced services, like preventive maintenance, none of the customers is willing to keep the equipment always connected to the internet. Even though all the firms claim to guarantee a high level of cybersecurity, the customers (whose products are also characterised by an high level of complexity and innovation) are always too worried about the potential dispersion of their industrial data. The interviewee of Alpha suggested that there may also be an opportunistic behaviour done by the underlings, because if the equipment was always connected, their foreman could understand which one had made errors.

The main technologies of Industry 4.0 adopted in the firms have been Simulation, Big Data and Analytics, Cloud Computing and Industrial Internet of Things.

Although these technologies have been adopted by all the investigated firms, there are differences in their relative importance. In SMEs (Alpha and Beta) simulation is of great importance, since it permits to shorten the delivery time of the product and to make it less costly and under a stricter control by the manufacturer. In larger companies like Gamma, even if they also adopt simulation, the attention now if more focused on machine learning and business intelligence, since their competitive advantage comes less from a flexible and rapid delivery of the product.

The firms have decided to put sensors in their products, applying remote monitoring technologies in order to provide advanced services. At present they are trying to sell services of remote and preventive maintenance, although experiencing the resistance of customers in keeping the equipment always connected. This resistance explains also why none of the firms is considering the implementation of Outcome-Based contracts or Pay-per-Use schemes.

A challenge reported by the firms has been the difficulty to properly understanding which sensors to put in the equipment, and which variables keep under control. This is a tough decision, not just from a technological reason, but especially for its economic consequences, since installing the sensors, connecting them, collect and storing the data are expensive activities. In addition to this, there is also a part in the context in which the equipment will be

inserted that will always be beyond the control of the manufacturer, as shows the example reported by Gamma.

Another challenge they are facing currently regards the pricing of services, since all the enterprises are convinced that the customer should perceive the value of the services also by seeing its separate prices, stopping seeing them simply as something included in the package. This challenge, although common to everybody, is particularly challenging for SMEs, since their installed base (and so potential sources of data) is lower and because, usually, they base their competitive advantage on customization, so it is less easy to refine pricing decisions on base of the agreements made before.

The attention to the installed base is characterising all the firms, smaller and bigger. The low costs of building basic boxes with sensors, data collectors and connectivity permits, potentially, to every firms to harness the value of their installed base. Bigger firms, though, may build a stronger advantage internalising more the development of these "black boxes".

All the firms have a global market and customers all around the world. This high level of internationalisation is not something new, in the history of the firms analysed. The new technologies of Industry 4.0, though, are changing the approach with which the firms are interfacing with the rest of the world. Particularly, as regards SMEs, these new technologies are seen as a way to internalize and control more properly after sales services, depending less on their network. Also bigger companies which can rely on a mostly internalised distribution network (like Gamma), see remote monitoring technologies as a way to control and centrally oversee their service management; especially in a phase like the current, where the sales force is undergoing a training process aimed at focusing on after sale service.

Another theme that emerged from the study is the different reaction of the organization to the challenges posed by digital servitization. Actually, the process of product development can rely on a greater level of feedbacks and information coming from the customers and from the other functions of the firm. This permits to have a higher and closer level of customization of the product, so that the customer have its needs met. In order to do that, it is fundamental to have a strong degree of integration between the different functions of the firm, permitting to the people to exchange information and feedbacks more easily.

Smaller companies, like Alpha, did not need a disruptive change in their organization, to cope with these needs, since their small dimensions already provide these features. Far different has been the case for companies like Gamma, which underwent recently a profound process of organizational renovation, so that now is organised per processes and per *obeyas* (nearly completely abandoning its previously hierarchical and divisional structure).

This permits to better understand the different organizational arrangements adopted for the implementation of remote controlling technologies in providing services for the customers. Alpha, the smallest, has no people especially devoted to this, nor has hired new people for this reason. Gamma, on the contrary, has established a new group of seven people, managed by a person with a long experience in data management inside the firm, composed by three newly hired graduates and three external consultants. Beta has established a smaller group of just two people devoted full time, of which one was a researcher at the University of Padova.

As regards the part of the organizational structure related to sales, none of the firms interviewed has decided to establish a separate unit especially devoted to new services; the main activities on the sales force are now regarding their training as concerns service culture, or the change of salespeople in the sales network with others with technical skills. All the firms show that, in order to fully apply a service culture, strong technical skills are needed. This is related to the fact that sales people, right now, are not able to properly understand the needs of the client and propose what the firm is actually able to do.

All the firms are facing a market that, also because of its global range, is very competitive and involved in a continual process of innovation, facing as competitors small and big multinational companies. What the case of Beta suggests is that firms may face unusual competitors, and they have to properly react to this possibility.

All the firms believe innovation is fundamental to compete in the global market and for this reason they all claim a great focus to research and development; this attention on research is particularly claimed by Alpha and Gamma (Gamma has even an its own centre of base research). They also have been able to insert themselves into the main innovation networks, above all collaborating with universities, and, in the case of Beta, also participating in the regional project of “Reti Innovative Regionali”. Being inside networks where exchange of information is done shows to be fundamental.

A further challenge is related to the problem of finding the right competences. Smaller firms had tried to solve it mainly through outsourcing, whilst bigger firms, like Gamma had relied more on training internal personnel. In particular, Alpha, for its dimensions, will continue to rely on external suppliers as regards certain software components; Gamma, on the contrary, is outsourcing mainly with the intention to have the possibility to learn more quickly.

The image of the Italian industry that results from this analysis is that of one aligned with the needs of their industries, and for some aspects even too advanced for them (as shows the usually ignored service of preventive maintenance that all they can offer). Their competitive advantage is solid, and the technologies coming from Industry 4.0 will permit to reinforce it and make it more sustainable. This is true for bigger firms but also for SMEs.

The adoption of advanced forms of contracts, like OBCs or Pay-per-Use seems rather distant now. None of the firms claim to have enough experience and expertise to properly manage predictive services, so going further is rather difficult, at the moment.

In order to make a final schematization let's capitalize on (Lay, 2014), that proposes two different outcomes in the evolution of the phenomenon of servitization in developed countries.

In the first scenario, the benefits of offering advanced services illustrated in the literature and applied by certain frontrunner firms will spread out across the manufacturing industries. The number of servitised manufacturers will increase more and more over time, and finally they'll become the majority of the firms in the industry. Some of the firms, as in every innovation process, are likely to physiologically fail in doing that.

In a second scenario, instead, servitization with advanced service offerings will remain restricted to niches. Manufacturers will mostly continue their traditional ways of doing businesses, including services in their business models, but never making them dominate their strategic orientations.

Which scenario will prevail depends on a series of factors.

The first factor to be considered is the role of manufacturing in developed economies, devalued before the 2008 crisis, largely re-valued after. Secondly, on the popularity itself of the concept of servitization in the world of business practitioners. At last, the diffusion of servitization will depend also from the definitions and measurement benchmarks employed to monitor it.

Regardless of the attention given by manufacturing industries in the future, servitization, in any case, will remain an opportunity for every manufacturing firms, as this analysis has tried to prove.

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