UNIVERSITA' DEGLI STUDI DI PADOVA

DIPARTIMENTO DI SCIENZE ECONOMICHE ED AZIENDALI "M.FANNO"

CORSO DI LAUREA MAGISTRALE IN ENTREPRENEURSHIP AND INNOVATION

TESI DI LAUREA

"TRANSITIONING TOWARDS DIGITAL SERVITIZATION: AN ECOSYSTEM PERSPECTIVE"

RELATORE:

CH.MO PROF. MARCO UGO PAIOLA

LAUREANDO/A: GIACOMO BULIAN

MATRICOLA N. 1206738

ANNO ACCADEMICO 2019 – 2020

Il candidato dichiara che il presente lavoro è originale e non è già stato sottoposto, in tutto o in parte, per il conseguimento di un titolo accademico in altre Università italiane o straniere.
Il candidato dichiara altresì che tutti i materiali utilizzati durante la preparazione dell'elaborato sono stati indicati nel testo e nella sezione "Riferimenti bibliografici" e che le eventuali citazioni testuali sono individuabili attraverso l'esplicito richiamo alla pubblicazione originale.

The candidate declares that the present work is original and has not already been submitted, totally or in part, for the purposes of attaining an academic degree in other Italian or foreign universities. The candidate also declares that all the materials used during the preparation of the thesis have been explicitly indicated in the text and in the section "Bibliographical references" and that any textual citations can be identified through an explicit reference to the original publication.

Firma dello studente

Bulian Giacomo

Table of Contents

Introduction

Nowadays, manufacturers from every sector are experiencing a drastic change in the way they navigate the competitive environment and design their value propositions, as services have increasingly assumed a predominant role in value creation strategies. For this reason, more and more manufacturing firms have started a process of servitization, as the way through which they progressively shift their main business focus from products to services.
Servitization is not really a new phenomenon, with the original formulation of the concept first appearing in the late 1980s thanks to the contribution of Vandermerwe and Rada, but it has been more widely studied and detailed in the last few decades by numerous researchers.
In particular, the advent of new digital technologies such as the IoT has fostered the emergence of the new concept of Digital Servitization, which makes use of such technologies to support a company's transformation towards a service-oriented business model, for instance by providing digital services embedded in physical products.

While transitioning towards the provision of digital services, there is a whole series of factors that a firm must take into account, especially for what concerns the influence external actors and stakeholders can have and the support they can provide along this path.
Such actors include, but are not limited to, suppliers, distributors, partners, consultants, customers, and many other kinds of organizations. Their presence gives rise to an ecosystem in which the firm must manage different interactions and relationships in order to get an edge on its rivals and accomplish its goals.

This research lays the theoretical foundations on the concepts of Servitization, Digital Servitization, and Ecosystem, and its essential aim is to assess the impact of external actors on the manufacturer's ability to approach a digital servitization pathway and implement digital service strategies. For this purpose, we conducted an empirical investigation based on interviews with managers and informants from six manufacturing firms.
The thesis is structured along four chapters, which are organized as follows.

The first chapter deals with introducing the concept of Servitization, providing some of the most prevalent definitions in the literature and explaining what are the drivers and motivations behind the choice of transitioning towards service provision.
Afterwards, it describes strategies for Servitization according to three relevant frameworks, illustrates some of its most classic cases and examples, and outlines what are the main challenges connected with the transition.

The second chapter focuses instead on Digital Servitization and begins by explaining the role of digital technologies in enabling the provision of digital services. In this context, it presents some of the main technologies associated with Digital Servitization, such as IoT, Cloud Computing, and Artificial Intelligence, stressing in particular the importance of data, and introduces the concept of DPSS, or Digital Product-Service Systems.
This chapter also presents a series of new business models that are enabled by digital technologies, and deals with some of the challenges that firms may experience while pursuing the digital transition.

The third chapter presents the notion of Ecosystem and outlines the importance of external stakeholders in enabling the focal company to implement digital technologies in its activities and products. In doing so, the chapter deals with the organizational shifts that a company must go through to modify its business structure and become a digitally-servitized firm, and then presents in more depth the actors that impact the transition.

The fourth and final chapter deals with the empirical investigation and its results, providing a detailed description of the sample and the methodology used.
In the findings, we present the main takeaways from the interviews, dividing them into seven key thematic areas. The last section of the chapter is the discussion, which creates a bridge between the theoretical concepts presented in the first three chapters and the results from the investigation, allowing to provide an answer to the research question.

Chapter 1- Servitization in Manufacturing Companies

1.1 Origins and Definitions

Over the past few decades more and more manufacturing firms have been experiencing a change in their business models' value propositions, gradually moving their focus away from a solely product-centered attitude towards a more service-oriented attitude, due to the gradually raising importance of such services as key drivers for the creation of sustainable competitive advantage. (Oliva & Kallenberg, 2003)
This convergence among products and services and the inter-relationships between the two are particularly relevant for manufacturers (Raddats et al., 2019) and can be explained through the phenomenon of Servitization.

In order to fully understand what we mean when we refer to Servitization, it is of the utter importance to investigate and grasp the origins of this concept, as well as the evolution of its definition over the years.
The first step in this direction requires the understanding of the two fundamental notions underlying the idea of Servitization, namely the notion of "product", which can be generally defined as a good in the form of a "material artifact", and the notion of "service", which is of more difficult definition, but can be described as an "offering, in form of an economic activity that does not result in ownership of a tangible asset" (Baines et al., 2009a)

The concept of Servitization initially emerged in the late 1980s, when early phenomenological studies by authors Sandra Vandermerwe and Juan Rada defined it as "the addition of services to core product offerings to create additional customer value" (Raddats et al., 2019), in order to "increase competitiveness, turnover and market power" (Kowalkowski et al., 2017).
Vandermerwe and Rada identified and consequently defined a "Servitization" movement regarding corporations that started offering full packages, or "bundles", to their clients, as a combination of "goods, services, support, knowledge and self-service" (Kowalkowski et al., 2017).
This initial study was just the beginning of a major research stream that is still very much alive today, with a growing number of studies and publications on the subject.
Over the years numerous definitions of the concept have been provided, and although they present some slight differences, they generally agree with the original one given by Vandermerwe and Rada.

To provide some examples, Oliva and Kallenberg (2003) define Servitization as the "transition from products to services", Desmet et al. (2003) refer to it as "a trend in which manufacturing firms adopt more and more service components in their offerings", while Ren and Gregory (2007) issue a broader definition, stating that it is "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". (Baines et al., 2009a)
A table provided by Baines, Lightfoot, Benedettini and Kay (2009a) summarizes some of the main definitions of Servitization.

Table 1 – Definition of Servitization

Author	Definition of servitization
Vandermerwe and 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 and 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 and Graves (2005)	"Increasing the range of services offered by a manufacturer"
Ren and 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"

By bringing together these different finding, Baines et al. (2009a) try to craft their own definition for the concept, describing Servitization as "the innovation of an organization's capabilities and processes to better create mutual value through a shift from selling product to selling PSS". In doing so, they also bring up the concept of PSS, or Product-Service Systems, previously defined by Baines as "an integrated combination of products and services that deliver value in use".
PSS and Servitization are closely related concepts that present many similarities but differ because of the perception of their ultimate scope. PSS represent the rare combination of value that a specific product and service create when merged in a unique solution and can be considered as a sub-element of the Servitization process, which instead encompasses the

whole transformational process that a manufacturing company goes through in becoming a service provider (Kryvinska et al., 2014).

A more recent definition of Servitization is provided by Peillon, Pellegrin, and Burlat (2015), who state that "servitization is integration between product and service activities rather than transition from products to services", allowing for a different interpretation of the notion compared to the more dated definitions.
These remarks make it clear that the concept of Servitization has changed and evolved over the years. On this note, the service-transition assumption established by Oliva and Kallenberg (2003) that "firms undertake a unidirectional repositioning along a product-service continuum… ultimately leading to the provision of solutions", is questioned by Kowalkowski et al. (2015), who state instead that "service-led growth and expansion is multifaceted and does not necessarily imply a unidirectional development".
Further remarks on the evolution of the Servitization concept will be covered in the following chapter, where the impact of digitalization and new technologies will also be taken into account.

1.2 Reasons for Servitization

The reasons and motivations that push a manufacturing company towards the adoption of a Servitization approach may vary across different industries but are generally connected with an improvement in profit margins and financial performance, with the aim of creating a sustainable competitive advantage over business competitors.

According to Oliva & Kallenberg (2003), drivers for introducing services in a company's offering portfolio can be grouped in three main categories, namely economic, competitive, and demand-based motivations.

For what regards the economic argument, Raddats et al. (2019) state that this driver focuses on service performance, and specifically on stability, profitability, and revenue growth. In their work they also present the findings of Wise and Baumgartner (1999), who found that "services can yield an attractive share of revenue", and that services market are often deemed of greater importance compared to product markets, estimating that revenues from service "can be one or two orders of magnitude greater that new product sale".
Further elaborating on this driver, Quinn (see Oliva & Kallenberg, 2003) stated that services can be considered a more stable revenue source, as they are not as likely to be affected by the "economic cycles that drive investment and equipment purchase", and this is also confirmed by Malleret (2006), according to whom services provide for a "more stable source of income, either counter-cyclical or more resistant to the economic cycles that influence product investment".
It is made clear that companies may pursue Servitization moved by this economic driver, but it is also important to point out that the process does not necessarily translate in financial benefits right away, as these also depend on the capability of the firm to carry out a strategically relevant plan of action in terms of what services to implement, as well as the most suited modalities and timing for their implementation. On this note, as pointed out by Malleret (2006), "the development of organized and profitable services in companies is not immediate. It spreads over time and service activities become profitable only when specific thresholds have been passed".
Another important remark is that according to Potts profitability can be extremely variable between different types of services, and that "service profitability depends on factors such as share of service sales in the firm's total", as stated by Suarez, Cusumano and Kahl. (see Raddats et al., 2019)

Competitive or strategic motivations are instead based on the importance of services for product differentiation (Raddats et al., 2019) and for creating a sustainable source of competitive advantage. This is possible thanks to the fact that services are much more difficult to imitate compared to products (Oliva & Kallenberg, 2003), given their less visible and more customizable nature.

Successful product differentiation allows a company to communicate the unique features of its offering and to raise brand awareness among existent and potential buyers, by delivering a strong image of the brand and instilling a sense of quality and reliability in the mind of customers.

Following up on the strategic motivation, the introduction of services in a firm's portfolio can enhance the relationship with clients, as the value added by services "can enhance the customer value to the point where homogeneous physical products are perceived as customized", as stated by Frambach (see Baines et al., 2009a).

A strong and close relationship with a customer is precisely one of those valuable, rare, and difficult to imitate resources that can create a competitive advantage. This is possible because of the intangible and more personalized nature of services, which allows a firm to compete on the creation of value and differentiation, rather than engaging in pricing wars.

According to Malleret (2006),in order to offer services that create value, a firm must know and understand its "key success factors, working systems, organization and processes", as well as to "maintain a close trust-based relationship with its customers, with frequent contacts".

This demonstrates the existence of a strong interdependence between service provision and customer relationship, where on one hand offering quality services is a key for strengthening the relation, while on the other cultivating a close relationship allows for a better understanding of customer needs and thus for a more suitable service offering.

The third driver relates to demand-based, or marketing motivations, with customers that are increasingly demanding for services (Oliva & Kallenberg, 2003), and are especially eager for quality, speed, and personalization of solutions.

Given the increasing commoditization of the markets, where according to Baines et al. (2009a) "differentiating strategies based on product innovation, technological superiority or low prices, are becoming incredibly difficult to maintain", companies now look at services as an opportunity to offer a more personalized and memorable customer experience, making them more willing to come back and thus improving the firm's position in terms of repeated sales.

This claim is supported by Mathieu and Malleret (see Baines et al., 2009a), according to whom services are a key for inducing repeat-sale and to increase contact opportunities with clients, putting the supplier in the right position to offer other products and services.
Moreover, in the same study Baines asserts that services help companies to "gain insight into their customers' needs" and enables them "to develop more tailored offerings", while Vandermerwe and Rada (1988) go as far as saying that "services… create customer loyalty to the point where the customer can become dependent on the supplier".
Clearly services represent an opportunity in terms of adding value to the core offer of a firm, helping both in consolidating the retention rate of current customers and in expanding the existing customer base.
Resuming the elaboration on demand-based motivations, according to Gebauer, Gustafsson, and Witell (2011) service differentiation assists manufacturers in addressing more complex customer needs, as firms that utilize service differentiation are "in a better position to handle dramatic changes in customer needs than pure goods providers are", allowing for improvements in both product and service performance.
Furthermore, in their study they also find that strong service differentiation can foster the demand by helping employees to better understand customers' value creation processes and gain more customer knowledge, making it possible to "design better goods and services, form better value propositions, and deliver better service".

1.3 Strategies for Servitization

A preliminary remark that must be made when talking about Servitization strategies is that there is no unique winning strategy for service implementation, as the process is often extremely firm-specific, and there are numerous factors that vary across industries and locations that influence the transition.

On this note, in their 2008 study Johnstone, Dainty, and Wilkinson declared that adopting an appropriate service strategy is a "complex process, taking place discontinuously, in incremental steps, without a clearly directed effort, but which is often driven by diverse customer requirements". Of the same notice is Josephson, who asserts about the great uncertainty that is connected with service-based business models, caused by "potential loss of strategic focus, resource constraints, and internal conflict". (Raddats et al., 2019).

A key feature that needs to be included in all Servitization strategies is customer centricity, with customers that should not be provided with just products, but with broader tailored solutions instead. These solutions represent the real driver for winning over a customer, as compared to a mere product, they consist instead of a "full package", which makes it possible to take a client from an initial state of unsatisfaction to his or her desired outcome (Baines et al., 2009a).

Various frameworks on strategies for service implementation have been proposed over the years, and we will briefly present three of them.

1.3.1 Oliva and Kallenberg's Framework

The first framework we will take into account is the one proposed by Oliva and Kallenberg (2003), in which they describe the transition of companies along the so-called "product-service continuum", from traditional manufacturers that simply offer add-on services, to service providers, where services become the focus of the value creation process.

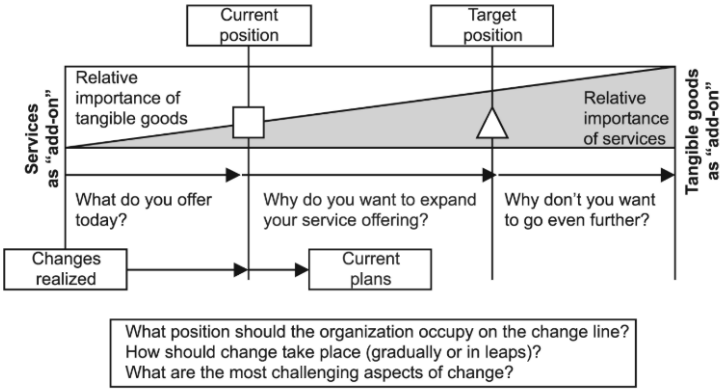

Figure 1 – Product-Service Continuum

Their analysis is based on a sample of 11 German capital equipment manufacturers and is strongly focused on the concept of Installed Base (IB). They define a product's Installed Base as the "total number of products currently under use", and consequently describe IB services as a "range of product- or process related services required by an end-user over the useful life of a product in order to run it effectively in the context of its operating process".
According to their model, the transition occurs in different stages:

1. Consolidating Product-related Services: In most manufacturing firms services are fragmented in different parts of the organization and considered an unprofitable necessity, so the first step is to consolidate the firm's service offering in a single organizational unit. This action is typically triggered by customers' complaints or competition and leads organizations to improve the efficiency, quality and delivery time of the services provided, as well as to add new services to their portfolio.
   The effectiveness and efficiency of service delivery is also kept under control through the establishment of monitoring systems, with the final aim of creating a reputation as a reliable service provider among customers.

2. Entering the Installed Base Service Market: A profit opportunity in the service market is identified, often because of the previously set monitoring mechanisms or by observation of a competitor's high margins in the same market, and the firm sets up the processes and structures to pursue it. In this phase companies typically face two challenges, the first one being a cultural change from product-centered to service-centered orientation, in which the creation of a separate organization can represent a critical success factor, and the second one being the need to create a global service infrastructure capable of responding locally to the IB's requirements.
   The focus in this stage is to build a well-functioning service organization and to establish an active presence in the market.

3. Expanding the Installed Base Service Offering: This stage occurs through two transformations. The first transition is from transaction-based to relationship-based customer interactions, that typically take the form of maintenance contracts in which the price is based on operational availability and response time in case of failure, and profitability depends on the accuracy of the firm in assessing the equipment's failure risks. On this end, manufacturers have the advantage of experience and better

knowledge of their own equipment compared to other maintenance organizations.
The second transition is the shift of focus in the value proposition from product efficacy, to its efficiency and effectiveness within the end-user's process, putting the emphasis not on the product itself, but rather on the end result. In this way, the firm becomes a solution provider rather than a machine manufacturer.

A fourth stage is ideally proposed by the model, namely "Taking over the end-user's operations", in which the firm assumes the full responsibility of the end-user's process, but is not further explored by the study as no organization in the sample moved to that space.
To sum up, the model implicates that for the purpose of the Servitization process "there is a particular order in which firms need to tackle challenges and develop capabilities", as not developing proficiency in basic product-oriented services often results in failure, and that firms that isolate their service operations and personnel from the rest of activities are more successful in exploiting market opportunities.

1.3.2 Gebauer's Framework

The second framework we will describe is the one provided by Gebauer in his 2008 publication. The study is based on an exploratory factor and cluster analysis on Western European firms and reveals four different environment–strategy fits that can be interpreted as service strategies in manufacturing companies. The four service strategies are:

1. After-sale Service Providers (ASP): They focus on cost leadership and in ensuring the proper functioning of the product, competing mainly through attractive prices, and often offering discounts. ASPs generally offer standardized and predefined after-sale services, such as spare parts, repair, inspection, hotline, and basic training.
   As low prices products experience sporadic breakdowns, ASPs focus their value proposition on guaranteeing reliable after-sale support, rather than dealing with more sophisticated services.

2. Customer support Providers (CSP): CSPs strongly invest in product and service differentiation, generally obtaining a high-quality reputation and lowering competitive pressure. Not only they maintain technological superiority and product differentiation, but they supplement it with impressive process-oriented services, leading to service differentiation, as they customize and bundle their service elements according to

customer needs, for which clients pay a fixed price.
As opposed to ASPs, CSPs' strategy is to prevent breakdowns altogether.

3. Outsourcing Partners (OP): They combine cost leadership with service and product differentiation to offer attractive prices for a high level of operational services.
   Compared to CSPs, OPs do not create customized service packages, but rather assume the operating risk and total responsibility for the customer's operating processes.
   In this sense, OPs can be considered as "pure" service companies, that to some degree also pay attention to product and service quality, as frequent product breakdowns would erode overall profitability.

4. Development Partner (DP): DPs provide research and development services to support customers to achieve outstanding process performance, creating a situation in which competencies are co-produced between them and the customer, which serves as a resource-acquisition barrier and as an entry barrier for competitors.
   DPs also pay attention to product reliability, along with after-sales and process-oriented services, as customers often use them as yardsticks when evaluating possible collaborative innovation efforts.

This model takes one step further compared to the previous one, as instead of generally trying to assess what position should manufacturers occupy on the product-service continuum, it identifies four specific service strategies, indicating how they supplement competitive positioning and their relation with the external environment.

1.3.3 Raddats and Kowalkowski's Framework

The last framework we are going to address is the one proposed by Raddats and Kowalkowski in 2014, based on a cluster analysis on a sample of 145 B2B manufacturers in the United Kingdom. They identify three categories of service offerings, namely product-attached services, operations services on own products, and vendor independent operations services, and use them to specify three generic service strategies:

1. Services Doubters: They show low focus on all three categories of service offerings and have an under-developed service business. Some manufacturers may have sought to isolate their service operations and present standalone dedicated Service Business Units (SBUs) , but this has not been successful due to the just mentioned low focus on

every category of service offerings. These companies ought to seek differentiation through nonservice factors.

2. Services Pragmatists: Services Pragmatists are predominantly focused on product-attached services, which are likely to be mainly related to own products and to a lesser extent the ones of other Original Equipment Manufacturers (OEMs).
   These firms are still able to generate a sustainable competitive advantage from their products, suggesting that they maintain a product-centric view of their businesses and use services for differentiation purposes. They do not generally separate product and service SBUs, which might be a deliberate choice as it allows them to benefit from strategic linkages between the two.

3. Services Enthusiasts: Services Enthusiasts recognize the great importance of all three categories of service offerings, focusing not just on vendor independent operations services, but also on product-attached and operations services on their own products. These companies present above average revenue from services, indicating that they have established successful service businesses, and compared to the other trajectories they believe that their products play a lesser role in creating a sustainable competitive advantage, shifting the focus instead on services as a source of differentiation and revenue growth.

Ultimately these three strategies do not represent a sequential trajectory, but rather three distinct ways of approaching services based on each individual's firm characteristics. This means that a "Service Doubter" does not necessarily need to aim at becoming a "Service Enthusiast", but instead that manufacturers should adopt the service strategy that best reflect their capabilities and the opportunities that their specific market display.

1.4 Classic Cases of Servitization

Some of the most classic examples of Servitization include manufacturers that were willing to revolutionize their business models' core offerings since the early 1990s, adopting a customer-centric approach that allowed them to grasp the value created throughout the entire product life cycle.

As Wise and Baumgartner had already foreseen in 1999, the companies that were able to thrive in an economic environment that was becoming stagnant for manufacturers, were the ones which decided to go downstream, towards the provision of services required to operate and maintain products.

In their 2009 literature review Baines, Lightfoot, Benedettini and Kay collected some of the most prominent case studies on servitization adoption, which are summarized in the table below.

Table 2 – Industrial Examples of Servitization

Organisation	Description	Source
Alstom	Maintenance, upgrade and operation of trains and signalling systems	Davies (2004)
ABB	Turnkey solutions in power generation	Miller *et al.* (2002)
Ericsson	Turnkey solutions to design, build and operate mobile phone networks	Davies (2004)
Nokia	Nokia's network-infrastructure solutions, providing network equipment and service to carriers	Wise and Baumgartner (1999) Davies *et al.* (2006a, b)
Thales	Pilot training and simulator-building management	Davies (2004)
Rolls-Royce	"Power by the Hour" guaranteed flying hours for aero engines	Howells (2000)
Xerox International	Document management services. Guaranteed fixed price per copy	Mont (2001)
WS Atkins	System integration services and outsourcing solutions	Davies (2004)

We are now going to analyze in more depth some of these cases and more, looking at what they have done to operate the transition from manufacturers to service providers.

Firstly we will look at two of the cases presented by Davies in his 2004 publication, Alstom and Ericsson.

Alstom Transport is the division of Alstom group that handles the design, manufacture, build and after-care services related to trains and signaling systems.

Following the break-up of British Rail in 1993 and the growth in demand for maintenance outsourcing contracts, Alstom seized the opportunity and established a Service Business in

1998 for rolling stock maintenance service, function that was previously conducted by national railway monopolies. By doing so, the company evolved from a "seller of goods to a system and service provider", providing its customers with complete transport solutions for 'train availability'.

The case of *Ericsson* presents two major business model shifts in company's history: the first in the late 1908s, when Ericsson moved from being a broad-based manufacturer of public telecoms equipment to focus on the mobile communications market segment, and the second after 1996, when the firm realized the importance of services in the mobile operators sector, and decided to drift away from its manufacturing heartland, in favor of more profitable systems integration and operational activities. In 2000 they set up a "Global Services" division to provide their services to mobile phone operators around the world.
Extending the scope of Davies' study, it is interesting to note that Ericsson proceeded on that trajectory to this day, as a quick look at the company's website reveals that their portfolio of activities encompasses to a great extent digital and management services, as well as customized smart solutions.

Other interesting classic cases are provided by Wise and Baumgartner in their 1999 article, in which they identify four categories of successful downstream business models, namely *embedded services*, that allow downstream services to be built into the product, (e.g. Honeywell); *comprehensive services*, like the ones offered by General Electric around its product markets; *integrated solutions*, in which companies go beyond their traditional product-centric vision, to delve into the overall needs of customers (e.g. Nokia), and *distribution control*, which entails entering the customers' business, as done by Coca-Cola (Baines et al., 2009a).
We will now look at these four cases in further detail.

Honeywell has traditionally been a producer of discrete navigation, air-data, and collision-avoidance systems for commercial aircraft. The company, pushed by competitive pressure, decided to look downstream and developed a new product, the Airplane Information Management System (AIMS), which enabled airline operators to improve efficiency, reduce labor costs and increase the speed of aircraft turnaround time. Such system turned out to be a great source of value for airlines, making Honeywell able to charge a premium price and become a preferred supplier of related components for many customers, gaining an enormous advantage in the market.

In the case of *General Electric*, the pursue of a comprehensive-services business model through their conglomerate's financing division, GE Capital, helped them to explore new opportunities in the service market and capture a rich source of sales and profits.
By focusing on customers' activities they were able to gain deep insights on their needs and better refine products and services to create a better fit, while building a strong bond to promote future sales. Through these activities GE Capital has grown from a small support financing operation to become the key profit generator at the heart of the company.

The third case described by Wise and Baumgartner is *Nokia*'s, which combines products and services into an integrated solution to address customer needs.
Nokia implemented a successful strategy by addressing all the equipment and service needs of its customers, the cellular carriers: other than creating a full array of products, they helped the carriers in managing their networks, meeting zone requirements for constructing new transmission towers, and provided maintenance and technical support.
Through this seamless offering the company was able to create formidable customer loyalty, capture large shares of customers' high-margin network infrastructure spending, and earn extra revenues connected to recurring service and upgrade.

The fourth case study is the one of *Coca-Cola* and it concerns distribution control, as the company was able to move forward in the value chain and gain control of profitable distribution activities.
This move was caused by technological changes and competitive pressure from regional bottlers, which made Coca-Cola decide to take action and consolidate its independent bottlers into the largest and most tightly integrated distribution network in the beverage industry. By doing so, the company obtained full channel control and was able to grab additional shelf space and halt price erosion in the low-profit supermarket segment, as well as to extend its dominance in the profitable but fragmented vending-machine market. These moves helped Coca-Cola to raise efficiency and profits, and to increase the firm's shareholder value during times of slowing growth for the industry.

Finally, we will look at two more cases that proved to be pioneering examples of servitization, specifically Rolls-Royce and IBM.

Rolls-Royce is, among the others, a manufacturer of aerospace engines that introduced the "Power by the Hour" service system, making their revenues not reliant just on one-off sales anymore, but instead connected to the flying hours of the aircraft. (Baines et al., 2009a)
With this model, the engines are not sold, but rented along with the provision of maintenance services that guarantee their constant functioning and reliability. With this method customers do not pay for the product itself, but rather for the certainty that the product will operate without problems or failures for all the hours "purchased" (Davies, 2004).
"Power by the Hour" shifts the focus from the product to the outcome: in this way maintenance work is carried out only when necessary and is not charged for, reducing the need and cost for unplanned maintenance, as well as and engine downtime.

In *IBM*'s case, the transition from product manufacturer to service provider was more of a forced choice rather than a proactive decision. In the early 1990s the company struggled with a stagnant, increasingly more commoditized hardware business, and was on the verge of failure, making a radical change needed for the organization's survival.
At the time CEO Louis Gerstner set in motion a major change process in the company's business model and internal culture, shifting the focus on customer needs and transitioning towards value co-creation, provision of solutions and services, as well as software and IT outsourcing (Spohrer, 2017).
IBM's revival was possible because Gerstner understood that their largest customers were not interested anymore in hardware and IT products and components, which were costly and highly complex compared to alternatives on the market, but rather in consulting services that helped them to integrate different systems and make them work securely together, task for which they trusted IBM above everybody else (Spohrer, 2017).

In conclusion, in all the mentioned cases the companies experienced some difficulties and challenges while pursuing the Servitization process, but it is made clear that going downstream and implementing a service strategy can often represent a great opportunity that should not be overlooked.

1.5 Servitization Challenges

It should be quite clear by now that manufacturing firms are inevitably forced to face a full array of difficulties and issues when trying to implement a service strategy in their business models, including changing value propositions, transitioning from a good-dominant to a service-dominant logic, and experiencing changes in sales and delivery methods, as well as in customer relations.

These challenges have long been studied and analyzed over the years, but it has been difficult to provide a rigorous classification due to the fact that the obstacles that emerge from time to time can be very firm-specific and contingent to the particular process employed, as challenges evolve along with new strategies and technological possibilities.

Nevertheless, numerous authors have tried to label the typical challenges that manufacturers need to overcome when operating the transition in becoming service providers.

Zhang and Banerji (2017) took into account a great extent of the challenges identified in previous publications by operating a systematic review of the relevant literature, which included 48 papers published between 1988 and 2016, and performed descriptive and thematic analyses to build a theoretical framework and consolidate the fragmented challenges into five main categories: organizational structure (OS), business model (BM), development process (DP), customer management (CM), and risk management (RM).

1.5.1 Organizational Structure

Organizational Structure (OS) can be defined as the formal allocation of work roles and the use of particular management mechanisms for controlling internal activities and supporting the implementation of the overall business strategy.

The first challenge in this dimension is given by the *changing culture* of the organization, intended as a shift from a product-oriented to a customer or service-oriented logic, as the value creation process changes after servitization, with value being now delivered through a bundle of manufactured goods, service offerings, and service personnel. In this phase, the "lack of a supporting structure, including roles and processes geared for services and service development", can represent a relevant obstacle (Kowalkowski et al., 2015).

Moreover, according to Martinez et al. (2010), the cultural legacy of a company may slow down the transition towards service provision, in which case it is important to change the mindsets of employees.

Another important aspect of the OS is effective communication across the organization, which requires the development and adoption of a particular *language* concerning services: this can represent an obstacle for manufacturers, as employees may lack understanding of specific service terminology, or have difficulties in describing and expressing customer expectations and values (Baines et al., 2009b).

Other obstacles in the OS dimension are the *acquisition and retainment of professional service specialists*, whose performance is directly related to service growth and customer satisfaction, and the realization of *intra-organizational synergy*, which is fundamental for developing and delivering integrated offerings, but could be challenging because of previous separation of product and service teams.

1.5.2 Busines Model

The Business Model (BM) represents the fundamental business logic of how a company creates, develops, and delivers value to its customers.

Servitization causes several modifications in the Business Model, and especially in the *value proposition*, which changes from being a unidirectional value delivery to value co-creation: this requires employees to start thinking from a buyer perspective to avoid misalignments with customers' interests, with an increasing number of staff members involved in customer interactions and in receiving and implementing feedback from clients (Martinez et al, 2010 ; Brax, 2005). A changing value proposition also requires commitment and leadership from the top management (Alghisi & Saccani, 2015), which proves to be critical in giving employees at every level of the organization a sense of understanding and alignment towards the new strategy of the company.

The second issue related to the BM's sphere is *resource utilization,* which faces potential changes like leveraging materials and workforce across different departments and the need of acquiring new resources for the reconfiguration of the internal structure.
The redesign of *costing* and *pricing* mechanisms may also present some challenges: on one hand there may be disagreements on the customer side because of the higher prices of services compared to production costs, while on the other there is a need for developing new integrated costing and pricing systems for servitized offerings.

One last issue pertaining Business Model changes is the modification of the *relation with supply-chain partners*, to whom a shift of mindset is required, as providing servitized offerings is different than supplying physical goods. In this sense, Martinez et al. (2010) argue that becoming a provider of integrated offerings "calls for a greater degree of cooperation between a provider and its supporting network" and that it "requires information and know-how intensive exchange", noting that collaboration practices should be established in order for servitization to be implemented successfully.
Furthermore, the intangibility of services involves a great deal of uncertainty, so risk-sharing policies should be agreed in advance between the company and its suppliers.

1.5.3 Development Process

The Development Process (DP) is defined as the overall approach that transforms an intangible idea into a deliverable solution.

In the servitization context, there could be challenges in the *design* of the advanced and *integrated development process* required for creating a suitable service offering, as well as a in obtaining the set of *tools, methods, and techniques* that are necessary for supporting the DP, which are often not readily available at the initial stage of servitization.
Another concern in this stage is the creation of suitable *performance measurement mechanisms*, which will be necessarily different from the indicators used in the product-focused logic of plain manufacturing companies, but are most definitely required for ensuring that the performance of the deliverable solutions meets the initially set standards.

The last challenge related to this matter is being able to engage customers in the development process, so that the output matches their needs and requirements and achieves high standards. According to Brax (2005), to overcome this challenge companies should ultimately work together with clients in the development phase of the offerings, as the intangibility of services makes it difficult to get instant feedback during the creation process.

1.5.4 Customer Management

Customer management (CM) entails building and maintaining a close relationship with customers through effective interactions and communications.

A first challenge in managing customer relationships is *matching customer needs*, as often the value perceived by the customer is not the same as that designed by the manufacturer due to a

misunderstanding of requirements, so again involving customers in the design phase is extremely important.
Another obstacle is the *long-term relationship* building needed, as the performance of the integrated solution depends heavily on the operations team effectiveness, but the human-based performance involves unstable factors that could create disadvantages and could be detrimental to the relationship.

A further issue could be represented by the *value co-creation* process, which requires the supplier service personnel to be integrated into a customer's operation system, with the risk of damaging the credibility of the supplier and the relationship itself if service employees appear to be unprofessional.
One last remark in the CM dimension regards the challenge that service providers face when they need to *access customer operational data*, with customers that are likely to deny information sharing because of its commercial confidentiality.

1.5.5 Risk Management

Risk Management (RM) involves the capability of handling risks within an organization, such as losses, failures, or unexpected consequences.

Financial Risks are quite typical while facing the servitization process, as the business transformation requires increasing investments, with likely low or no financial returns in its early stage. Zhang and Banerji also quote studies from Gebauer et al. (2005) and Benedettini et al. (2017), stating that selling servitized offerings “does not always produce the expected returns” and it “does not necessarily increase the chance of business survival”.

Operational Risks include instead all the uncertainties and modifications that are connected with a company building and extending its service portfolio to provide additional value for business customers, for instance estimation of failure events, maintenance needs and related costs (Alghisi & Saccani, 2015).

Finally, *external risks* include factors that are outside of the organization’s control and can modify the business landscape, like changes in technology development, regulation, market trends, globalization, and capital markets. This type of risks is not necessarily connected with service provision and could actually be experienced by any kind of firm, but facing the servitization process makes companies naturally more susceptible to such externalities.

Chapter 2 - Servitization 2.0: Digital Servitization

The advent of new digital technologies has completely revolutionized the way in which firms compete and create value for their customers in the 21st Century, with a particular effect on the manufacturing industry, as the emergence of smart and connected products has further accelerated and changed the servitization process of manufacturers and reshaped their offerings and business models, creating new spaces and opportunities in the service market.

Digitization, in the sense of transforming analog into digital and expanding the possibility of "connecting people, systems, companies, products and services" (Hsu, 2007), has been a key driver behind digitalization, which is defined by Gartner as "the use of digital technology to provide new value-creating and revenue-generating opportunities" (Skylar et al., 2019). Digitalization is regarded as an enabling factor for manufacturing firms to "pursue distinct customer process-oriented servitization pathways" (Coreynen et al., 2017).
In this context, Coreynen et al. (2017) elaborate that digital technologies did not simply enable the improvement of manufacturers' back and front-end operations, but have rather represented a mean to create digitally-enabled offerings with a profound impact on both customer processes and provider-customer relations.

Digitalization, along with the emergence of new technologies such as the Internet of Things, Cloud computing and Artificial Intelligence, can be regarded as the main force behind the transition from traditional Servitization to Digital Servitization, which can be defined as "the provision of digital services embedded in a physical product " (Vendrell-Herrero et al., 2017), or more comprehensively as the "deployment of digital technologies to support the transformation from a product-centric to a service-centric business model" (Tronvoll et al., 2020).

In the following paragraphs we will try to explain the role that digital technologies and specifically smart products have in enabling Digital Servitization, we will further explore this new notion, and introduce the concept of DPSS, or Digital Product-Service Systems. Following up on this topic, we will explore what are the particular Business Models that emerge within this background and which are the strategic and organizational challenges related to DPSS and Digital Servitization.

2.1 The Role of Digital Technologies in Enabling Servitization 2.0

2.1.1 The concept of Smart Products

In the last couple of years the concept of smart products started gaining relevance as a mean for enabling organizational shifts and expanding the range of opportunities and activities that manufacturing and service firms can focus on.
Smart products are intended as products that are not a simple combination of mechanical and electronical parts, but rather sophisticated systems that combine hardware and software, sensors and microprocessors, and are equipped with advanced data storage and connectivity capabilities.

In this regard, the emerging concept of IoT, or "Internet of Things", refers to the growing number of such intelligent products and the connectivity potential between them and other devices or external actors, that results in the generation of an unprecedented amount of data with an enormous potential in terms of value creation for both companies and consumers around the world (Porter & Heppelman, 2014). IoT is a fundamental concept as it can be considered the main technological base for equipping stand-alone and isolated "things" with a computational capability and transmission protocols, hence transforming them in the actual smart and connected products (Paiola & Gebauer, 2020).
These products may include various features, such as online monitoring or live tracking, and enable manufacturers to provide improved services in the areas of repair, maintenance, and field operations (Coreynen, 2017).

In their 2014 article "How Smart, Connected Products Are Transforming Competition", Porter and Heppelman outline the main characteristics of smart products, which according to them present three core components:

- *Physical* components, that include the mechanical and electrical parts of the product
- *Smart* components, which comprise sensors, microprocessors, data storage, controls, software, as well as an embedded operating system and enhanced user interface.
  In numerous products, software has effectively replaced several hardware components or has enhanced the functionalities of a single device
- *Connectivity* components, including ports, antennae, and protocols enabling wired or wireless connections with the product. These components allow the product to exchange information with its operating environment and enables some of its functions to exist outside the physical device, in the so-called product cloud.

Connectivity can take one of three forms, which are *one-to-one*, when an individual product connects to the user, manufacturer, or another product, *one-to-many*, when many products are simultaneously connected to a central system, either continuously or intermittently, and *many-to-many*, when multiple devices connect to many other types of products and often also to external data sources.
All three types of connectivity are important in achieving high levels of functionality.

In order to fully exploit the potential of smart products, companies need to build a specific "*technology stack*", which is an infrastructure made up of the *product* itself, and specifically its hardware and software components, *network communications,* that enable connectivity with other devices, and a *product cloud*, which is software running on remote servers. This overall infrastructure is supported by three additional components, which are identity and security tools, a gateway for information from external sources, and tools that integrate the data from smart products with other business systems, like ERP and CRM (Porter and Heppelman, 2014).

This infrastructure allows for completely revolutionary product capabilities, namely *monitoring, control, optimization, and autonomy*.

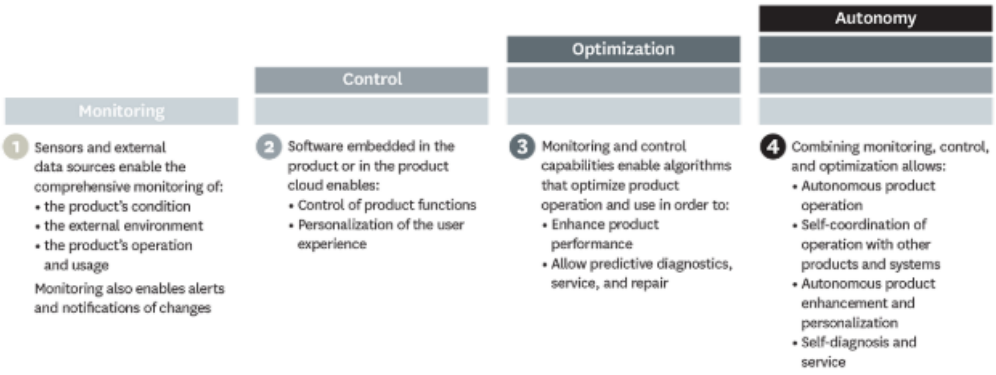

Figure 2 – New Capabilities of Smart Products

First of all, products can now *monitor* and report on their own condition, operation, and external environment, helping to generate previously unavailable insights into their performance and use, and possibly alerting users in case of changes in circumstances or performance. Monitoring also allows to track a product's usage history, with important implications for design, market segmentation and after-sale service.
The second function refers to the products being *controlled* remotely by the users or through specifics algorithms built in the device or available in the product cloud, allowing users to customize product performance and functions even when they are not physically present.

Algorithms can be particularly useful when a product is demanded to autonomously switch its activities due to specified changes in its condition or environment, to prevent a dangerous or unwanted situation.

Optimization is also made possible by the rich flow of data that products create, as they can apply analytics to their usage data to improve output, utilization, and efficiency, as well as how they work with related products in broader systems, such as smart buildings, farms or factories.

Finally, smart products allow for an unprecedented level of *autonomy*, with products that are able to learn from and adapt to their operating environment and to user preferences, self-diagnose their own service needs, and ultimately operate on their own.

Autonomy can improve safety in hazardous environments and ease operations in remote locations, reducing the need for human operators, who often just need to monitor performance or watch over the whole system, rather than individual units (Porter and Heppelman, 2014).

2.1.2 How Smart Products enable Digital Servitization

Smart Products have revealed unexplored opportunities in service markets, as the real-time data and advanced functionalities they provide enable firms to address a completely new range of issues and experiment different organizational structures and business models, allowing for even more differentiation in the offerings and in the way the value creation process is designed.

By exploiting the connectivity between smart products, manufacturing companies will be able to grasp critical information within the end-user's activities and operations, which will in turn help in upgrading products and solutions, developing new products and services, enhancing customer segmentation and positioning, and in developing dynamic capabilities for the continuous optimization and improvement of BM's components (Paiola & Gebauer, 2020).

Elaborating on the definition of Digital Servitization we gave at the beginning of the chapter, we can say it is the process through which firms deploy digital technologies in moving from a product-oriented to a service-oriented logic, or from the provision of basic to more advanced service offerings. Given this background, we can examine how smart and connected products influence this process by offering new and unprecedented possibilities to companies, specifically in exploiting *product data*, enhancing *customer relationships*, and exploring new *business configurations*.

The real difference-maker in this scenario is *data*, which is not generated just by internal operations and transactions through the value chain like in the past, but is instead also created by the products themselves, becoming a core asset for the corporation.
Hashem et al. (2015) argue that progress in cloud computing technology allows for easier storage, access, and processing of the huge amount of data that is generated by smart products-embedded sensors.
By combining and integrating real-time data from various sources, such as service histories, inventory locations, commodity prices, and traffic patterns, data can unveil hidden patterns and give precious insights, which can be captured and better understood through data analytics techniques, enabling far greater efficiency in many service industries. In order to leverage data in the best possible way, many companies create dedicated data groups that are responsible for data collection, aggregation, and analytics, and for spreading such information across different functions and business units (Porter & Heppelman, 2015).

Real-time monitoring data on product condition and control capability is an enabler of service optimization, as in case of imminent failure it is possible to perform proactive maintenance and sometimes even complete repairs remotely, consequently reducing product downtime and the need to send appropriate technicians. Even in cases when on-site repair is necessary, the product itself provides information on what is broken and what components are needed, reducing service costs and raising first-time fix rates (Porter & Heppelman, 2014).
Further elaborating on service optimization, smart products' remote monitoring capabilities allow to obtain information on their location, condition and usage, as well as to diagnose possible faults and problems in advance, opening up opportunities of preventive maintenance (Baines & Lightfoot, 2013) by deploying predictive analytics techniques. Moreover, their usage data enables better "design for service", which reduces the complexity of parts that are prone to failure and thus simplifies repairs (Porter & Heppelman, 2014), and sometimes allows to identify and address design problems that initial testing did not expose (Porter & Heppelman, 2015).

It should be clear how in this new paradigm data has become both a necessity and a driving force for businesses. However, it is not sufficient by itself (Skylar 2019), as in designing Digital Servitization strategies, changing customer relationships and value proposition modifications can be equally significant.
In this regard, according to Vendrell-Herrero et al. (2017), digital technologies "disrupt the way product firms compete and offer services, changing employment relations and increasing

firm productivity", and play a crucial role in the management of relations between different stakeholders (Skylar, 2019), altering all the activities across the value chain.

An area of business in which smart products can have a radically disruptive effect is customer interactions, as according to Paiola and Gebauer (2020) "IoT technologies can improve manufacturers' visibility of activities in customer-specific contexts, leading to a better understanding of users and improved strategies". Smart and connected products enable firms to develop much tighter *customer relationships*, allowing to better segment customers and create tailored offerings accordingly, customize products based on individual clients' preferences, and set prices to better capture value. With regard to value, companies can also exploit usage data for improving positioning and obtain more effective value communication to customers (Porter & Heppelman, 2014), as well as learning from them and adapting to their individual and dynamic needs (Coreynen et al., 2017)

In this scenario, the focus on customer relationship shifts from selling, which is often just a onetime transaction, to maximizing the customer's value from the product over time, adding importance to the final outcomes that derive from the product-use and to its ongoing performance, rather than the single transaction (Baines & Lightfoot, 2013). Consequently, the goal of salespeople becomes establishing an ongoing dialogue and providing customer success over time. Companies can use all the data generated from products to learn more about customer experience, and specifically about customer preferences and satisfaction, in order to prevent defections and reveal where a customer could get benefits from additional product capabilities or services (Porter & Heppelman, 2015).

Finally, smart products can act as enablers of different BMs in the Digital Servitization context, creating a substitute for ownership-based business models, and making companies switch from transactional selling (Porter & Heppelman, 2015) to non-ownership-based models, as for instance pay-per-use, subscription or sharing models (Paiola & Gebauer, 2020). Porter and Heppelman (2014) identify three newly enabled Business Models:

- Product as-a-service model: the manufacturing firm maintains ownership and takes complete responsibility for the costs of product operation and service in return for an ongoing charge. Here the profitability depends on the ability of the manufacturer to capture the value of improvements in product performance and service efficiencies, and on the pricing and terms of contracts

- Product sharing: in this model products are used intermittently by different customers, who pay for the use of the product when they need it, while the company retains responsibility for the cost of maintenance and every other aspect. This is the typical case of car or bike-sharing services, but is also spreading to nonmobile products such as houses
- Service contracts: the manufacturing firm maintains the service in-house and looks at capturing additional value from service efficiencies. One type of service contract is a performance-based contract, in which the company does not only sell the product, but also the assurance that it will perform to certain standards. In this case the ownership is transferred, but the manufacturer maintains responsibility and its profitability is connected to product performance, with possible penalties in case of shortcomings

2.1.3 Other Enabling Technologies

Up until this point we focused on Smart Products and the Internet of Things as enablers for digitalization and digital servitization, but there are several other technologies that can play a key role in facilitating the process.

The advent of the fourth industrial revolution, or Industry 4.0, has been powered by various foundational technology advances, such as Industrial IoT, Big Data and analytics, Additive Manufacturing, Cloud Computing, Autonomous Robots, Artificial Intelligence, Augmented Reality, and more (Rüßmann et al., 2015). Most of these technologies have had an important function in allowing manufacturers to improve their internal processes and operations, enabling enhanced productivity and industrial growth, and in giving birth to the so-called smart factories, but these considerations lie beyond the scope of this research.

We will focus instead on the digital technologies that have had a more profound effect on the way firms handle and design better and expanded service strategies.

We have already described *IoT* as a set of intelligent communicating devices that are seamlessly integrated in a broader information network, allowing for better collaboration at multiple levels and enabling improvements in fulfilling and even exceeding customer needs, thus increasing profitability (Rymaszewska et al., 2017). We also talked extensively about the importance of data, for which Big Data technologies are an essential driving force, as they allow to examine and analyze large data sets to uncover hidden patterns, unknown correlations, market trends, customer preferences and other useful insights (Martinelli et al., 2019).

Artificial Intelligence (AI) is another technology with interesting implications for service provision. Artificial Intelligence is defined by Encyclopedia Britannica (2020) as "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings", and is strictly connected with the concept of *Machine Learning*, intended as the autonomous learning of computers from experience and data, without human intervention.

AI can be a very precious resource for firms, allowing to better estimate and manage risk factors, identify the probability and impact of certain events, and providing decision-making tools for making informed and watchful choices (Bellini, 2019). It can also help service providers to better understand customers, thus allowing for improved service customization and value co-creation, to manage new product development decisions and to offer more personalized service interactions (Paschen et al., 2020).

AI and ML have strong predictive capabilities which can be fundamental in identifying relevant trends, customer needs and future consumers' consumption patterns. Together they enable and maximize the effectiveness of as-a-service models and integrated solution provision (Casali, 2019).

The other fundamental technology that enables the provision of digital services is *Cloud Computing* (CC), which is defined as "a model for allowing ubiquitous, convenient, and on-demand network access to a number of configured computing resources (e.g., networks, server, storage, application, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Hashem et al., 2015).

According to Hashem (2015), Cloud Computing presents several advantages, including enhanced security and integration of data, virtualized resources, and parallel processing, as well as operational advantages such as reduced infrastructure maintenance cost, efficient management, and user access.

In the Servitization context, CC enables three service models (Ardolino et al, 2018):

- Infrastructure as a Service (IaaS), which provides access to a remote infrastructure that end users can configure to install and run operating systems and applications
- Software as a Service (SaaS) that refers to software applications running on a remote cloud infrastructure, which users can access directly through the Internet
- Platform as a Service (PaaS), which consists in providing computing platforms that allow to develop, test, and implement applications, without incurring in hardware and software-associated costs

2.2 Digital Servitization and DPSS

2.2.1 From Servitization to Digital Servitization

In the first paragraph of this chapter we provided a definition of the concept of Digital Servitization and explained what are the main supporting technologies that make it feasible at an organizational level, but besides for the already mentioned digital infrastructure, we still have not explained in detail in which ways it differs from traditional servitization.

According to Vendrell-Herrero et al. (2017), there are three elements that differentiate digital servitization from mainstream servitization, which are:

- Compared to traditional services, the marginal cost of digital services is near to zero
- Traditional services are usually complementary to a product offering, while digital services are often substitutes for classic products
- Digital technologies, like other disruptive technologies, open up new business opportunities for new entrants, such as hardware and software developers or retailers

They argue that digitalization is a driver for developing cost-efficient operations and higher-quality services, as it allows better allocation of resources and more accurate information sharing across firm boundaries.
On this respect, digital methods may create opportunities for different types of service innovation (Coreynen et al., 2017) and further advance servitization by enabling sophisticated and novel service offerings (Paschou et al., 2020).

In moving towards digital servitization, digital technologies play a key role in increasing strategic and operational effects of classic servitization (Paschou et al., 2020), which can result in new challenges for traditional manufacturing strategic culture, impacting substantially on the value distribution, creation of value and capture mechanisms of business models, with the bearing of risk that shifts from the end-user firm to the manufacturer (Paiola & Gebauer, 2020).
Other important factors affecting the degree of service digitalization are two firm-specific attributes, namely size and share of sales from exports. Large corporations are more likely to have the necessary resources and competences for offering digital services, and international orientation goes hand in hand with digital opportunities, as they allow remote-controlled services, and thus downstream activities, to be offered independently from the location (Lerch & Gotsch, 2015).

According to Paschou et al. (2020), digital servitization can enable new busines models, create new strategic assets and competitive advantages thanks to data and information, provide novel ways for value co-creation, and improve the firm's operational and environmental performance.
They believe it can bring several benefits to customers, allowing for better differentiation, access, flexibility, and customization, and to solution providers, by improving efficiency and effectiveness of maintenance, enhancing customers' perception of the company and increasing customer lifetime value and profitability. Moreover, they suggest that digital servitization can also create benefits for the environment, by reducing energy consumption and environmental impact and helping the transition towards a circular economy, and deliver more value to society as a whole, fostering the well-being of citizens.

It becomes clear how digitalization and servitization, although possibly being pursued by manufacturers as separated trajectories, present a strong link between each other (Vendrell-Herrero et al., 2017), as a developed service orientation that includes more complex service offerings typically demands for digital solutions to a greater extent, with more support needed from smart ICT solutions (Lerch & Gotsch, 2015).
In the first chapter we have seen that in traditional servitization manufacturers move along the product-service continuum (Oliva & Kallenberg, 2003), but Lerch and Gotsch (2015) argue that in digital servitization there is another dimension to be considered, as the transition path is influenced by both digitalization and servitization at the same time, and shaped by the individual characteristics and activities of the manufacturer.
Hence, they present a model which encompasses both dimensions:

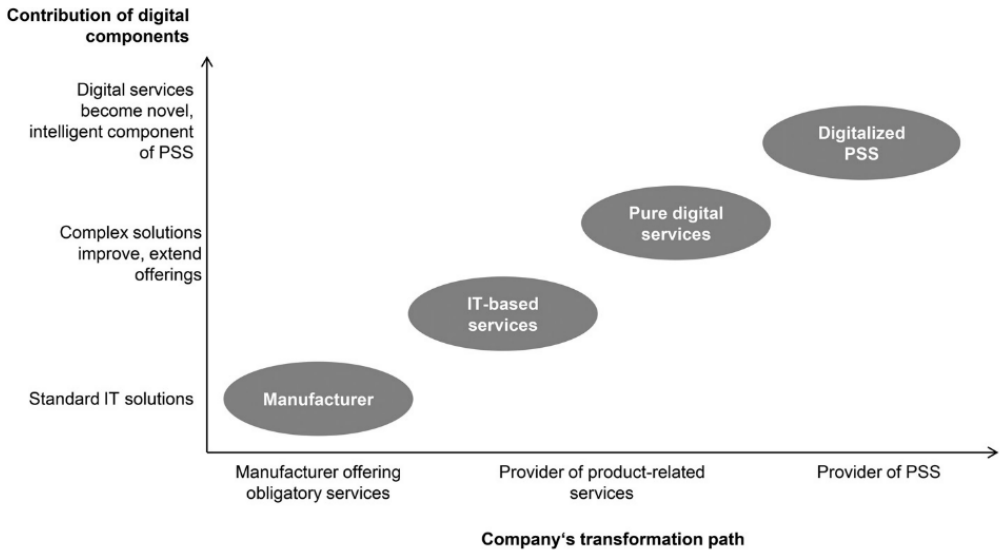

Figure 3 – Servitization-digitalization transformation framework

The transformation model is made of four stages:

1. *Manufacturer*: In this first stage, they provide obligatory product-related services, such as installation or maintenance and repair, and deploy standard ICT solutions to support services, which are used for daily work but have almost no impact on offerings differentiation
2. *IT-based services*: Here ICT solutions are employed to improve existing service offerings, for instance with teleservices, the monitoring and controlling of machines over distance. At this stage, companies are able to provide higher quality, faster, and less resource-consuming services
3. *Pure digital services*: At this stage, companies offer novel services enabled by ICT systems, that on one hand extend the company's service offerings and on the other significantly enhance the performance of the core offering's product or service
4. *Digitalized PSS*: In this final stage manufacturers provide complex PSS that also incorporate ICT solutions, creating intelligent, independent operating systems that deliver the highest level of availability possible and enable the optimization of operations while reducing resource inputs

We can see that in this last stage Lerch and Gotsch (2015) introduce the concept of DPSS, which will be further explained and analyzed in the following section.

2.2.2 DPSS

In the first chapter we introduced the concept of PSS, described as a combination of products and services created to satisfy a specific customer need (Tukker, 2004). Here we will take a step further and look at how digitalization influenced and reshaped this concept and led to the emergence of new types of PSS, that are called DPSS.

DPSS, Digitalized or Digital Product-Service Systems, are defined by Lerch and Gotsch (2015) as "an integrated bundle of physical products, intangible services, and digital architectures designed to fulfill individual customer needs via automated, independent operation, with the goal to significantly improve customer outcomes".

In their work they identify three types of DPSS:

- *Smart Service Delivery*: It improves the service process itself, by shortening the time and reducing the required resources, consequently decreasing the costs associated with

the service offering. Smart service delivery typically provides support for maintenance and repair, optimizing service processes and maintenance schedules through intelligent systems that communicate their service needs, allowing companies to avoid breakdowns. It mainly improves the intangible component of the PSS.

- *Smart Product Optimization*: It deploys digital technologies such as digital remote monitoring and supervision services to optimize the performance and efficiency of the core product. Smart optimization may save resources or increase the output or capacity of the product during operation, thus delivering increased value to the customer and creating a competitive advantage. It mainly improves the physical component of the PSS.
- *Digital Brain*: It is the most sophisticated form of digitalized PSS, in which digital and physical systems come together to deliver comprehensive remote services. These systems deliver important information to the provider, that is used during research and development and fed back into the innovation process in order to improve the next generations of products and service offerings. Such activities upgrade the level of autonomy, independence and efficiency of the DPSS, either through software updates or new physical or service modules, thus benefitting the customer.
  The digital brain improves both the physical and the intangible part of the PSS

DPSS differ from classic service offerings as they have a high level of automation, the ability to forecast maintenance needs and likely failures (Lerch & Gotsch, 2015), and because they can carry out various value-added activities, like monitoring, configuring and optimizing the product range (Adrodegari et al., 2020)

Overall, DPSS can simplify the digital servitization path of a firm and create new revenue streams based on the provision of advanced services, like collecting useful data for the manufacturer and the value-chain to meet service contract terms, monitoring the service key performance indicators to clearly show them to the customer, and accounting for the service price in case of advanced pricing models (Butti, 2020).

In general, advanced services can be described as complex value propositions in which the manufacturing firm aims at providing performance outcomes to clients, and can be seen as substituting services that replace the purchase of the product (Baines et al., 2020).

In this context, DPSS are often offered through outcomes-based business models, in which revenues depend on the level of efficiency of the product-service bundle (Lerch & Gotsch, 2015).

According to Adrodegari et al. (2020), DPSS enable several new services, which differ from one other because of their price (or gratuitousness in one case) and based on which actor is bearing the risk. They identify the following typologies:

- *Service for free:* the final customer is not willing to pay for the digital service, at least until it provides economic benefits to its business. Here the service is provided for free
- *Premium service:* the final customer is willing to pay for high-level services, but the digital component is not sold separately, but integrated in the annual assistance package
- *Full risk:* the final customer is willing to subscribe to a full-risk contract to receive paid assistance services, as the contract transfers malfunction operating risks to the manufacturer. Monetization on the digital component is absorbed in the price of the advanced service
- *Service for fee:* the final customer is willing to pay for the digital monitoring service, as it solves a major and recurring problem for them. The digital service solves a real problem of the client, for which they are willing to pay

We have seen that DPSS can play a major role in facilitating the servitization path of a firm and in building tighter relationships with customers, as well as in revolutionizing the value creation process in manufacturing in general, but their development does not come without effort, as their creation requires close collaboration between manufacturers and electronic equipment providers (Lerch and Gotsch, 2015).

2.3 DPSS-enabled Business Models

Digital servitization and DPSS have a great importance in enabling firms to build new and different business models and value propositions to better address their customers' needs. According to Kiel et al. (2017), Industrial IoT and digital technologies have a profound effect on companies' value offers and existing networks, as they reshape collaborative relationships and human resources needs, shifting the role of employees from operators to problem solvers, and thus altering their organizational structures. These dynamics change the way in which firms compete between each other and create value for their customer, fostering the emergence of new business models.

Numerous authors have studied and analyzed the various typologies of BMs that are made possible by the combination of digitalization and servitization, and in this paragraph we will look at some of the most preeminent frameworks that are presented in the literature.

In particular, we will take into account and present the typologies identified by Kowalkowski et al. (2015), Suppatvech et al. (2019) and Kohtmaki et al. (2019).

2.3.1 Kowalkowski's Typologies

In their 2015 publication Kowalkowski, Windahl, Kindström and Gebauer challenge the service transition assumption and identify three different service-led growth trajectories, which lead to different roles, each representing a possible business model configuration.

In this framework digitalization serves as a catalyst for all the trajectories, as it enables smart services and is fundamental for the creation of integrated solutions, changing the way in which firms compete with each other.

Kowalkowski et al. resume the research of Helander and Möller (2007), who argue that manufacturing firms typically start offering services as equipment suppliers, which means that the focus remains on product sales and that services are product-oriented, transactional, and standardized, as they simply play a supporting role for the product business.

Departing from this consideration, they identify three roles as possible outcomes of the service transition, namely availability provider, performance provider and industrializer, and argue that most suppliers do not completely transition into new roles, but rather expand trying to become more of a certain role.

Availability providers are suppliers that started expanding from basic to more advanced services to differentiate themselves from competitors , trying to increase customer loyalty and ensure more stable revenues streams.

The first step in this transition is the bundling of products and services previously sold separately, for instance with more extensive service level agreements, such as maintenance, repair, and overhaul services. However, not many firms move beyond these bundled offerings, and some are able to become availability providers only to a limited number of their customers.
Some of the facilitators of this trajectory are separate service units, top management attention, and customer maturity, whereas barriers include internal resistance, lack of overview and coordination, and product-centric sales force, as well as the difficulty of charging for services that were previously provided for free.
A practical example is using sensor technologies which capture real-time information of product usage, to offer services focused on customer processes and asset efficiency.

Performance providers strive to offer even more advanced solutions that solve strategically important customer-specific problems, typically long-term objectives, with the aim to better meet customer demand, build strategic partnerships and sometimes achieve lock-in effects. Compared to availability providers, in this trajectory compensation becomes linked to the customers' value-in-use and business targets to an even greater extent.
General enablers include long-term customer relationships, common interest to share 'pains and gains', and risk mitigation capabilities, while increased operational and financial risks, and increased need to coordinate with third parties, are some of the main obstacles.

Finally, *Industrializers* depart from customized operational solutions, such as long-term service agreements and equipment rental, and make the most of the knowledge and experience accumulated in the more complex, resource-demanding and relationship-intensive offerings, by downsizing them and standardizing various elements, thus being able to expand the offering to more customers.
Economies of scale, utilization of in-house knowledge and resources, and the potential to address a larger customer base are some of the key drivers for this standardization process, which is enabled by deep customer knowledge, long-term service experience and modularization capabilities. Barriers include lack of internal resources, managerial attention, and ability to standardize and scale up solutions.

2.3.2 Suppatvech's Typologies

Suppatvech, Godsell and Day conducted a systematic literature review in 2019 in which they identified four archetypes of business models that are enabled by IoT and digital technologies.

In the *Add-on business model*, IoT is used to enable additional functions or adding personalized services to the existing physical products or service, giving rise to four possible business models:

- Innovative digital service BM: physical products are integrated with sensor-based digital services, in order to create a hybrid offering and offer new value propositions for customers
- Facilitate service provision BM: here IoT is deployed to simplify existing product-related or service provisions that increase efficiency and decrease complexity of the delivered service, for example helping to process customer orders more efficiently
- Leverage customer data BM: the service provider is able to offer customized services or integrated offerings by utilizing information obtained from customer during the use of a specific product
- On-demand BM: customers are able to require and immediately get access to an additional service or information during the use of a product. An example is the remote control of distant objects through smartphones or personal devices.

In the *sharing business model*, customers are charged for using or accessing a product for a limited amount of time, allowing different users to continue using the product when available. Firms can benefit from increased asset utilization, but they also retain responsibility for providing sufficient products available for utilization.
Although it is conceptually similar to renting, with ownership that remains with the provider and continuous user changes, in this model the changes are more frequent and the use periods shorter, as the objects (often vehicles, like cars or bikes) do not need to be returned after each use, thus precluding the need for booking requirements. Mobile applications can play a major role in allowing more accurate use tracking and payment.

In the *usage-based business models*, IoT enables to measure the amount of product usage and allows customers to pay for or subscribe to a plan, on the basis of their actual usage needs, with the provider who retains responsibility of delivering the expected utility in use. Within this background, providers can adopt two types of business models:

- Pay-per-use BM: digital technologies are used to monitor and measure the product during its usage, and the customer is only charged for the actual consumption of the product or service

- Subscription BM: customers pay a fixed fee to get unlimited access to the product or service, restricted to the time span of the subscription

Finally, the *solution-oriented business model* refers to the utilization of IoT to provide advanced or integrated solutions to customers, which in B2B relates to supporting customers' core operations and increases in efficiency, and expanding business capabilities. Two types of solution-oriented business models are identified:

- Availability BM: customers are guaranteed continuous utilization and uninterrupted usage of products that provide a certain utility, with the providers who are responsible for product maintenance, operational support, and for ensuring that the products are constantly able to provide the specified utility without disruptions. Here IoT feeds providers with real-time information that helps to offer better product maintenance
- Optimization/Consulting BM: providers create solutions or give advice to customers for their core business operations, by using IoT to monitor current product usage and analyze patterns of operations, not only ensuring product availability but also supporting customer's processes and operations. In this case customers typically sign long-term contracts to obtain the integrated solution, instead of buying ownership of a machine, thus optimizing production and increasing asset utilization

2.3.3 Kohtamaki's Typologies

The last framework regarding digitally enabled BMs that we will analyze is the one provided by Kohtamaki, Parida, Oghazi, Gebauer and Baines in their 2019 publication.
They adopt the perspective of the theory of the firm to understand and build four different digital servitization business models, arguing that there are a variety of dimensions that can be used to construct digital offerings in this context.
They identify three fundamental dimensions that shape the offerings:

1. Solution customization: it represents the transition from standardization to customization in offerings, with value that gets created by tailoring the product, service, or software solution to the customer needs. This dimension can play a significant role on the effectiveness and efficiency of the BM
2. Solution Pricing: it refers to the ability to capture value through the chosen pricing logic, which could be product oriented, agreement oriented, availability oriented, or outcome oriented

3. Solution Digitalization: this dimension refers to the level of digitalization and technological advancement in the design of the smart solution. Here the core features of IoT come into play, with solutions that vary in their degree of autonomy, moving from simple monitoring, to control, optimization, and finally complete autonomy

These three dimensions influence the type of business model configuration that a firm can adopt, and as we can see in the figure below, five typologies of BMs are outlined.

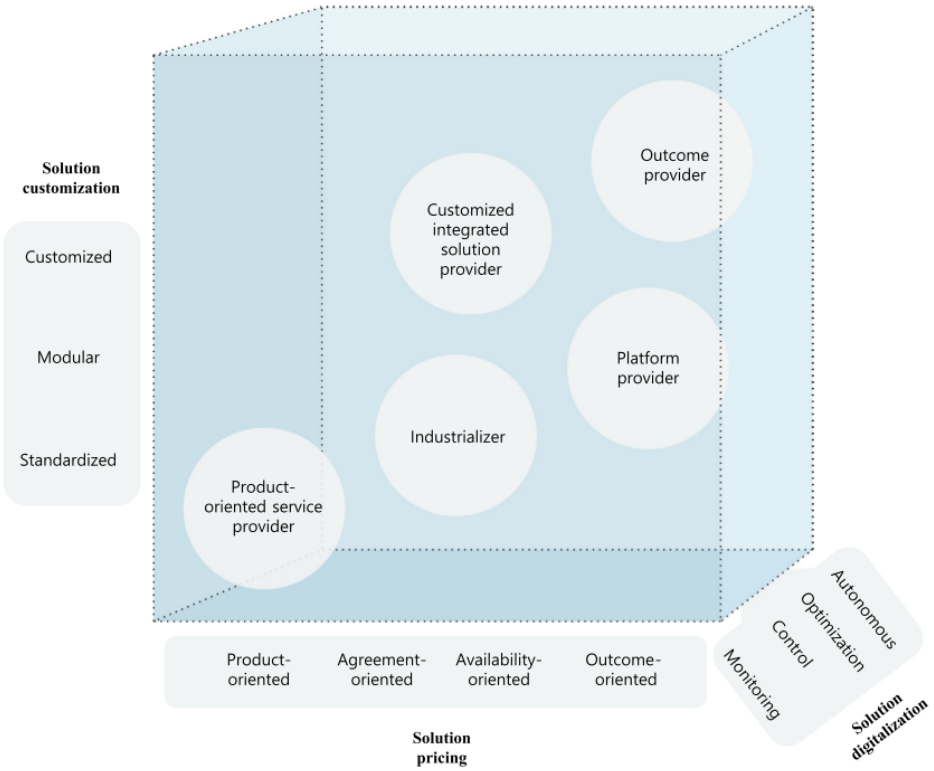

Figure 4 - Characteristics of solution offerings in digital servitization BMs

*Product-oriented service provider*s resemble a traditional product BM, as they are firms which offer products and add-on services. The capabilities they need are mainly efficient design, manufacturing, and delivery of products, with a service portfolio made up of quite basic services. These firms are trying to evade the commoditization trap and do not have a lot of bargaining power with customers, as the latter typically have low switching costs.

Industrializers attempt to increase product and service modularity to improve the efficiency of their processes, by combining effective solution customization with efficient order delivery. These firms should emphasize their capabilities in modularity, as their bargaining power is based on relatively low prices combined to some degree of efficient modular customization.

Their identity is still strongly built on manufacturing, with engineering playing an important role in the company's culture.

Customized integrated solution provider are companies that focus on integrated product-service solutions, stretching the importance of availability and customization. They use their capabilities in digitalization, like monitoring, control and optimization, to sell, design and deliver unified lifecycle solutions. Deep knowledge of customers and partner companies' equipment and processes are fundamental to develop such solutions, as well as the ability to integrate technologies from different firms.
Their bargaining power is mainly based on knowledge integration to create and retain value from customers or customers' customers.

Outcome provider is a business model in which, instead of products or services, providers sell outcomes and retain ownership of the product, actually selling the value created by it. These companies need to be able to accurately measure the generated performance, and to do so they require precise monitoring and control of the fleet of products, which in turn allows to continuously optimize equipment and processes.
Outcome-based BMs set very high capability-requirements for solution providers, as well as the need for tight collaboration with other actors in the ecosystem and continuous technological development to be able to provide performance.

The last digitally enabled BM is *platform provider*, in which the company creates a platform that connects various providers and customers. The digital platform helps to share information, facilitate exchanges, and monitor, control and optimize products and services, allowing for the reduction of energy consumption and waste by effectively deploying economies of scope. Platform providers typically have strong bargaining power because of the services usage data they collect, which they can exploit to create new business opportunities
In the platform context, digital technologies show the potential for using automation to minimize transaction costs.

2.4 Emerging challenges of Digital Servitization

Along to the path towards digital servitization there are several challenges that need to be addressed, which might hinder the transition towards the provision of digital services.
In the first chapter we have seen some of the classic obstacles associated with traditional servitization, and in this paragraph we will notice how digital servitization presents some similarities in terms of challenges, as well as some new ones connected with the deployment of more advanced technologies.

Some of the general challenges that are frequently linked with digital servitization include the complex nature of IoT products, which increases the need for direct and intensified contact with customers, as well as the degree of difficulty in designing appropriate IoT-based service contracts, where the lack of experience tend to make them incomplete and subject to adjustments and modifications over time (Paiola, 2017).
According to Kohtamaki et al. (2019), some typical challenges of servitization are present also in this new digital variation, such as customers expecting smart solutions to be customized to their needs, wanting to buy hardware instead of outcomes, and having a general hesitancy when it comes to trying out really innovative smart solutions.
Another aspect to be considered is the importance of company's culture in accepting and embracing digital technologies and a service-centric view, as manufacturers that previously produced and sold hardware now have to handle software development and data mining. This requires a shift in the mindset of both employees and upper-level managers, who should assume a customer's viewpoint and take into account their problems, requirements, and expectations (Kiel et al., 2017).
Technical issues, such as problems deriving from the relative immaturity of the technology itself, or the lack of compatibility of the systems among all the different stakeholders in the service network, must also be considered (Suppatvech et al., 2019).

While trying to provide a more comprehensive framework, Marcon et al (2019) claim that there are some challenges related to approaching digitalization in general, and they identify the existence of three major types of barriers that can hinder digital servitization, namely strategic, operational and human resource barriers.

Strategic barriers refer to strategic issues, such as market-related issues, like market acceptance and market entrance, where service-oriented models may create uncertainty and time-to-market is essential, with technologies that could easily be copied by competitors.

Belonging to this category are also customer needs, for which close relationships are fundamental and new provider-customer interaction skills need to be developed (Suppatvech et al., 2019). Moreover, collaboration is also highly required among different stakeholders in the manufacturer's ecosystem, and they could struggle with maintaining the relationships, and with coordination costs and risks (Kohtamaki et al., 2019, Suppatvech et al., 2019).
Other challenges pertaining to the strategic barrier are governance, with possible decision-making issues, having a short-term vision and neglecting the potential of digitalization, and aspects related to risks, transparency of information, and trust in the context of data confidentiality (Marcon et al., 2019).

Operational barriers include functional aspects of digitalization, such as the financial elements, with rising costs for IT facilities, software and platforms associated with IoT (Kiel et al., 2017), and the need for high capital investment, in terms of notable expenses related to product design, sensors insertion and data implementation in the IoT infrastructure (Suppatvech et al., 2019). Data security is also a major concern, as with the threats of hacking and lack of confidentiality, data protection mechanisms become essential for safeguarding customers' privacy and preventing unauthorized access, data manipulation and data destruction (Kiel et al., 2017, Suppatvech et al., 2019).
Other aspects related to operational barriers are the industrial context, the life cycle and obsolescence of digital technologies, as well as the need of appropriate tools, infrastructures, and resources (Marcon et al., 2019). Finally, usage must be taken into account, in terms of the need for data management skills and expertise and compatibility with current technologies (Marcon et al., 2019, Suppatvech et al., 2019).

The last challenge is represented by the *human resource barriers*. These barriers include training and the need for specific digital competences, with employees operating in this area who need to possess specific IT, development, data analytics, and software knowhow. Therefore, firms need to focus on technical education, but also not overlook market expertise, as it is essential to explain, sell and convince customers of the benefits of smart products, or it could create some acquisition and consultation challenges (Kiel et al., 2017).
Other challenges related to HR barriers are the view that employees have of digital technologies, as they might fear of being replaced by machines, and the resistance to change with respect to an established company's mindset (Marcon et al., 2019)

Chapter 3 – Ecosystem Role in Enabling Digital Servitization

Up until this point we analyzed the servitization process and digitalization phenomenon by adopting the perspective of a single manufacturer, without focusing too much on the importance or influence of external stakeholders in this context.
Taking one step further, we can start to broaden the view and take into account the countless actors that are directly or indirectly involved with the transition towards the provision of services and digital solutions, giving rise to an ecosystem concept in which the focal firm needs to be able to manage different interactions to successfully accomplish its goals and objectives.

In doing so, we start off in the first paragraph by describing what are the fundamentals shifts and organizational changes that a company has to go through in order to explore this new trajectory and become a service provider.

Secondly, we introduce the ecosystem concept, provide its definition and strategic implications, expanding the range of issues and opportunities that a firm should consider when approaching a servitization pathway.
In an ecosystem, a key role is played by the embeddedness of its actors, as well as the levels of centralization and integration that the focal firm present in its organizational structure. A further elaboration of these concepts is presented in the paragraph regarding the Ecosystem Role.
At the end of the paragraph are also presented some examples of who the external stakeholders of the ecosystem may be, along with their importance in supporting the focal firm and in fostering value co-creation and relationship learning.

3.1 Organizational changes for Digital Servitization

As we have previously discussed, modern manufacturers have the chance to foster their servitization strategies by deploying the seemingly endless possibilities offered by digital technologies. However, it is important to underline that technologies themselves are not the only enablers in the path towards service provision, as corporate culture renovation and organizational restructuring play a fundamental role for this transition.
More specifically, while pursuing digital servitization strategies manufacturing firms necessarily go through a series of transformational changes that allow them to modify their business structure and adapt to the challenges that this trajectory implies.

These organizational shifts have been presented by Tronvoll, Skylar, Sörhammard, and Kowalkowski in their 2020 publication, named "Transformational shifts through digital servitization". In this paper they adopted a discovery-oriented, theories-in-use approach, and conducted in depth interviews with senior managers and executives from their selected case study firm, which is a global market leader in the provision of maritime solutions.
With this approach, they identified three aggregate themes, which represent the three dimensions that enable the transition from traditional and siloed firms to digitally-servitized firms. These three dimensions are labeled Identity, Dematerialization and Collaboration.

Identity refers to the self-perception of a firm's core business and operations. In order to approach digital servitization, a company must understand the importance of continuously developing new digital initiatives and technologies, and instill this vision in all its employees, as a mean for maintaining a competitive edge over competitors.
The transformation of the identity of a company depends heavily on two mechanisms, that are *legitimization* and *agility*.
Legitimization is the mechanism that allows to justify digital servitization efforts to key stakeholders, both internal and external, creating a vision of how the company and its customers will operate in the future, with clients' close involvement deemed to be essential. In this phase, the presence of change agents is very important: they are resilient individuals who support the transformation process and help to win over people who were initially doubtful or hesitant about it.
The other requirement for identity transformation is agility, intended as the ability to develop and pilot things faster, to quickly switch direction and make adjustments, and to adapt to the fast-changing environment around the organization. Emphasis is also put on disciplined management structures to maintain the changed mindset.

Dematerialization refers to the fundamental role played by data and information, compared to physical products and equipment, in enabling digital servitization.
Fostering dematerialization requires an extensive focus on data, and specifically on the importance of *data-centricity* and *data-related opportunities*.
Data-centricity includes data-enabled properties, mechanisms, and activities, which enable to recombine data in different ways and create new service offerings. It requires novel employees' capabilities in terms of digital skills and handling unprecedented amounts of data.
Data-related opportunities relate to the fact that data is very flexible and can be used in different and creative ways to allow for new and better service provision, without the necessary homogenization to pre-constructed business model typologies.
To give an example, data could be used for solving a customer problem, saving costs, or creating a packaged solution that automates a service previously provided by an operator.

Collaboration refers to interactions between the firm, its customers, and other partners, aimed at giving rise to an array of co-creation activities, all of which are facilitated and reinforced by the new digital infrastructure.
During collaboration, different actors come together to pursue joint activities and give life to relevant value propositions, for which companies typically exploit their in-depth customer knowledge.
Working with external partners becomes essential in expanding the scope of digital offerings, in what is called Multi-actor coupling. These partners are not limited to suppliers and customers, but could include universities, research centers, and academic institutions, as well as, for specific purposes, competitors and rival firms, and other relevant stakeholders.
Effective collaborative efforts allow to access new knowledge sources and improve internal company's practices, thus improving the level and quality of delivered services and strengthening the relationship with clients, increasing loyalty and trust.
In this regard, a key enabler for digital servitization is *reciprocal value proposition*, which relates to core offerings that are driven by customers themselves. It requires transparency and advanced knowledge of customer needs, and it can improve coordination and the alignment of relevant stakeholders.

We will further elaborate on this collaborative perspective later on in the chapter, while talking about the importance of different stakeholders in a firm's ecosystem.

These three dimensions of Identity, Dematerialization and Collaboration, are the drivers that enable the path towards the provision of digital services, changing the company's identity from planning to discovery, moving from data scarcity to data abundance, and finally shifting the organizational structure from hierarchical to partnership-based.

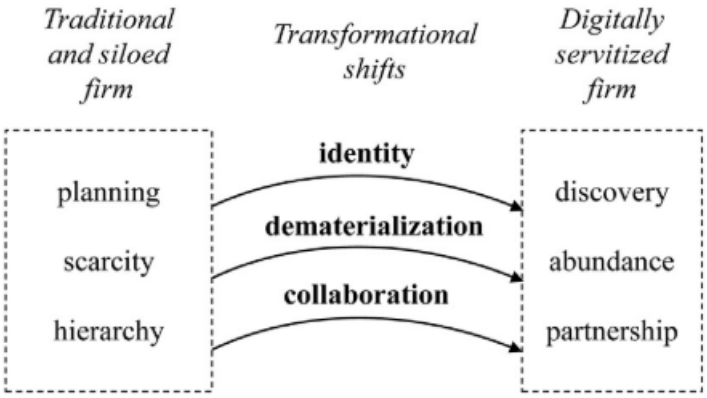

Figure 5 - Transformational shifts for digital servitization

The first transformation requires cultural openness to digital technologies, to mutate the firm from a planning-oriented identity to a more discovery-oriented identity, shifting the focus on new ways of working facilitated by technology. We have seen that legitimization and agility are two critical elements for building trust, service culture, and customer focus, and for coping with the fast-paced development life cycle of new digital products.

The second transformation is from data scarcity to data abundance: while traditional firms have always seen data as something to protect, digitalization has made data transmission cheaper and more reliable, creating a state of abundance, and thus inviting firms to share such data with trusted stakeholders and explore new opportunities.
This in turn created the need for more qualified employees who possessed digital and analytics skills, making dematerialization and data management capabilities become critical elements to create a sustainable advantage in the new competitive scenario.

Finally, the third transformation relates to breaking the silo mentality and shifting from hierarchy to partnership, as service transformation depends also on actions of actors that are beyond the firm's boundaries. Here building trust and enhancing firm's reputation are extremely important for a successful transition.

3.2 Ecosystem Role

From the analysis of the organizational changes that a manufacturer has to go through to become a digitally servitized firm, a clear picture emerges, specifically that companies need to redesign their corporate culture and start taking into account the multitude of actors in the external environment that can influence their competitiveness and ability to create adequate service offerings for their customers.

In particular, the last transformational shift entails the adoption of a collaborative approach towards relevant stakeholders, implying that partnerships and external support are vital for a firm's success in the competitive landscape.

Within this background emerges the concept of ecosystem, originally defined by Moore in 1996 as "An economic community supported by a foundation of interacting organizations and individuals", which also includes "…customers… suppliers, lead producers, competitors, and other stakeholders…" who, over time, "…coevolve their capabilities and roles, and tend to align with the direction set by one or more central companies" (Adner, 2017).

Paiola and Gebauer (2020) also assert that a company often requires an ecosystem of suppliers, complementors, and stakeholders, to get support in exploiting IoT technologies and thus borrow competences that the firm does not possess internally.

Below we will address the conceptualization of the Ecosystem notion, mainly based on Ron Adner's work, published in 2017.

3.2.1 Ecosystem as a Structure

According to Adner (2017), the definition provided above refers to the concept of ecosystem-as-affiliation, which emphasizes the importance of the actors linked to a focal firm, the relationships between them, and the rise of interdependence in the ecosystem.

Adner provides a more structuralist approach to ecosystem, which emphasizes instead value creation and the associated value proposition, then determines the essential activities which will shape and produce such value, and only afterwards identifies the relevant actors to carry out these activities. This approach starts with the value proposition, and then looks at identifying the set of actors that need to interact in order to realize the proposition.

He therefore defines the ecosystem as "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize", and then proceeds to disentangle the different elements of the definition.

The “alignment structure” refers to the defined positions and activity flows that members of an ecosystem have among them, and the extent to which they have mutual agreement regarding such positions and flows: different actors may have different end goals, but for an ecosystem to be successful, all of them should be satisfied with their respective positions. In this regard, digitalization can help to align ecosystem actors, improve coordination, and foster collaboration between established partners, generating new service and partnerships opportunities among different stakeholders (Skylar et al., 2019).

“Multilateral” means that for the ecosystem construct to matter there must be a set of relationships among a multiplicity of partners, and that these relationships cannot be decomposed to an aggregation of bilateral interactions.

The “set of partners” implies that membership is defined, which does not mean that it is complete, unvarying, or uncontested, but rather that the participating actors in the system pursue a joint value creation effort as a general goal. Partners can be defined as such if their participation is essential for the value proposition to come about, even if they do not have a direct link to the focal firm.

Finally “for a focal value proposition to materialize”, refers again to the fact that here the value proposition is placed as the foundation of the ecosystem, the essential element that defines the endogenous boundaries of the latter. The focus on the value proposition naturally expands the analysis to explicitly incorporate partners, who may have in any case divergent interests on value capture and value creation.

It is important to distinguish the concept of ecosystem from the notion of interorganizational networks, where ecosystems mainly emphasize value creation and capture between interrelated firms, while interorganizational networks are often described as hybrid forms between markets and hierarchies, with a higher level of integration compared to the market, but lower compared to a hierarchy.
Ecosystems typically emerge when there is a shift towards IoT and smart connected solutions are developed, allowing to move beyond single-firm boundaries. They are not necessarily organized as interorganizational networks, as they are indifferent to whether exchanges are coordinated through markets or network-type mechanisms. Therefore, ecosystems could well be organized as markets (Kohtamaki et al., 2019).

In Adner's vision, ecosystems consist of four basic elements, that collectively characterize the configuration of activities and actors required for the realization of the value proposition:

- Activities, that are the various actions that need to be carried out in order for the value proposition to materialize
- Actors, which are the entities that undertake the activities. It is possible that a single actor carries out different activities, or vice versa that multiple actors undertake a single activity
- Positions, which specify where system actors should locate themselves in the flow of activities, and characterize who is responsible for what, and to whom
- Links, that are transfers across different actors, and may include materials, information, influence, or funds

Table 3 – Elements of Ecosystem Structure

Elements of Ecosystem Structure

Elements of Ecosystem Structure	Ecosystem-as-Structure Perspective	Ecosystem-as-Affiliation Perspective
Activities	Discrete actions to be undertaken in order for the value proposition to be created	Not applicable
Actors	Entities that undertake activities	Entities that are tied to the focal actor
Positions	Specified locations in the flow of activities across the system	Derived from links to other actors
Links	Transfers across positions, which may or may not include the focal actor	Ties between the focal actor and other actors

While in the affiliation approach positions are derived from links, in the structural approach links derive from the alignment requirements, which in turn give rise to positions in the overall value blueprint. The former approach focuses on actors who are directly tied to the focal organization, whereas the latter explicitly expands the strategic view to include activities and actors over which the focal organization may have no control, and with whom they only have indirect contact.
Most of the times in mature industries the ecosystem is latent, as activities, actors, positions, and links are stable over time, but when innovation occurs, a change in the configuration of these elements is set in motion and ecosystems dynamics become crucial.

Adner (2017) argues that several concerns arise around the alignment that needs to take place for the ecosystem to come forth, specifically how the alignment will occur, who will take a

leadership role in guiding the transition and who will accept the role of follower, and what rivalries will need to be managed.
Therefore, he defines a firm's ecosystem strategy as "the way in which a focal firm approaches the alignment of partners and secures its role in a competitive ecosystem".

The "alignment of partners" refers to the ability of the firm to bring its partners in the positions and roles that its strategy envisions. In order to do so, the company needs to recognize gaps and create the conditions to fill them.
A series of gaps can arise from activity-based challenges of the partners, specifically co-innovation risks, which is the challenge partners face when they have to develop and carry out new activities for the sake of the venture, and adoption chain risk, which relates to the willingness a partner has in undertaking such activities, raising questions of priorities and incentives. Gaps can also arise from partners' expectations, in particular structural expectations, regarding what are the positions in the ecosystem, and role expectations, which regard the leader-follower dyad.

"Secures its role" directly connects with the above-mentioned expectations, as it means assuming the role of leader of the ecosystem, which implies setting and enforcing governance rules, determines timing, and obtaining the largest quota of gains. Successful leadership depends on willing followership, as without consent there can be no appropriate alignment. Shared leadership can also be a possibility in certain types of ecosystems.

An important distinction exists between competitive strategy and ecosystem strategy, where in the former the focus is on creating a competitive advantage and keeping rivals at bay, while in the latter it is on the search for alignment and maintaining critical relationships.
In an ecosystem strategy, the focus expands to consider partners who have a critical role in creating value, while the view of competition does not only include rival firms, potential entrants, and substitutes, but also rival ecosystems that offer similar value propositions. The example of Uber is illustrative in this case, which finds its rival ecosystems in other ride-hailing business models, but also in traditional taxi service models (Adner, 2017).

Competitive, corporate, and ecosystem strategies can present strong connections and interdependencies between each other, for instance leveraging the relationship with a partner in one setting to obtain a better position in a different setting, or making specific acquisitions to simplify repositioning and alignment in the ecosystem.

In this context, digital servitization may entail changes in the whole service ecosystem, emphasizing how social and economic actors cocreate value in a specific context (Tronvoll et al., 2020).
Firms need to figure out which skills, capabilities, and technologies available in the ecosystem best complement and support their business operations, as well as how much to rely on and how to structure relationships (Dahlström et al., 2017), in order to provide a unified vision and goals to benefit all the participating actors (Skylar et al., 2019).
It is also important to note that, within a single firm, there could be various activities that are necessary for realizing the value proposition, thus requiring multiple efforts for alignment, with different divisions of an organization appearing at separate positions in the ecosystem.

3.2.2 Embeddedness, Centralization, and Integration

We have seen that in deploying an ecosystem strategy, collaborative efforts of intrafirm and interfirm actors are essential, and a fundamental component of this collaborative process is its embeddedness.
According to Granovetter (see Skylar et al., 2019), embeddedness is the assertion that "economic action and outcomes, like all social action and outcomes, are affected by actors' dyadic (pairwise) relations and by the structure of the overall network of relations".
Embeddedness is important for the ecosystem because it influences actors' actions and the outcome of their relationships, impacting the overall structure of the ecosystem itself.
In the digital servitization context, such relationships are for instance established when companies look at acquiring or partnering with software firms for smart products initiatives, adding new perspectives and talent to their organization (Porter and Heppelman, 2015).

According to Skylar et al. (2019), embeddedness in a relationship depends on three levels:

- level of closeness, which refers to the frequency of contacts between actors
- level of adaptation, intended as being flexible with partners and sharing strategies and decisions
- level of trust between factions, which is the foundation for collaboration and is reflected in the degree of transparency

Relational embeddedness presents differences if it is considered intra-firm, or between different firms of the ecosystem.

In intra-firm relational embeddedness, the focal actor accesses and combines resources from its corporate counterparts, and it influences their knowledge and competences depending on how strongly it is internally embedded. In this case, the focal firm acquires most of its service knowledge by deploying in-house development and operations, thus maintaining more control over labor and domain-specific expertise.
On the other end, externally embedded firms rely on other actors in the ecosystem to get support in their digital servitization initiatives, which could be challenging when those actors are very large and powerful, when they compete for the same customer relationships, or if they have the same goals in terms of servitization processes (Skylar et al., 2019).
Embeddedness also requires awareness of changes that can happen in an ecosystem structure, with actors that are closely embedded (thus sharing resources, knowledge and skills to a greater extent), that need to adapt to such changes, modifying their activities in accordance to each other, including service development and production processes.
Here digitalization can help in reconfiguring the necessary resources to respond to the exogenous changes of the ecosystem (Skylar et al., 2019).

Beyond embeddedness, the mechanisms of centralization and integration play a key role in the ability that a firm has to organize for digital servitization.

Centralization refers to the degree to which decision-making responsibilities are concentrated at the top levels of an organization.
Typically, product-centric firms that pursue servitization place more emphasis on local service operations and decentralization of decision-making authority, but in the case of digital servitization, centralization and standardization of service processes are deemed to be essential for a firm's success.
Centralizing allows to enhance global efficiency and responsiveness to customer needs at the same time, as it supports coordination of back-end product and service units with local customer-facing units.
Managing digitalization centrally enables to ensure software platform consistency and data quality, as well as to face cybersecurity challenges and support local units, making it easier to engage with actors in the ecosystem and to strengthen integration inside and beyond the boundaries of the firm.
Some centralization initiatives include the creation of pools of commons resources and the introduction of key IT competences (Skylar et al., 2019).

Finally, integration refers to the coupling between front-end and back-end, and between product and service units, inside of an organization.
Along with a service centric mindset, integration is critical to secure the benefits of digital servitization, as it allows to obtain the needed IT resources that are often unavailable at the local level because of the considerable investments required. In this sense, integration is strictly correlated with centralization, as a greater degree of integration between central and local units is a key for providing more advanced service offerings, with central-local integration allowing for better resource allocation and local support (Skylar et al., 2019).

The table below summarizes the main contingencies and organizing activities that are related to the embeddedness, centralization, and integration mechanisms.

Table 4 - Key contingency factors and organizing activities for digital servitization

Theme	Contingency factors	Organizing activities
Embeddedness	• Market dynamics, rules, and competition • Ecosystem characteristics • Position in the ecosystem • Digitalization-related issues and expectations	• Close collaboration with internal and external parties for digital servitization, given the high dynamism and complexity of digitalization. • Setting out a comprehensive vision for digital servitization prepares employees for change and brings key stakeholders on board. • Sharing knowledge and information via digital platforms further supports trust and continuous interaction across parties.
Centralization	• Administrative heritage of operating and organizing globally • Local organizations' competences and degrees of freedom • Intrafirm readiness for transformation	• Centralized decision-making and strategies scale up digital servitization through maintaining management structures, practices and routines. • Ensuring that critical IT competences are available locally requires their global centralization. • Sharing digital tools and resource pools across the firm for transparency, benchmarking, and comprehensive digital servitization initiatives. • Achieving scalability of technologies enables digital servitization across the firm.
Integration	• Separation, power, and collaboration of product and service organizations • Front-end and back-end roles and responsibilities • Prevailing product-centric or service-centric mindset	• Front-end integration through creation of digital centers with global customer support allows all customer-facing technology to be unified. • Integration of back-office functions and roles allows structuring of data and interconnection of information across the firm. • Close collaboration between service and product organizations and consolidation of their R&D efforts enable digital servitization. • Moving toward software independence from the firm's products extends the scope of digital servitization.

3.2.3 Importance of External Stakeholders in Value co-creation

We have seen that there is a whole ecosystem of actors who influence the way the focal firm approaches digital servitization, with different stakeholders providing support and paving the way to new opportunities and challenges.
Technological capabilities are essential in enabling a company to provide digital solutions for its customers, but these capabilities may not always be present within the boundaries of the firm's skills and knowledge portfolio. In such cases, firms must look outside of their own organization, search for companies who can facilitate their transition towards the provision of digitally-servitized offerings, and consider building partnerships with external firms (Tronvoll et al., 2020).

In this instance, manufacturers should define their boundaries and position in the ecosystem, and determine what value-adding activities should be performed internally, and which ones should be outsourced instead (Huikkola et al., 2020), as competitors are also investing in digital servitization to strengthen their position and increase market penetration (Skylar et al., 2019).
Servitization calls for a redefinition of a firm's corporate identity and for new capabilities. This does not relate only to technology, but also to system integration, project management, consulting, finance, delivery, and after-sales service, as well as coordination, learning, and relational capabilities (Huikkola et al., 2020). All these competences could be either developed internally, or through the support of external stakeholders.

Examples of relevant stakeholders include suppliers, partners, distributors, providers of digital solutions, other manufacturing firms, customers and more.
These stakeholders may affect the firm's performance and capabilities directly or through the intervention of third parties, while other actors, such as governments or other institutions, are more likely to have an indirect impact by means of laws and regulations.
Other important stakeholders are schools, universities, and research centers, which could provide organizations with advanced knowledge and skills. Educational institutions also play the essential role of building and developing the new generation of workers: firms may decide to partner with them in order to fill particular skills needs by offering specific training courses, whose participants would later become employees who possess the required competences. A prime example of this is offered by Cisco with its Networking Academy, a CSR initiative created in partnership with schools, governments, and non-profits organizations, thanks to which millions of students learn ICT skills every year (Moorhead, 2019).

For manufacturing firms, suppliers of digital solutions and services might be the most important stakeholders, because they allow them to go beyond their existing capabilities and implement IoT, AI, and other new technologies within their products and operations.
Within this background, companies must make a decision concerning what layers of technology should be developed and maintained inside of the organization, and which ones should be outsourced to partners. The most successful companies often choose a combination of the two, as both internalizing and outsourcing present advantages and disadvantages (Porter & Heppelman, 2014).

On one hand, companies that develop smart products within the organization are more likely to internalize key skills and infrastructure, maintaining a greater control over features, functionality, and product data, as well as possibly getting first-mover advantages and influencing the future direction of technology development. On the other hand, doing everything internally might be very challenging, as it requires considerable skills, time, and costs, while outsourcing might prove to be easier and faster.
However, outsourcing leads suppliers to demand for a larger share of the value created, thus increasing the costs for the focal firm, which might also compromise its innovation and learning capabilities.
In this scenario, companies should identify and internalize the technological elements and knowledge that are most crucial for their competitive advantage going forward, and outsource the components that are more likely to become commoditized (Porter & Heppelman, 2014).
As we will see in the following chapter, firms often choose to rely on external partners in the early stages of their digital servitization path, but later look at internalizing the most critical skills for the continuation of their efforts, in order to become independent from their digital suppliers.

In building relationships with external stakeholders, the co-creation of value becomes possible between suppliers and client firms. Grönroos and Voima (2012) define value co-creation as the "joint process whereby firms and customers together, in interactions, create value", and argue that it is likely to happen in contexts regarding KIBS (Knowledge Intensive Business Services), which are manufacturers' product-related services that develop knowledge for building customized solutions, as they support customers' innovation and ongoing interactions between suppliers and clients (Kohtamaki & Partanen, 2016).
Co-creating value from KIBS requires relationship learning, which is defined by Selnes and Sallis (2003) as a " joint activity between a supplier and a customer in which the two parties share information, which is then jointly interpreted and integrated into a shared relationship domain-specific memory", thus involving knowledge sharing, joint sense-making and integration (see Kohtamaki & Partanen, 2016). Relationship learning has the potential to improve suppliers' performance in the context of KIBS, by increasing its understanding of customers' needs, improving its customization capabilities, and enabling the co-creation of value, which leads to enhanced customer experience, satisfaction, and loyalty.
In order to implement relationship learning mechanisms, account managers need adequate tools and resources to develop appropriate mechanisms and integrate customers in the value creation process (Kohtamaki & Partanen, 2016).

Chapter 4 – Empirical Investigation

In order to more comprehensively grasp the effects related to pursuing innovative servitization pathways, and to get a better understanding of the impact that different actors in the ecosystem have on the adoption and implementation of digital strategies, we decided to conduct an empirical investigation based on qualitative data from multiple case studies.

The object of the study includes companies that are currently pursuing new service strategies by following an approach based on emerging digital technologies such as IoT and AI. The driving motivation behind this research is to understand to what extent external actors and stakeholders, and specifically suppliers of digital solutions, play a key role in enabling manufacturers to implement such strategies and sustain them over time.
The research question may therefore be formulated as *"How does the external environment influence the way the focal firm approaches a digital servitization pathway , and specifically what is the effect of external actors of the ecosystem on the focal firm's ability to implement digital service strategies?"*.
Collecting qualitative data also allows to further elaborate on other themes that have emerged in the previous chapters, mostly the importance of developing a service-focused mindset and the relevance of implementing digital technologies to revamp established businesses.
In this investigation, we chose an approach for data collection based on conducting semi-structured interviews with knowledgeable representatives from the selected companies. This approach will be further detailed in the following sections.

This chapter will focus on illustrating the main findings connected with this empirical research, laying the foundations for presenting the conclusions of the thesis.
The first paragraph deals with explaining the methodology of the research, describing the chosen case studies and the methods used for collecting and analysing the data.
The second paragraph is centered on outlining the main outcomes of the investigation, presenting a series of thematic areas, and analysing the similarities and differences in the approaches adopted by the companies.
Finally, the third paragraph will deal with the discussion of the results, illustrating the connections between the theoretical assumptions and the empirical findings per each of the identified thematic areas.

4.1 Methodology

4.1.1 Methods and sample description

The chosen methodology for this empirical investigation is a cross-case analysis based on multiple case studies.

According to Yin (2018), adopting a case study methodology is particularly appropriate when three conditions are in place, namely that the research question is formulated as a "how" or a "why", that the study requires no control over behavioral events, and that it focuses on contemporary rather than historical events. These three conditions are satisfied in this investigation, as the research question is formulated as a "how", studying the influence that certain conditions have on a specified phenomenon, and the study is contemporary and based on interviews with people currently involved in the events.

Moreover, according to Bryman and Bell (2011), the case study approach is a very popular and widely used research design in business research, as it can facilitate the understanding of complex social phenomena (see Skylar et al., 2019), which makes it notably fitting for studying an emerging concept such as digital servitization. In particular, multiple case studies are recommended for exploratory research because they give more robust results compared to a single case study and provide more detailed data on managerial challenges (Yin, 2018; Paiola & Gebauer, 2020).

The collection of data occurred through semi-structured interviews with key-informants and top managers of the companies, with the aim of getting detailed information on the kind of DPSS (Digital Product Service Systems) adopted by the firms, the potential use of such technologies with respect to services, and the influence of the external network of actors on DPSS' adoption.

Semi-structured interviews are based on an interview guideline, which is a list of questions on quite specific topics to be covered, but the nature of the interview is open-ended (Yin, 2018), leaving a certain level of freedom to the interviewee in their replies (Bryman & Bell, 2011). On one hand, this approach allows for a considerable degree of adaptability, emphasizing the sensemaking process of the interviewee, which consists of how they frame and understand issues and events, and affects the way they explain them. On the other hand, among different types of interviews, semi-structured interviews are the most appropriate for the purpose of our investigation, as in the case of multiple case studies they ensure better cross-case comparability (Bryman & Bell, 2011).

In our specific case, the interview guideline was intentionally designed as quite flexible, allowing for further elaboration of concepts expressed by the interviewees, as well as the possible emersion of new questions during the interviews.
The interviews were performed through online video conferencing software, such as Zoom and Microsoft Teams, and were conducted in Italian. They lasted an average of around 50 minutes each.
As mentioned above, respondents include managers at various level and positions in the selected companies, and specifically in charge of service or technological activities, including general managers, business development executives, software managers and R&D officers.

For what concerns the choice of the companies to analyze, the sample is based on the previous research project of Paiola and Gebauer (2020). In their research, between the end of 2016 and the end of 2017, they collected data coming from key informants in 25 Italian manufacturing companies belonging to different industries.
Their original criteria for selecting the companies were that firms had to be BtoB companies headquartered in Italy, with at least one IoT project related to their installed base, and willing to recognize and commit to the research work, providing access to relevant information and knowledgeable informants.
For the purpose of this investigation, out of this sample we extracted a sub-sample that included some of the companies which demonstrated greater activity in terms of Business Model Innovation based on Digital Transformation.
We were able to get in contact and schedule interviews with representatives of six companies, which ultimately constituted the sample for our work.

The six selected companies are all headquartered in the North of Italy, with three companies based in the Veneto region, two in the Lombardy area, and one in the Emilia Romagna region.
All firms in the sample can be classified as large companies according to the Ministerial Decree of 18 April 2005, posting annual turnovers that range from 150 million to 1.5 billion euros, and with hundreds or in some cases even thousands of employees.
Starting from this premise, the selected companies still present a certain degree of heterogeneity, as they all produce different types of machines and equipment and operate in diverse sectors.

Here below is presented a table which illustrates some of the main facts and figures about the selected companies, collected through the Aida[1] database. It also includes, for the purpose of this analysis, the digital technologies implemented by each of them, as well as the role of the interviewee in the company and the duration of the interview.

Company	Sector	Turnover (2019)	Number of employees	Implemented technologies	Interviewee's role	Interview duration
Company A	Manufacturing of Machinery for pharmaceuticals and cosmetics Packaging	1595 mil.	5949	IoT, Cloud	Business Development Director	43'
Company B	Manufacturing of Machinery for stone-working	279 mil.	855	IoT	Intelligence Manager, Software Division	1:13'
Company C	Manufacturing of pumps and compressors	185 mil.	346	IoT	General Manager	55'
Company D	Manufacturing of electrical and electronic equipment for motor vehicles	161 mil.	794	IoT, Big Data, Cloud	Business Development Manager	57'
Company E	Manufacturing of Heating and air-conditioning equipment	148 mil.	603	IoT	Corporate R&D Officer	59'
Company F	Packaging of plastic articles	219 mil.	1011	IoT, Cloud	Machinery General Manager	20'

Table 5 - Main characteristics of the interviewed companies (From Aida)

4.2.1 Data analysis

For the purpose of the analysis, all the interviews were recorded and subsequently transcribed, in order to conduct a detailed analysis and ensure that the interviewees' answers got captured in their own terms. The procedure of recording and transcribing interviews is particularly useful as it helps to correct our memories' natural limitations, allows more thorough examination of what people say and permits repeated examinations (Bryman & Bell, 2011). After transcription, the interviews were reread multiple times and we conducted a summarization of the most relevant parts for the purpose of our investigation.

[1] Aida (Analisi Informatizzata Delle Aziende Italiane) is a database developed by Bureau Van Dijk that contains comprehensive information on approximately 1 million Italian companies.

From this summarization, we were able to identify some emerging thematic areas and discern them in seven distinct key factors, that enable better comprehension of the companies' intentions with regard to services, digitalization, and relationships with external stakeholders. These seven main thematic areas are specified in section 4.2.
To follow up, we grouped relevant sentences from each interview into the identified thematic areas, and codified the various remarks made by the interviewees into approaches, in order to better grasp similarities and differences between the companies.
For the purpose of this codification process, we translated relevant concepts and sentences from Italian to English, obtaining a first table containing short descriptions of the different approaches. The table is included in Appendix 1.
From this first table, we operated a reduction aimed at synthetizing the initial approaches into a few key sentences or keywords. The result is a second table, that is the one presented at the beginning of the following section, containing a summarized version of each approach.

The approaches are the starting point for the cross-case comparison and analysis, which highlights common aspects among the companies and outlines some distinct traits or initiatives that specifically distinguish one from the other.
To enrich the comparisons and further complement information coming from the interviews, we also adopted a data triangulation approach (Yin, 2018). In this respect, the information from the interviews was in some cases integrated with secondary data sources, such as articles and companies' websites, to provide an increased level of detail in outlining the findings.

The findings are illustrated in the following paragraph, while section 4.3 deals with the discussion of the results, showcasing the connections between the theory presented in the first three chapters and the empirical findings, and laying the foundations for the conclusions.

4.2 Findings

Table 6 – Identified factors and companies approaches

	IoT and Digital Tech	Services and *Remote Monitoring*	Importance of Data and *Data Security*	Internalization of Competences and *new HR Needs*	External Resources and Stakeholders	Customer Relationships	Costs and Revenue Models
Company A	Development of remote-control center. Importance of connecting products. Expansion of digital services. Implementation of ML and analytics.	Offering excellent service 24/7 and developing a new service-focused mindset. *Provide remote services and personalization.*	Accumulation and integration of data. *Deployment of advanced data security systems.*	Internalization of digital competences. Greater reactivity and flexibility. *Adding data elaboration and BD experts.*	Strategic partnerships with platform and technology supplier, system integrator. Possible outsourcing of specific technical competences. Creation of training courses for developing needed professional figures.	n/a	n/a
Company B	Provide learning opportunities through IoT. Use of ML and data driven mechanisms.	Inclusion of services in products. Development of integrated packages. *Using platform connectivity for monitoring.*	Accumulation of production and process data. Considering data as very valuable. Importance of managing data internally.	Importance of importing know-how. Autonomy on value-adding activities. Hiring consultants to mentor internal employees. Externalization of less valuable activities. *Hiring data mining and ML experts, salespeople experienced in software sales.*	Importance of networking and collaboration opportunities. External actors as technology suppliers. Cross contamination of ideas. Using external consultants when lacking vertical competences in a non-critical sector.	Focus still on selling machines. Clients' low familiarity with services. Importance of maintaining brand image.	Possibly going towards a pay-per-use model. Machines' additional functions shrink marginality.
Company C	Developing connectivity solutions for data insights on machine functioning. Saving costs. Future implementation of AI for analytics.	Importance of service-centric mindset. Different salespeople for products and services and balancing priorities. Focus on providing great service quality.	Enormous quantity of data produced by their machines. *Privacy challenge. Hesitancy of customers to embrace connectivity or share data.*	n/a	External partner develops physical products. Company provides qualification. External suppliers provide added value with ideas and product development.	Importance of relationships and creating value for customers. Maintenance as great business opportunity. Providing advantages for customers.	Possible model of service plan Performance contracts, with firm managing every aspect in the PLC.
Company D	Digitalizing clients' machines. Providing remote assistance. Expanding number of connected plants. Planning the implementation of sensors and smart technologies in their devices.	Deployment of more focused service assistance compared to bigger companies. Offering a much greater level of attention to clients. Better customization.	Accumulation of data and upload on Cloud. Idea of monetizing on data. Enhancement of machines performance through data analysis.	Importance of maintaining internal know-how. Building applications with the internal personnel. Appreciation of employees' proactivity. *Possible addition of User Experience experts and data analysts.*	Aiming at having different small system integrators. Importance of participating in networking opportunities. Outsourcing less strategic activities. Leaving freedom to suppliers on the technology used.	Client's willingness to spend on smart technologies is not always guaranteed.	Currently deploying a fee model. Need to reduce internal fixed costs to create more margins on services.

Table 6 (Continuation)

Company E	Criticality of IoT. Improving products functionality. Monitoring to improve efficiency and durability. Allowing to use smartphone and devices to control functionality from a distance.	Possibility of predictive maintenance. Monitoring of components breakdowns and functionality losses. *Allowing users to control products remotely.*	Future extension of data base for performing data analysis. No current homogeneity of data. *Importance of privacy, safeguarding clients' data safety.*	Transferring external consultants' work inside of the organization. *Searching for an electronic or informatic engineer. Challenge of finding an IoT expert.*	Working with suppliers to develop product connectivity. Development of a Cloud platform with Vodafone for machine connection. Possible partnership with Enel. Outsourcing of all electronic systems, but keeping customizaiton. Idea of outsourcing data analysis.	Allowing customers to directly handle products functionality. Direct relationship with final clients. Devices allow to know clients' behavior and ubication.	Costly to add connectivity modules to low-end devices. Focus on using Wi-Fi modules to decrease connectivity costs
Company F	IoT to be carried on as a separate project. Connecting any types of machines. Personalizing algorithms. Providing correct information to the final user.	Offering condition monitoring services to their clients. Prevention of breakdowns or other issues. Not aiming at predictive maintenance.	Negotiating with partners to connect machines. Possibility of obtaining info, reports, offering condition monitoring. Data monetization as future possibility. *Less clients' oppositions to data sharing.*	Importance of continuous learning. Requirement of high standards and example from top management.	Offering support to external companies for developing their connectivity solutions. Integration with companies that deal with processing, to offer a complete control platform. Possible outsourcing of maintenance activities to suppliers particularly close to final clients.	Importance of establishing trust relationships. Opportunities for cross-selling. Customer relationships and knowledge as a major asset.	n/a

4.2.1 Identified Thematic Areas

The table displayed in this page and in the previous one presents the different approaches the six companies of our sample adopted with respect to the seven key factors we identified.

These seven key factors are outlined in the first row of the table, and represent the main common thematic areas that emerged from the interviews with the companies' respondents. Such thematic areas consist of aspects that were touched in all or most of the interviews, either through direct answers to specific questions, or during the sensemaking process and vocal reflection of the respondents.

The seven thematic areas identified are: 1. IoT and Digital Technologies, 2. Services, 3. Importance of Data, 4. Internalization of competences, 5. External resources and stakeholders, 6. Customer relationships, and 7. Costs and Revenue Model.

Some of the thematic areas also include sub-categories.

The criteria for their identification are that they must be factors that were mentioned multiple times in the interviews and had relevance on their own, but can also be seen as part of broader thematic areas. With this respect, the identified sub-categories include Remote Monitoring (falling under Services, as it entails

providing services remotely), Data security (falling under Importance of Data), and New Human Resources Needs (falling under Internalization of competences, as it concerns acquiring new talents to bring inside the organization). For distinction purpose, in the table the key concepts and sentences related to these sub-categories are written in italic.
To complete the explanation of the table, as mentioned the first row contains the key thematic areas, the first column contains the name of the companies, and the cells contain for each of the identified factors the approaches adopted by every company, expressed in the form of few key sentences.

4.2.2 Main Findings

As a whole we can say that all firms in the sample have implemented *IoT and digital technologies* in their operations to a considerable extent, as they all believe that digital technologies are essential and will make a difference in the future competitive environment. Two companies have explicitly stated that they are planning the expansion of their digital service offerings and are looking forward to adding even more advanced technologies to their machines in the near future.
On the same note, half of the firms from the sample have affirmed their aim of implementing technologies such as Artificial Intelligence and Machine Learning algorithms, in order to improve their data analysis capabilities and better manage data coming from different sources. One company in particular expressed the willingness to create an entirely new business for IoT solutions, with the idea of building a separate project with a dedicated Business Unit, to explore opportunities in the sector.

For what concerns the concept of *services*, what emerges from the interviews is that all companies understand the importance of such notion and are currently trying to shift their internal focus to a service-centric mindset, to be better equipped for facing future challenges. On that note, Company A and Company C claim that services are still not given the level of attention they deserve, and that a profound renovation is required on that front.
In particular, the general manager of Company C stated that “in ten years, the service component is as valuable as the initial sale of the machine, but with much higher profits… thus when selling a machine, we potentially create an almost certain additional revenue… but with much greater marginality”. Consistently with these claims, the company deploys different salespeople for machines and services, in order to provide both with an appropriate level of focus and not overlook any opportunities.

Company D makes an interesting case about the level of attention that a smaller firm like them can give to their clients, compared to bigger players. In this sense, they highlight their ability of giving much more focused assistance on the services offered, allowing customers to save on costs and time.
On the side of *remote monitoring* and assistance, half of the firms of our sample have declared they are currently implementing remote services to some extent.
In particular, Company E has stressed their ability of offering predictive maintenance services on their client's machines, as opposed to Company F, which is not interested and still far from providing predictive maintenance, but can rather offer condition monitoring, controlling machines' parameters in real time and providing customers with key insights and urgent warnings.

With regard to *data*, all firms recognize their importance for succeeding in the digital era, but some of them are better equipped than others to collect and use data for their benefit.
Half of the firms from the sample have mentioned that they are currently using their proprietary platforms or tools to gather a lot of data from the machines deployed by their clients. Company A and Company B in particular rely on internally developed applications for collecting real-time monitoring data on machines' parameters and performance, with the aim of improving efficiency. On the same page, Company D uses Cloud technologies to upload data on an online storage, making it more easily available for the clients.
On the other side, handling data also presents several obstacles, with two companies highlighting the challenges connected with the quantity of data collected, and with their heterogeneous nature, which makes it sometimes difficult to analyze properly.
Other challenges, which are underlined by three companies from our samples, include ensuring privacy and security of data, in terms of preventing breaches and data losses, which also relates to convincing clients to share data.
With this respect, Company C and Company F reflect on how resistances and barriers on data sharing are beginning to fall within large client firms, as they are becoming more and more willing to find the proper system to connect their machines and start sharing data.
Company D and Company F also mention the aspect of data monetization, which they envision as the next step to take and the horizon in terms of data exploitation.
As a whole, it appears like data are perceived as a quite controversial topic, as all firms from the sample recognize their importance, but while half of them have a quite optimistic view on the opportunities connected with their collection and exploitation, the other three assume a more cautious stance and are more focused on the challenges they bring.

The next key factor taken into account is *internalization of competences*, which is an aspect that came up in several interviews, and is connected to the notion of ecosystem, as it represents the expression of the dichotomy "Do it inside" versus "Externalize".
Specifically, four interviewees have spontaneously mentioned the importance of internalizing key competences, and especially digital competences, or the ones that create the most value for the clients. On this note, Company B's software division manager has stated "On everything that creates a value for the customer, we need to be autonomous", while less valuable activities could and should be externalized.
In particular, three companies from our sample reported that they have been working with external consultants for some time, and are looking forward to transferring the relative know-how and specific skills internally. The aspect of mentorship emerged in these conversations, as the consultants should teach and provide their knowledge to the internal employees.
Company A summed up the advantages of developing solutions internally, saying that it makes the firm "much quicker and more flexible, able to implement changes whenever needed, and to solve problems more rapidly".
Following un on the concept of developing new internal competences, Company D and Company F also mentioned the importance of continuous learning at all levels of the firm, with top management that should lead by example and employees that could proactively provide suggestions for improvements.
Finally, related to internalization of competences is also the concept of acquiring new human resources, fostering the company's internal growth. On that front, four companies from the sample are looking forward to add new resources to their personnel, mentioning the need to acquire experts or knowledgeable people in the fields of IoT, Machine Learning, data mining, elaboration and analysis, Big Data, and User Experience.

The following thematic area, which is the one most directly linked with the concept of ecosystem, is *external resources and stakeholders*, that inherently refers to all the actors collaborating or having an influence on the focal firm's activities and operations.
With this respect, all companies from our sample work with multiple external partners and technology suppliers.
Two companies in particular have mentioned the importance of fostering networking opportunities, and thus maintaining relationships with all kinds of stakeholders in the sector, which can potentially open up new and unexplored possibilities of business.
Stakeholders can also supply valuable assets in the form of new ideas and different points of view, with this aspect being particularly underlined by Company C. On the same note,

Company D refers to the concept of cross-contamination of ideas among a firm and their business partners, as a mean to promote innovation and enable the growth of all actors involved in the exchange.

For what concerns the scope of the activities to be externalized, Company B and Company D unsurprisingly reveal that they aim at outsourcing all the less strategic activities, while Company F mentions the possibility of externalizing maintenance activities to suppliers who are closer to the final client. In general, three companies from the sample explicitly stated that they have been resorting to the support of external consultants or consultancy firms, and two companies have brought up the relevance of having system integrators to align different IT systems.

Partnerships are also possible with extremely large corporations and big players in the market. This is the case of Company E, currently cooperating with one of the world's top ten telecommunications companies, which helps them to improve their connectivity solutions by providing an integrated IoT platform.

On another note, external partnerships may be formed not only with the aim of developing a new solution, product, or service, but also with other purposes in mind. Such is the case of Company A, which is collaborating with other large organizations to provide education and specific training courses. The idea is to generate a pool of talent specialized in scientific disciplines, which will later help the company to fulfill their HR needs by providing people with the specific competences and skills required for higher level jobs.

An additional aspect of this thematic area is touched by Company F. According to their Machinery General Manager, the relationships that manufacturing firms develop do not necessarily need to be unidirectional, in the sense that manufacturers should not only look at receiving support from suppliers of digital solutions, but should instead focus on how they can develop digital competences and know-how internally to become digital solutions providers themselves.

This is an approach that Company F has started adopting, with the idea of using their more advanced position in terms of digitalization to provide support and guidance to other companies and help them develop their own digital solutions.

Company F also provided a final remark on the role of external actors, stating that "the ecosystem is changing, not only at a competence and service level, but also because you need to balance such competences and services in different places and different countries", highlighting how ecosystems are not simply constellations of local actors, but have evolved and reached a much greater scope than ever before.

Another aspect that was mentioned during multiple interviews is *customer relationships*, which is as well partially related to the concept of ecosystem, as customers probably represent the most important stakeholders for a firm and the ones who have the most influence on its decisions and business trajectories.

In this respect, half of the firms from our sample highlight the importance of establishing close and durable customer relationships.

Company C and Company E in particular mention how relevant it is to be in habitual contact with clients and to build direct relationships, which enables to obtain more information about them, provide them with more advantages, and in general to serve them better and with a higher level of customization. On the same page are Company A and Company D, which underline their ability and willingness to personalize services and machines according to individual user needs.

Furthermore, Company C and Company F remark that being close to clients also creates opportunities for cross-selling and in general to foster future sales. Company C's General Manager summed it up by stating that "everything is done to become more connected with the clients, to sell more services, if we want to take into account just the economic perspective… but besides the profits, there is much more, that is the relationship with the client".

On the other hand, Company B reported a more challenging aspect of the relationship with customers, specifically that some clients are still not necessarily familiar with services, and thus that for such group the focus should remain on selling the machines and maintaining the brand image. On the same note, Company D highlights the challenges of selling advanced technology to clients, who in some case might still be reluctant and unwilling to spend more for additional functions and smart devices, as they still do not fully grasp the potential and the benefits connected with their use.

The seventh and final thematic area that emerged from the interviews is *Costs and Revenue Models*, which was mentioned less compared to other factors, but is still interesting to take into account as it entails the more challenging aspects of implementing new technologies and reveals some interesting insights on possible business model configurations.

The choice of grouping together costs with revenue models is given by the fact that they are two interrelated aspects, as they represent the flow of financial resources within and outside the firm, and they both impact the companies' profit maximization strategies.

The main challenge here is clearly represented by the costs associated with digitalizing activities and products, and especially for what concerns the improvement of machines with additional functionalities and connectivity modules.

This obstacle was underlined by two companies of our sample, which mentioned that in some cases the costs to pursue such initiatives are not worth the investment, as adding new modules and functions may not meet the current needs of clients and could in fact hinder sales because of the higher sale prices of the improved machines. On this note, Company B explicitly stated that "It is not because the machine is very costly, that I can add additional costly modules into it, as that is where the marginality lies", with Company D adding that "To reach the break-even point, we need to reduce internal fixed costs, and only then we will gain from margins".
On the other hand, with respect to how financial resources enter the firm, three companies mentioned different types of contracts that they are currently or possibly trying to deploy. Company B revealed that their idea is to go towards a pay-per-use model based on a license-centric approach (rather than a product-centric one), by creating interesting packages that appeal clients and prepare them for a "use, and pay what you have used" mindset.
On the contrary, Company C mentioned that adopting a pay-per-use model is not yet seen as very feasible in Italy, as retaining ownership is still a very important aspect for entrepreneurs. On their side, Company C offers service plans, in which they take full responsibility for the functioning of the machines sold to the clients, so that they do not need to worry about breakdowns or malfunctions. In some cases Company C even offers rental contracts, where customers' pay only for performance and know in advance what will be the full costs associated with the machines, as they will not have to pay for additional maintenance or repairments.
Finally, Company D mentioned that they are currently deploying a fee model lasting five years on the leasing of their machines.

4.3 Discussion

In order to better sketch out the discussion of the results, we propose a table that sums up the incidence and importance of the seven identified key factors for each of the companies of the sample.

Table 7 – Incidence of key factors on each company[2]

	IoT and Digital Tech.	Services and Remote Monitoring	Importance of Data and Data Security	Internalization of Competences and New HR Needs	External Resources and Stakeholders	Customer Relationships	Costs and Revenue Models
Company A	***	***	**	**	***	/	/
Company B	***	**	***	***	***	**	***
Company C	***	***	*	/	**	***	***
Company D	***	**	***	***	***	*	**
Company E	***	***	*	**	***	**	*
Company F	***	**	**	*	**	***	/

The criteria to build the table was to grade each factor by the importance it was given during the interview, based on:

- If the manager of the relevant company explicitly stated the greater or lesser importance of a certain thematic area
- How much the manager of the relevant company spontaneously elaborated on that specific thematic area, giving it a lot of space during the interview, and thus implicitly communicating the importance of that particular factor

For the purpose of better structuring the discussion, we grouped some of the thematic areas together based on their level of interrelation and their overall affinity with key theoretical concepts that were presented in the first three chapters.

The following sub-paragraphs deal with linking the theory with the empirical discoveries, paving the way for the conclusions. We kept for last the section dealing with the concepts of Ecosystem and External actors, as it is the most important one for the purpose of this study.

[2] */ Factor not mentioned * Medium-low incidence ** Medium-high Incidence *** Very high Incidence*

4.3.1 Digital Technologies and Importance of Data

This first broader thematic area encompasses factors (1.) "IoT and Digital Technologies" and (3.) "Importance of Data and Data Security", as they both relate to the sphere of possibilities offered by Digital Servitization.

As we have explored in the second chapter, the phenomenon of Digital Servitization is fundamentally based on the emergence of smart devices and connectivity solutions, which have gradually enabled manufacturing firms to improve their back and front-end operations, as well as to develop innovative digital offerings (Coreynen et al., 2017).
This exponential growth in the number of connected devices was allowed by the emergence of the Internet of Things, the smart products described by Porter and Heppelman (2014 and 2015), capable of communicating among themselves and adapt their functioning to improve customer experience, and of generating real-time data and sending it back to the manufacturer for remote monitoring, control and optimization. Such smart devices permitted to foster the exchange of information, enabling for both better collaboration and better fulfillment of customer needs (Rymaszewska et al., 2017).

As we have seen in our empirical investigation, all case studies confirmed the importance of developing and exploiting IoT and digital technologies, with Company E even stating that "the whole IoT field is an important business, which will be essential for the survival of the company and to provide technologically advanced solutions".
By looking at Table 7 we can see that "IoT and Digital Technologies" is the only factor for which all companies have expressed the maximum level of attention and importance, as the focus given to creating and using IoT solutions was widely confirmed in all the interviews.
Manufacturers typically exploit IoT's connectivity to obtain key information within the end-user's activities and operations, which allows to improve solutions, foster dynamic capabilities, and develop new products and services (Paiola & Gebauer, 2020).
In this sense, all firms from the sample have developed IoT modules to be deployed in certain machines lines they sell, and have even built DPSS solutions.
Specifically, referring to Lerch and Gotsch (2015) typologies, the analyzed firms provide examples of "Smart Service Delivery", as in the case of Company B, which is able to optimize and accelerate service processes, and of Company C and Company E, which offer advanced predictive maintenance services.

On the other hand, Company A, Company B, Company D, and Company E are good examples of "Smart Product Optimization", as they all deploy digital remote monitoring services, sending alerts to their clients in case of excess of specific KPIs and providing support for improving machines' efficiency and performance.
As a whole, all companies from the sample are looking at improving their ability of delivering digital solutions, with Company A and Company D in particular planning the expansion of their digital service offerings in the near future.

With regards to other advanced technologies, in the second chapter we also described Artificial Intelligence and Machine Learning for their predictive capabilities of relevant trends and customer needs (Casali, 2019), as well as Cloud Computing, which presents several advantages when it comes to the provision of digital services, as for instance virtualized resources, enhanced security and integration of data.
In this respect, several firms from our sample have stated their intention of implementing AI and ML algorithms and techniques to improve their analytics capabilities and data management.
For what concerns Cloud technologies, five out of six firms are currently using them to a considerable extent, especially Company D that is regularly uploading data to make it more easily accessible to clients. Even the sixth firm, Company E, is foreseeing their implementation in the near future, with its Corporate R&D Officer explicitly reporting that "As soon as we will have enough data available, having a Cloud will become fundamental, also for handling and simplifying privacy issues".
As stated by Hashem (2015), cloud computing will be essential to store, access and process the enormous amount of data generated by smart products and devices more easily.

In relation to Data in particular, there were some mixed opinions among our interviewees, as all of them recognized its importance to thrive in the competitive environment, but not all respondents were equally optimistic about certain issues connected with data management.
In this context, Tronvoll et al. (2020) noted that the transmission of data has become cheaper and more reliable due to digitalization, facilitating firms in sharing such data with trusted stakeholders and in exploring new data-related opportunities.
In the second chapter we discussed about how the combination and integration of data from various sources enables to discover previously unknown patterns and to improve service quality based on updated customer information (Porter & Heppelman, 2015).

In particular, data coming from smart products and devices allows to perform service optimization and reduce costs, and it has been highlighted by Baines and Lightfoot (2013) as a key enabler for offering predictive maintenance.
With this respect, all companies from the sample mentioned their ability of offering either remote (or condition) monitoring or predictive maintenance services, which implicitly confirms that they have already been collecting and analyzing data for this purpose, but clearly some firms have more resources and are better prepared to use data at a larger scale. Specifically, Company A and Company B have been collecting real-time data from machines to increase their level of performance for the clients' benefit.
On the other hand, the interviews unveiled several challenges connected with data usage, as for instance the fact that data from different sources may not be homogeneous, which increases the complexity of its analysis, or issues related to privacy and security. With reference to these latter aspects, companies that are looking to exploit data for their purposes need to have the right technological infrastructure in place to guarantee the safety of such data and to ensure the security of clients' confidential information.
For instance Company A has developed an advanced cybersecurity solution through which they can physically interrupt communications between their remote-control center and all their machines deployed outside.
On this matter, the main takeaway from the empirical results is that all companies that want to increasingly exploit data should design appropriate technological solutions to ensure their protection and security, as this will be the only way to convince more and more clients to share their data.

4.3.2 Services

Services have been indeed one of the main focuses of this work, as the whole concept of servitization is based on the transition from being a pure manufacturer, to becoming a service provider as well.
We have seen in the first chapter that firms have been progressively shifting their focus from a product-centered logic to a service-centered logic, often prompted by customers' demands of more personalized solutions (Oliva & Kallenberg, 2003).
In this sense, according to Baines et al. (2009a) services enable companies to get to know their clients better, to develop more tailored offerings and to consequently improve customer retention rates.

This notion of services as a key driver for obtaining a competitive advantage is confirmed by our empirical investigation, with all companies sharing the vision that services and attention to clients are extremely important aspects, and that adopting a service-centric mindset should become a top priority for their organizations.
With this regard, Company A and Company C have mentioned how the potential of service sales is often underestimated, while they can actually be a very stable revenue source and present a lot of value to be captured (Wise & Baumgartner, 1999; Malleret, 2006; Raddats et al., 2019).
Specifically, Company C's General Manager explained how they experienced a profound internal renovation that over time made them completely reconsider the importance of selling services and becoming more service oriented, as services can yield much greater margins and profitability compared to products.

It is not surprising that all the companies from our sample share this vision on the importance of services, as the fact that they are involved with implementing IoT solutions means that they all have to deal with integrating services in their offerings.
On this note, digitalization can be considered a driver for the development of higher-quality services (Vendrell-Herrero et al., 2017) and more sophisticated service offerings (Paschou et al., 2020), facilitating different types of service innovation (Coreynen et al., 2017).
This directly relates to Lerch and Gotsch's (2015) "Company's transformation path" presented in the second chapter in Figure 3, where we have seen that digitalization and servitization often go hand in hand in the route towards becoming a provider of DPSS.
According to their trajectory, if we had to position our six case companies on the transformation path, they would all fit at the last stage of it, "Digitalized PSS", as we have seen in the previous section as well.
As a whole, we can say that strengthening a service-centric mindset and being able to implement appropriate digitalization strategies are indeed the most crucial aspects for all firms aiming at developing their own DPSS solutions.

4.3.3 Revenue Models

This section refers to the seventh thematic area, and specifically to the part concerning Revenue Models.

In the second chapter we reflected on the importance of digital servitization in prompting change in the environment and enabling companies to build new value propositions and business models to better address their customers' needs.
Looking back at some of the business models we explored in the chapter, such as "Performance providers" (Kowalkowski et al., 2015), "Solution-oriented business models" (Suppatvech et al., 2019), "Customized integrated solution providers" (Kohtamaki et al., 2019), we see that the concept of paying for the performance of the product is a recurring theme.
In "Usage-based business models" (Suppatvech et al., 2019) and "Outcome providers" (Kohtamaki et al., 2019), this aspect of paying for the output rather than the product itself is even more stressed, to the point that ownership is not transferred to the client and what is sold is instead the value created by the product. This was also reflected in the example of Rolls Royce from the first chapter, with their "Power by the hour" business model that was based on renting and on providing constant functioning and reliability of the product along its lifecycle (Baines et al., 2009a).

Our empirical investigation also brought some examples connected with these typologies of business models.
In particular, Company B has expressed their intention of moving towards a pay-per-use approach in the near future, creating a license-centric infrastructure, and in this sense they are trying to prepare their clients to switch to a "pay for what you have used" mindset.
This is also the case of Company C, that offers rental contracts to some customers in which they pay only for the performance and for the level of output they have actually used, without having to worry about reparations or problems with the machines.
This pure "pay-per-use" is strictly correlated with the "Usage-based" and "Outcome provider" business models mentioned above, with customers that do not pay for the products themselves, but just for the certainty that their machines will operate continuously without failures or breakdowns (Davies, 2004).

Company C also mentioned another type of contract they are offering, which is more a performance-based contract, in which they actually sell the product to the clients but maintain the responsibility over the product's functioning and performance. In this case, they are selling service plans, in which the client pays a fixed price at the beginning, and then the firm takes care of every other aspect during the product's lifecycle.

This model directly relates to the first three business models mentioned at the beginning of this section, in which the manufacturer does not only sell the product but also the assurance that it will perform to certain standards, with profitability connected with performance and possible penalties in case of shortcomings (Porter & Heppelman, 2014).

4.3.4 Ecosystem and Relationships with External Actors

This last section encompasses several key thematic areas from the interviews, namely (4.) "Internalization of Competences and New HR Needs", (5.) "External Resources and Stakeholders", and (6.) "Customer Relationships", and can be considered the most important one as it deals directly with the topic of the research question.

The logic behind grouping together these thematic areas is that all three of them relate to the concepts of Ecosystem and External Stakeholders to a substantial extent.

In fact, *Internalization of competences* refers to the ability of obtaining know-how from the outside and bringing it inside the organization, dealing with a series of external actors for this specific purpose, and the same can be said for *acquiring new Human Resources*, which relates to selecting people or convincing external professionals to join the organization and bring in their knowledge and expertise.

For what concerns *External resources and stakeholders*, it is the thematic area that by design includes all references to relationships with the external actors that contribute to the value creation process, whether they are suppliers, partners, or any other kind of institution or organization.

The third thematic area taken into account in the discussion of this section is *Customer relationships*, which as mentioned in the Findings is an important part of what happens in an ecosystem, with customers representing one of the most relevant groups of external stakeholders that a firm can have.

External stakeholders can play a key role in fostering a firm's capability of pursuing its goals in the context of digital servitization, as according to Tronvoll et al. (2020) service transformation depends to a considerable extent on actors that are beyond the organization's boundaries. Moreover, we have seen that digital technologies can disrupt the way firms compete and offer services, changing employment relationships (Vendrell-Herrero et al., 2017) and altering activities along the value chain, but they can also support the alignment of ecosystem actors by improving coordination and enhancing collaboration between partners, creating new networking opportunities among stakeholders (Skylar et al., 2019; Adner, 2017).

On this note, our empirical investigation revealed that all companies from our sample are currently working with external partners, suppliers and consultants to obtain support in the development of their projects, confirming the assumption that firms require an ecosystem of complementors to borrow some key digital competences and exploit IoT technologies (Paiola & Gebauer, 2020).

In some instances, companies may be interested in internalizing such specific key competences, as it is the case for four firms from our sample, that are focusing on building internal know-how by transferring it from external consultants to employees inside the organization, in order to become more reactive and flexible.
This is consistent with Porter and Heppelman's vision (2014), according to which firms should internalize the technological elements and knowledge that are most crucial for their competitive advantage, thus maintaining a greater level of control over operations.
Overall, it is important that firms determine in advance what will be their position in the ecosystem, defining beforehand what activities will be performed internally and which ones will instead be outsourced (Huikkola et al., 2020).
In this sense, Porter and Heppelman (2014) argue that doing everything internally might be very challenging and that companies should externalize the components that are most likely to become commoditized. This last remark is reflected in the behavior of Company B and Company C from our sample, which have been outsourcing their less strategic activities.

Nevertheless, external actors maintain a great level of importance in the context of digital servitization, as firms often do not have the abilities or resources needed for developing digital solutions internally, and have to rely on technology partners such as software developers, hardware constructors and platform providers (Vendrell-Herrero et al., 2017).
External partners may also include other types of companies, for instance distributors, system integrators, consultancy firms, and providers of financial or legal services (Huikkola et al., 2020) or even other kinds of organizations, such as trade unions, policymakers, and educational institutions. An example in this sense is provided by Company D from our sample, which mentioned how they have been participating in networks that included many different typologies of stakeholders.
In this scenario, companies need to figure out what skills, capabilities, and technologies available in the external environment best complement their operations (Dahlström et al., 2017), considering the multitude of actors in the ecosystem and their different interest, and trying to align their vision and goals (Adner, 2017; Skylar et al, 2019).

This view is also confirmed and shared by the firms from our sample, with Table 7 showing that all companies have expressed a medium-high or very-high importance with respect to the relevance of external stakeholders in their operations and activities.

Another important group of external actors are customers, who play a key role in the definition of a business' future decisions and strategies.
In this context, implementing digital technologies in their machines allows manufacturers to increase their understanding of clients' needs and strengthen customer relationships by developing much more tailored offerings (Paiola & Gebauer, 2020). Moreover, new technologies also enable better customer segmentation and customization based on individual needs, as well as more effective communication of value (Porter & Heppelman, 2014).
The empirical results support these assertions, as three companies explicitly underlined the importance of developing close and stable customer relationships, with Company C and Company E mentioning how being in contact with clients enables to obtain more information on their accounts and provide them with higher-quality services.
In addition, Baines and Lightfoot (2013) highlighted that the focus in customer relationships shifts from a single transition, to maximizing the customer's value from the product over time by enhancing its performance, opening up opportunities for longer relationships and repeated sales. This aspect has also been confirmed in the empirical investigation, as Company C and Company F reported how being focused on customers and their needs fosters cross-selling opportunities.

Overall, looking back at the research question posed at the beginning, we can most definitely argue that external actors and stakeholders have a profound influence in shaping how firms pursue digital servitization pathways and on their ability to implement digital technologies in their activities and products.
Going into greater detail, after having taken into account both the theoretical concepts and the results of our empirical investigation, we can say that external partners and suppliers impact the focal firm in a number of ways:

- Providing Technological Infrastructure: the support of technology suppliers is essential in allowing the focal firm to design and develop their digital offerings, as not all the required capabilities might be in place internally.
  In this area, actors such as hardware producers, software developers, or system integrators are extremely important in guiding the manufacturer's decisions on which

technologies to implement in their products, and on how to do it in a successful manner.

- Developing new Ideas and Projects: we have seen that cooperating with external partners can be a great way for fostering the cross-contamination of ideas and creating innovation, by promoting the exchange of information and innovative thinking. A collaborative environment where actors can share their ideas and different points of view is the basis for innovation and the growth of an organization, and it is even more essential in a less explored context such as digital servitization
- Developing Internal Know-how: external consultants can provide expertise and knowledge to a company, but they can become even more valuable if they teach and mentor the firm's employees, transferring their specific know-how to people inside the organization. Know-how could include their methodology of work, the ability of using particular tools, or specific digital competences
- Providing Networking Opportunities: partnerships with external organizations may also allow to enter in specific networks and help in developing new contacts and explore new business opportunities. On this note, maintaining relationships with relevant stakeholders in the sector enables companies to grasp new business trends and increase collaboration opportunities with previously unknown actors, allowing to acquire new partners. Networking is also a good chance for learning from other organizations and sharing best practices
- Reducing the burden of workload: hiring external firms to carry out less strategic activities allows to decrease the time spent by the employees on repetitive or not very important tasks , helping to shift the focus on the most value-adding activities instead

Conclusions

The purpose of this research was to identify the effects that the interaction with external stakeholders has on a manufacturer's ability to go through a change process in the context of Digital Servitization, and specifically in moving towards the provision of digital solutions.
By conducting an empirical investigation over a sample of manufacturing firms and analyzing the obtained results, we concluded that there is indeed a strong effect and impact of external actors when it comes to supporting the focal firm in implementing digital technologies.
Before going into further detail on what these effects are, we will briefly touch upon some of the main aspects we encountered along this thesis, starting with the concept of Servitization, which represents the essential point of departure for the whole work.

Servitization has reshaped the way manufacturing firms compete and provide value to their clients, highlighting the importance of services as key differentiators in obtaining a competitive advantage and gaining control over a larger share of the market.
In order to understand what are the drivers behind this growing phenomenon, we explored the different kinds of reasons that push a firm towards servitization, grouping them into economic, competitive, and demand-based motivations. The latters have proved to be particularly important, as the growing demand for services on the customer side increasingly pushed manufacturers in this direction, with those who refused to make the transition often being left behind and missing on key business opportunities.
Undoubtedly, a change of this magnitude does not come without challenges, as firms face profound organizational changes and modifications in the relationships with their network of partners, having to redefine their value propositions, develop new capabilities, and design complex service strategies in order to satisfy their clients' needs.

It is extremely important to remark that Servitization, although having been studied for several decades, is still an evolving phenomenon. In the last few years in particular, the concept of Digital Servitization has emerged, linking the classic notion of Servitization with the more modern one of Digitalization, and fostering a new strand of research on the topic.
With this regard, the emergence of digital technologies has been the primary driver behind the new phenomenon, as smart devices and new connectivity solutions accelerated the servitization process and opened up new opportunities for service offerings.
Technologies such as the Internet of Things, Cloud Computing and Artificial Intelligence have allowed for tremendous developments in product upgrades and service provision,

enabling to obtain a much larger amount of data and information on customer habits, and to design much more tailored and personalized solutions.
Technological developments have also paved the way for the creation of new business models based on DPSS and digital services, enabling firms to pursue revenue growth through new and unexplored sources.
On the other hand, Digital Servitization brings with itself its own set of challenges.
In addition to the already mentioned challenges connected with Servitization, there is also a new set of obstacles that relates in particular to Digitalization, as for instance the complex nature of IoT products, issues with data security, risings costs for IT facilities, and a general lack of experience and specialized know-how.

Overall, digital technologies have not only disrupted product and service provision, but also heavily impacted relations between manufacturers and their suppliers, as well as the interactions with a whole new range of stakeholders in the external environment.
This was already underlined as a challenge in the context of classic Servitization, but by adopting a different perspective it could also be seen as an opportunity.
This recurring theme of changing relationships caught our attention, and is what essentially led us to formulate our research question, as we asked ourselves if the choice of starting a Digital Servitization process and the activities carried out along this path were at all influenced by the presence and possible interactions with external actors of the ecosystem.

In order to obtain more insight on this topic, we looked into the concept of Ecosystem, considering the role of manufacturers in such setting and the multitude of actors that they entertain relationships with, and giving particular emphasis to the importance of adopting a collaborative approach towards relevant stakeholders.
Among these actors, we hypothesized that the stakeholders that have a more prevalent role in supporting the focal firm are the suppliers of advanced services and digital infrastructure, such as software developers or producers of connectivity modules, as they enable the firm to acquire the capabilities and expertise needed to develop their own digital architecture and solutions.
To test this assumption and gather more intel on the influence of external actors, we conducted an empirical investigation based on a sample of six Italian manufacturing firms, collecting qualitative data through interviews with representatives of each company.

The interviews were mainly aimed at assessing the degree to which the selected firms had implemented digital technologies in their activities and products, and the role of their network of partners in supporting and enabling such activities.
For the purpose of this analysis, the interviews were transcribed, summarized, and coded into relevant thematic areas, for which we derived approaches for each company.
We then proceeded with discussing the different approaches and findings, providing connections with the theoretical background.

Our results have shown that manufacturing firms generally agree on the importance of developing and implementing digital technologies in order to increase their service portfolio and better connect with their clients. In this sense, all companies from our sample shared the conviction that digital technologies will be a crucial determinant to stand out from their competitors, and in particular that the ability to gather and analyze data will be a key differentiator for providing additional value to their clients.
Moreover, manufacturers are also increasingly aware of the relevance of services, with all of our sample firms understanding and agreeing on the importance of adopting a service-centric mindset, and of intensifying the focus on customer service. This becomes even more evident in the context of digitalization, as it fosters service innovation and enables firms to develop more advanced service offerings.
However, these themes also involve the emergence of a whole new series of challenges, such as organizational and cultural changes, the need for a decided mindset shift, difficulties in developing the right skillset to exploit digital technologies, and specific issues connected with data protection and security.

Given this context, we can fully express the relevance of our research question, as we precisely aimed at assessing to what extent external actors could become key enablers for Digital Servitization and help manufacturers to overcome the above-mentioned challenges.
Going back to the effects we mentioned at the beginning, we can most definitely confirm the decisive importance external suppliers have in providing the focal firm with the required competences and skills needed to succeed in the digital environment, but their impact is not limited to this.
More specifically, besides providing the required technological infrastructure for designing digital solutions, external actors can affect the manufacturer in a number of ways, for instance by fostering the development of new ideas and projects, giving relevant inputs and feedbacks, and promoting innovation and creative thinking.

External partners can also be essential in allowing the firm to develop internal know-how and capabilities by making their expertise and knowledge available, and providing mentorship to the company's employees. Moreover, they can reduce the workload of the focal firm for what concerns non-strategic activities, allowing their employees to focus on more productive or useful tasks.
Finally, they can provide a great source of networking opportunities, as they may enhance the manufacturers' ability to develop new partnerships and obtain new leads, by putting them in contact with previously unknown actors.

In conclusion, in this scenario where the importance of digital technologies is rapidly increasing, products are becoming more and more commoditized, and customers are used to getting their needs satisfied very quickly, for manufacturers it is more important than ever to explore new ways to keep up with the wave of technological advancement and to get closer to their clients. To do so, it is essential that they leave old mindsets behind and successfully develop a network of partners and suppliers to improve their digital strategies and get an edge in their competitive environment.

Bibliography

Adner, R. (2017). *Ecosystem as Structure: An Actionable Construct for Strategy* Journal of Management Vol. 43 No. 1, pp 39–58. Available at https://doi.org/10.1177/0149206316678451

Alghisi, A., & Saccani, N. (2015). *Internal and external alignment in the servitization journey—Overcoming the challenges*. Production Planning and Control, 26(14–15), 1219–1232. Available at https://doi.org/10.1080/09537287.2015.1033496

Ardolino, M., Rapaccini, M., Saccani, N., Gaiardelli, P., Crespi, G., Ruggeri, C. (2018). *The role of digital technologies for the service transformation of industrial companies.* International Journal of Production Research. 56:6, 2116-2132. Available at https://doi.org/10.1080/00207543.2017.1324224

Baines, T. S., Lightfoot, H., Benedettini, O., & Kay, J. (2009a). *The Servitization of manufacturing: A review of literature and reflection on future challenges*. Journal of Manufacturing Technology Management, 20, 547–567. Available at https://doi.org/10.1108/17410380910960984

Baines, T. S., Lightfoot, H. W., & Kay, J. M. (2009b*). Servitized manufacture: Practical challenges of delivering integrated products and services.* Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 223(9), 1207–1215

Baines, T., & Lightfoot, H. W. (2013). *Servitization of the manufacturing firm*. International Journal of Operations & Production Management, 34(1), 2–35. Available at https://doi.org/10.1108/IJOPM-02-2012-0086

Baines, T., Bigdeli, A. Z., Sousa, R., Schroeder, A. (2020) *Framing the servitization transformation process: A model to understand and facilitate the servitization journey*. International Journal of Production Economics. Volume 221. Available at https://doi.org/10.1016/j.ijpe.2019.07.036.

Brax, S. (2005). *A manufacturer becoming service provider-challenges and a paradox*. Managing Service Quality: An International Journal, 15(2), 142–155. Available at https://doi.org/10.1108/09604520510585334

Bryman, A., Bell, E. (2011). *Business Research Methods*. Third Edition. Oxford University Press.

Cenamor, J., Rönnberg Sjödin, D., & Parida, V. (2017). *Adopting a platform approach in servitization: Leveraging the value of digitalization.* International Journal of Production Economics, 192, 54–65. Available at https://doi.org/10.1016/j.ijpe.2016.12.033.

Cenamor, J., Parida, V., Wincent, J. (2019). *How entrepreneurial SMEs compete through digital platforms: The roles of digital platform capability, network capability and ambidexterity*. Journal of Business Research. Volume 100, pp 196-206. Available at https://doi.org/10.1016/j.jbusres.2019.03.035

Coreynen, W., Matthyssens, P., & Van Bockhaven, W. (2017). *Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers*. Industrial Marketing Management, 60(1), 42–53. Available at https://doi.org/10.1016/j.indmarman.2016.04.012

Davies, A. (2004), *"Moving base into high-value integrated solutions: a value stream approach"*, Industrial and Corporate Change, Vol. 13 No. 5, pp. 727-56. Available at https://doi.org/10.1093/icc/dth029

Eloranta, V., Turunen, T.(2016). *Platforms in service-driven manufacturing: leveraging complexity by connecting, sharing, and integrating*. Industrial Marketing Management. Volume 55, pp 178–186. Available at http://dx.doi.org/10.1016/j.indmarman.2015.10.003.

Gawer, A., Cusumano, M. A. (2014). *Industry platforms and ecosystem innovation. Journal of Product Innovation Management*. Volume 31(3), pp 417–433. Available at https://doi.org/10.1111/jpim.12105

Gebauer, H. (2008). *Identifying service strategies in product manufacturing companies by exploring environment–strategy configurations*. Industrial Marketing Management, 37, 278–291. Available at https://doi.org/10.1016/j.indmarman.2007.05.018

Gebauer, H., Gustafsson, A., & Witell, L. (2011). *Competitive advantage through service differentiation by manufacturing companies. Journal of Business Research*, 64, 1270–1280. Available at https://doi.org/10.1016/j.jbusres.2011.01.015

Grönroos, C., & Voima, P. (2012*). Critical service logic: Making sense of value creation and cocreation*. Journal of the Academy of Marketing Science. Volume 41(2), pp 133–150. Available at 10.1007/s11747-012-0308-3

Hashem, I. A. T., Yaqoob, I., Anuar, N. B., Mokhtar, S., Gani, A., & Ullah Khan, S. (2015). *The rise of "big data" on cloud computing: Review and open research issues*. Information Systems, 47, 98–115. https://doi.org/10.1016/j.is.2014.07.006.

Hsu, C. (2007). *Scaling with digital connection: Services innovation*. 2007 IEEE International Conference on Systems, Man and Cybernetics. vols. 1–8. (pp. 4057–4061). New York: IEEE. Available at https://doi.org/10.1109/ICSMC.2007.4414260

Huikkola, T., Rabetino, R., Kohtamäki, M., Gebauer, H. (2020) *Firm boundaries in servitization: Interplay and repositioning practices.* Industrial Marketing Management. Volume 90, pp 90-105. Available at https://doi.org/10.1016/j.indmarman.2020.06.014

Kiel, D., Arnold, C., & Voigt, K. (2017). *The influence of the industrial internet of things on business models of established manufacturing companies – A business level perspective*. Technovation, 68, 4–19. Available at https://doi.org/10.1016/j.technovation.2017.09.003

Kohtamäki, M., & Partanen, J. (2016). *Co-creating value from knowledge-intensive business services in manufacturing firms: The moderating role of relationship learning in supplier–customer interactions*. Journal of Business Research. Volume 69(7), pp 2498–2506. Available at https://doi.org/10.1016/j.jbusres.2016.02.019

Kohtamäki, M., Parida, V., Oghazi, P., Gebauer, H., Baines, T. (2019) *Digital servitization business models in ecosystems: A theory of the firm.* Journal of Business Research. Volume 104, pp 380-392. Available at https://doi.org/10.1016/j.jbusres.2019.06.027

Kowalkowski, C., Gebauer, H., Kamp, B., & Parry, G. (2017). *Servitization and deservitization. Overview, concepts, and definitions*. Industrial Marketing Management, 60, 4–10. Available at https://doi.org/10.1016/j.indmarman.2016.12.007

Kowalkowski, C., Windahl, C., Kindström, D., & Gebauer, H. (2015). *What service transition? Rethinking established assumptions about Manufacturers' Service-led growth strategies*. Industrial Marketing Management, 45, 59–69. Available at https://doi.org/10.1016/j.indmarman.2015.02.016

Kryvinska, N., Kaczor, S., Strauss, C., Greguš, M. (2014). *Servitization Strategies and Product-Service-Systems*. IEEE Fourth International Workshop on the Future of Software Engineering FOR and IN Cloud (FoSEC 2014). pp. 254-260. Available at https://doi.org/10.1109/SERVICES.2014.52

Lerch, C., Gotsch, M. (2015). *Digitalized Product-Service Systems in Manufacturing Firms: A Case Study Analysis*. Research-Technology Management, 58:5. 45-52. Available at https://doi.org/10.5437/08956308X5805357

Malleret, V. (2006). *Value creation through service offers.* European Management Journal, 24, 106–116. Available at https://doi.org/10.1016/j.emj.2005.12.012

Marcon, É., Marcon, A., Le Dain, M., Ayala, N. F., Frank, A. G., Matthieu, J. (2019). *Barriers for the digitalization of servitization*. Procedia CIRP, Volume 83, pp 254-259. Available at https://doi.org/10.1016/j.procir.2019.03.129

Martinelli, A., Mina, A., Moggi, M. (2019). "*The Enabling Technologies of Industry 4.0: Examining the Seeds of the Fourth Industrial Revolution*". LEM Papers Series 2019/09. Laboratory of Economics and Management (LEM). Sant'Anna School of Advanced Studies, Pisa, Italy. Available at https://ideas.repec.org/p/ssa/lemwps/2019-09.html

Martinez, V., Bastl, M., Kingston, J., & Evans, S. (2010). *Challenges in transforming manufacturing organisations into product-service providers.* Journal of Manufacturing Technology Management, 21(4), 449–469. Available at https://doi.org/10.1108/17410381011046571

Ministerial Decree of 18 April 2005. Available at https://www.gazzettaufficiale.it/eli/id/2005/10/12/05A09671/sg

Oliva, R., & Kallenberg, R. (2003). *Managing the transition from products to services*. International Journal of Service Industry Management, 14, 160–172. Available at https://doi.org/10.1108/09564230310474138

Paiola, M. (2017). "*Digitalization and servitization: opportunities and challenges for Italian SMES*". 20th Excellence in Services International Conference. Available at: https://sites.les.univr.it/eisic/wp-content/uploads/2018/07/20-EISIC-Paiola.pdf

Paiola, M., Gebauer, H. (2020). *Internet of things technologies, digital servitization and business model innovation in BtoB manufacturing firms.* Industrial Marketing Management. Available at https://doi.org/10.1016/j.indmarman.2020.03.009.

Paschen, J., Paschen, U., Pala, E., Kietzmann, J. (2020) *Artificial intelligence (AI) and value co-creation in B2B sales: Activities, actors and resources*. Australasian Marketing Journal, https://doi.org/10.1016/j.ausmj.2020.06.004

Paschou, T., Rapaccini, M., Adrodegari, F., Saccani N. (2020). *Digital servitization in manufacturing: A systematic literature review and research agenda*. Industrial Marketing Management 89, 278-292. Available at https://doi.org/10.1016/j.indmarman.2020.02.012

Porter, M. E., & Heppelmann, J. E. (2014). *How smart connected products are transforming competition*. Harvard Business Review, November, 65–88. Available at https://hbr.org/2014/11/how-smart-connected-products-are-transforming-competition

Porter, M. E., & Heppelmann, J. E. (2015). *How smart connected products are transforming companies*. Harvard Business Review, October, 97–114. Available at https://hbr.org/2015/10/how-smart-connected-products-are-transforming-companies

Raddats, C., Kowalkowski, C. (2014) *A Reconceptualization of Manufacturers' Service Strategies,* Journal of Business-to-Business Marketing, 21, 19-34. Available at https://doi.org/10.1080/1051712X.2013.857500

Raddats, C., Kowalkowski, C., Benedettini, O., Burton, J., Gebauer, H. (2019). *Servitization: A contemporary thematic review of four major research streams.* Industrial Marketing Management. Volume 83, 207-223. Available at https://doi.org/10.1016/j.indmarman.2019.03.015.

Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). *Industry 4.0: The future of productivity and growth in manufacturing industries*. Boston: The Boston Consulting Group. Available at https://www.bcg.com/it-it/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries

Rymaszewska, A., Helo, P., & Gunasekaran, A. (2017). *IoT powered servitization of manufacturing – An exploratory case study*. International Journal of Production Economics, 192, 92–105. https://doi.org/10.1016/j.ijpe.2017.02.016

Sklyar, A., Kowalkowski, C., Tronvoll, B., & Sörhammar, D. (2019). *Organizing for digital servitization: A service ecosystem perspective.* Journal of Business Research. Available at https://doi.org/10.1016/j.jbusres.2019.02.012

Spohrer, J., (2017). *IBM's service journey: A summary sketch*. Industrial Marketing Management, 60 , pp. 167-172. Available at https://doi.org/10.1016/j.indmarman.2016.09.005

Suppatvech, C., Godsell, J., & Day, S. (2019). *The roles of internet of things technology in enabling servitized business models: A systematic literature review*. Industrial Marketing Management. https://doi.org/10.1016/j.indmarman.2019.02.016

Tronvoll, B., Sklyar, A., Sörhammar, D., Kowalkowski, C. (2020). *Transformational shifts through digital servitization*. Industrial Marketing Management. Volume 89, pp 293-305. Available at https://doi.org/10.1016/j.indmarman.2020.02.005

Tukker, A. (2004), *"Eight types of product service system: eight ways to sustainability? Experiences from SUSPRONET"*, Business Strategy & The Environment, Vol. 14 No. 4, pp. 246-260. Available at https://doi.org/10.1002/bse.414

Vandermerwe, S. and Rada, J. (1988), *"Servitization of business: adding value by adding services",* European Management Journal, Vol. 6 No. 4.

Vendrell-Herrero, F., Bustinza, O. F., Parry, G., & Georgantzis, N. (2017). *Servitization, digitization and supply chain interdependency.* Industrial Marketing Management, 60, 69–81. https://doi.org/10.1016/j.indmarman.2016.06.013

Wise, R. and Baumgartner, P. (1999), *"Go downstream: the new profit imperative in manufacturing"*, Harvard Business Review, September/October, pp. 133-41. Available at https://hbr.org/1999/09/go-downstream-the-new-profit-imperative-in-manufacturing

Yin, R. K. (2018). *Case study research and applications: design and methods*. Sixth Edition. SAGE Publications.

Zhang, W., Banerji, S., (2017). C*hallenges of servitization: A systematic literature review.* Industrial Marketing Management,Volume 65. pp 217-227. Available at: https://doi.org/10.1016/j.indmarman.2017.06.003

Websites

Adrodegari, F., Rapaccini, M., Butti, S. (2020). *Il Digital PSS: nuove soluzioni per la servitization e la data monetization*. Industry4Business. Available at https://www.industry4business.it/servitization/il-digital-pss-nuove-soluzioni-per-la-servitization-e-la-data-monetization/ Access date: 1 September 2020

Bellini, M. (2019) *Ecco come l'Intelligent Manufacturing ci porta nella data economy con IoT, connected product e servitizzazione*. Industry4Business. Available at https://www.industry4business.it/industria-4-0/ecco-come-lintelligent-manufacturing-ci-porta-nella-data-economy-con-iot-connected-product-e-servitizzazione/. Access date: 30 August 2020.

Butti, S. (2020). *Servitization and Digitalization, a two-dimensional space*. Servitly. Available at https://www.servitly.com/en/blog/servitization-and-digitalisation-a-two-dimensional-space/ Access date: 1 September 2020

Casali, A. (2019). *Artificial Intelligence e Machine Learning accelerano la service transformation*. Industry4Business. Available at https://www.industry4business.it/servitization/artificiale-intelligence-e-machine-learning-accelerano-la-service-transformation/. Access date: 30 August 2020

Copeland, B. J. (2020). *Artificial Intelligence*. Encyclopedia Britannica. https://www.britannica.com/technology/artificial-intelligence. Access date: 30 August 2020.

Dahlström, P., Desmet, D., & Singer, M. (2017). *The seven decisions that matter in a digital transformation: A CEO's guide to reinvention*. McKinsey&Company 1–8. Available at http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/theseven-decisions-that-matter-in-a-digital-transformation Access date: 1 September 2020

Moorhead, P. (2019). *Cisco Increases Its Societal Impact As Documented In Its 2019 CSR Report*. Forbes. Available at https://www.forbes.com/sites/moorinsights/2019/12/26/cisco-increases-its-societal-impact-as-documented-in-its-2019-csr-report/#70b3a6a26e2f Access date: 10 September 2020

List of Figures and Tables

Appendix 1 – First Table of Firms' Approaches

	IoT and Digital Technologies	Services and *Remote Monitoring*	Importance of Data and *Data Security*	Internalization of Competences and *new HR Needs*	External Resources and Stakeholders	Customer Relationships	Costs and Revenue Models
Company A	Currently developing a machine analytics platform and their own remote-control center for connected products. Looking forward to expanding digital services, and implementing machine learning, analytics and anomaly detection mechanisms to support such services.	Having a division that offers 24/7 excellent service, to support customers who have complex machines. Need to become more service-centric, and develop a new service-focused mindset. *Using their platform to provide remote services, and send alerts when needed, in a personalized way for each client.*	Importance of gathering large amounts of data and integrating it in their operations and tools. *To enhance security of data, they do not just use software, but physical systems and hardware for alternatively enabling or cutting off the connection between inside and outside the company.*	For what concerns digital competences, the aim is to do as much as possible internally, as it allows for greater reactivity, speed and flexibility. *In terms of personnel's addition, they look at competences in Data elaboration, data mining, Big Data.*	Contract with a platform and technology supplier, with an external society as system integrator. More than a contract, it is a strategic partnership with SLAs to guarantee availability, reaction times, maintenance… No current external KIBS, but willingness to look at the exterior for very specific technical competences. Partnership between them and other large companies to create specific courses for training and developing the needed professional figures.	n/a	n/a
Company B	Using IoT devices to provide learning opportunities to their clients' employees (Video Tutorials, provision of multimedia content). Include data-driven mechanisms, such as machine learning, to develop a service vision.	Including services in the products, adding them for free to the machines. Creating an integrated package, a Smart package, that includes various services which don't cost much and offer a lot of value, like licensed software which can be renovated after 1 year. *Using platform connectivity, to receive data and show it to the client.*	Gathering of data through their tools, both production and process data, to obtain indications such as the useful life of an asset. Data is considered very valuable, as well as the ability to manage it internally, in order to explore new opportunities and reduce risks.	Importance of importing know-how and fostering it internally. Focus on being autonomous on aspects that create value for the client, first of all services, to build trust in the clients. An approach is to hire consultants, who provide guidance and mentor the company's younger employees, making the team grow, while activities that are less valuable get externalized. *Hiring priorities include data mining and machine learning experts, as well as salespeople experienced in software sales.*	External partners include two important digital consultants. Importance of networking to enhance collaboration opportunities. The company has the idea, while the external actors provide the technology for its development. Relevance of cross contamination of ideas, to foster innovation and enhance new business opportunities. Time & Material type of contract, where the external company sells their time, with their own resources working directly for the client company. Using external consultants when there is a lack of vertical competences in a sector (not a critical one), which allows to reduce internal costs and risk, and enables rapid changes.	Clients are still not very familiar with services, therefore the focus is on selling the machines. It is not feasible at the moment to reduce machine prices by using services as new revenue sources, so the focus remains on sales and maintaining the brand image.	Idea of going towards a pay-per-use model. Might be costly to include a lot of additional functions in the machines, even if they are sold at high prices, because that would shrink marginality. Focus on creating interesting packages, that the client tries freely for the first year, and then decides to buy or not.

Company C	Provide connectivity solutions such as a user-friendly monitoring application that gives complete data insight on their machines' functioning at the customer's site. This allows to save costs on the display on the machines. Looking forward to implementing AI for analytics of all the data coming from the connected machines (over 1 milion machines).	Importance of having a service-centric mindset, as it has better margins and produces much greater profits than products. Having different salespeople for products and services, so that both get more focus, with importance of balancing priorities between new sales and maintenance. Importance of giving good or great service quality, as for some bigger clients it's essential even just to make the sale	Their machines produce an enormous quantity of data, of which they use just around 10%. *A challenge is represented by privacy, as customers tend to be hesitant to embrace connectivity or share data, mostly because they feel like they are getting monitored.*	n/a	Giving inputs to an external partner who designs and develops the hardware and the physical product. In this context, there is also an evolution of the external supplier, who increases its capabilities by developing more advanced connectivity solutions. On one hand the company provides qualification, while the external supplier provides an added value in the form of ideas and product development. Another external partner is an engineering company which sells them services.	Importance of relationships and value creation for customers, as well as being close to them. In this sense maintenance is a great business opportunity, to either be in a position for replacing rivals' machines, or get to know the client better. Providing advantages for the customer and showing them possible paybacks is essential, and this is enabled by connectivity (Covid19 in this sense actually helped to convince clients to connect).	In reference to the pay-per-use, in Italy ownership is something that is still really felt. Model of service plan (like perf. contracts), where the firm manages every aspect in the machine's lifecycle (the client knows in advance what they will pay for it).
Company D	Their main digital aims concern digitalizing their machines and providing remote assistance. Plan on expanding the number of plants connected to their cloud (from 2000, to 4000 by end of 2021). It is the right time to invest in I4.0, creating tailored solutions for constructors. Planning on the implementation of sensors and smart techs. in machines, but also depending on client's willingness to spend on it (relevant associated costs)	They can deploy more focused service assistance compared to bigger companies. Possibility of offering a much greater level of attention to the clients, and better customize the product with respect to their needs, but with more contained costs compared to big players.	They gather a lot of data and upload them on the Cloud, for the client's availability. The idea is to start monetizing on data, so to deploy data analysis to offer a superior service to the customer, such as identifying the level of performance of a machine, if it is likely to break down, or how it could be more efficient. They aim at redacting reports very quickly from the available data.	Importance of retaining people who the company has invested on, to maintain the internal know-how (willingness to spend on HR is essential). Interest of building applications with the internal personnel, as the current approach of externalizing presents risks. Proactivity from employees is much appreciated, but they need to be motivated, or it could limit innovation. *Looking forward to add experts in User Experience and a data analyst (which is a figure they are transforming internally).*	Aim of having 4 or 5 small system integrators on the Italian and international markets, to help increasing business by digitalizing their machines. Importance of participating in the sector conventions, as it is a great networking opportunity. They have two external consultancy companies, and IT infrastructure suppliers. Outsourcing the less strategic activities. The condition is that partners must work with company's back-end frameworks and applications (there are coordinators for the ext. partners.), but leaving freedom to suppliers on the technology used.	Client's willingness to spend on smart technologies implemented in the machines is not always a given.	Currently deploying a fee model lasting 5 years, on the machine's leasing to the clients. As Cloud costs are high, services remain at a high price, unless the company is able to reduce its internal fixed costs and create more margins.

Company E	IoT is deemed as essential for the company's survival. Planning on a IoT platform to improve machines' functionality, and for monitoring of the products, to improve efficiency and check components durability. Using communication protocols that give access to the fundamental parameters of their machines. Allowing users to use smartphone to control functionality of the products.	Possibility of predictive maintenance, to follow remotely how a product is performing and if it needs reparations. Better monitoring of components breakdowns and functionality losses allows for improved maintenance. *Technologically advanced products allow users to command them remotely, enabling a whole new level of control.*	Challenge of data coming from different kinds of plants and products, and thus not uniform in nature. Still not having an enough extended data base to perform systematic analysis. *Importance of privacy, safeguarding clients' data safety and abide by the GDPR rules. Once they will have a Cloud in place, it will be easier to handle privacy issues.*	Having worked with an external consultant for some time, the next step is to transfer his type of work and skills to a person inside of the organization. *Searching for an electronic or informatic engineer, that needs to be an IoT expert, but this is challenging as experts in such areas are not likely to join a company that values electronics, but does not have it as its core business.*	Working with suppliers specialized to their core business for developing the connectivity of their products. Development of a Cloud platform with a large player of the telecommunication sector (based on 4g, but looking forward at implementing Wi-Fi) to connect their machines. Idea of implementing the platform also for medium and entry level products. Possible partnership with a large Italian energy company, to become pure service providers, but risk of losing contact with clients. Outsourcing of all electronic systems, which are however customized. Working with 3 external partners. Idea of outsourcing data analysis.	Giving customers the possibility to handle the functionalities of the products through an application on their smartphones. Direct relationship with final clients, as devices allow to know where clients are, their behavior, and so on.	Adding costly connectivity modules to low-end devices is penalizing. Connectivity costs are an issue. Using Wi-Fi rather than 4g can greatly decrease them, with Chinese suppliers that can provide extremely cheap Wi-Fi modules. With 4g, costs are also related to Vodafone's support in handling data.
Company F	They understood that the IoT technology in their machines was a product by itself, and could be carried on as a separate project, to create new business and new clients. Ability to connect any types of machines and personalize algorithms based on the different machine types, to provide the correct information to the final user, or for their use	They can offer condition monitoring services to their clients, looking at factors and variables that influence the performance and effectiveness of the machines, possibly preventing breakdowns or other issues. They are not aiming at offering predictive maintenance on an elevated number of machines.	Negotiating with partners to connect machines and obtain data on efficiency. Momentarily just to obtain information, reports, or offering condition monitoring, possibly in the future for data monetization. *Clients' oppositions in terms of sharing data are beginning to fall, as they look more and more at connecting machines.*	Importance of continuous learning, which needs to start from the top levels of the company. The top management has to lead the way on the way to improvement and require high standards, or it is very unlikely that employees will do it by themselves.	Offering support to external companies (that produce different kinds of machines) to develop advanced technological and connectivity solutions. Looking at the integration with companies that deal with processing, to offer a complete control platform, over both packaging and processing. Considerations on the changing ecosystem (not just at a competence level, but at the international level), with suppliers particularly close to the final client, to which some maintenance activities can be outsourced.	When a trust relationship is established with a client, there is opportunity for cross-selling, with increased sales, even with orders that could be more logically satisfied by other suppliers. Customer relationships and knowledge are a major asset, that lead to better quality of services.	n/a