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THE ROLE OF THE INTERNET OF THINGS FROM A SERVITIZATION PERSPECTIVE.

Opportunities and challenges for the implementation of Product-Service Systems. A multiple case study.

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Abstract

This research explores how the Internet of Things (IoT) might affect and provide advantages in the servitization shift of manufacturing companies. In particular, it inquires the role IoT is able to play for the implementation of offers based on the integration of products and services, or Product-Service-Systems (PSS). These kind of "servitized" offers have been identified, classified and related to IoT possibilities. Furthermore, through a multiple case study, different companies operating in dissimilar industries, which employ IoT in their product portfolios, have been selected, analyzed and compared, in order to generate theory through an inductive approach. The research demonstrates that IoT is a catalyst for the servitization and an enabler for the PSS implementation, as it allows companies to trigger different kinds of bundles of product-service offerings. In doing this, the paper provides practical and detailed opportunities and challenges related to the integration of IoT possibilities in the value proposition of different business portfolios. The presented IoT-driven possibilities can be explored to ameliorate the offer of manufacturers, that can move one step ahead from the competition by developing customer-focused, responsive and/or predictive service opportunities.

Keywords: Servitization, Internet of Things, IoT, Product-Service-Systems, PSS, Product-service offering portfolio.

"THE ROLE OF THE INTERNET OF THINGS FROM A SERVITIZATION PERSPECTIVE:

Opportunities and Challenges for the Implementation of Product-Service Systems. A multiple case study"

by Andrea Bureca

This master thesis has been written within the Double Degree program between Gothenburg University, School of Business, Economics and Law (Gothenburg, Sweden) and LUISS Guido Carli (Italy, Rome), during the Academic Year 2016-2017.

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Abbreviations:

PSS = Product-Service Systems

- **PoPSS** = Product oriented, Product-Service-Systems
- **UoPSS** = Use oriented, Product-Service-Systems
- **RoPSS** = Result oriented, Product-Service-Systems

IoT = Internet of Things

ICT = Information and Communication Technologies

A.I. = Artificial Intelligence

SLA = Service-Level Agreements

1. Introduction

1.1. An overview about Servitization, Product-Service Systems and Internet of Things

With *Servitization,* an increasing number of authors refer to the overall tendency of manufacturing firms to expand their own product-based offers with integrated services (Tukker, 2006). The "Servitization" term was coined by Vandermerwe and Rada in 1988, describing the modern willingness of corporations to offer "fuller market packages or *bundles* of customer-focused combinations of goods, services, support, self-service and knowledge" (Vandermerwe and Rada, 1988, p.314). Under this perspective, manufacturers are not anymore focused on selling brick-and-mortar, pure, physical, products to customers, but rather on delivering capabilities to them (Baines et al., 2007). This means offering solutions, by delivering *bundles* of product and services, called by authors including Goedkoop et al. (1999), Tukker (2004), Mont (2002), Manzini et al. (2001) and Baines et al. (2007), "Product-Service Systems" (PSS).

There are many rationales that might lead manufacturers to servitize their own offer through the implementation of PSS, and by scrolling the existing literature, it is possible to group up and distinguish previous contributions in four main categories or drivers: Environmental, Economical, Customer-related and Technological. To have a brief overview, the first category refers to a more sustainable consumption, increasing in the deployment of underutilized assets and less environmental impact advantages (Goedkoop, 1999; Manzini et al., 2001; Oman, 2003; Baines et al., 2007). The second is about economic advantages, deriving from stabilization and increase of revenue streams (Baines et al., 2007), but also from the provision of more strategic choices (and alternatives to standardization and cost leadership; Mont, 2002), lock-out effects for competitors (increasing also the inimitability; Gebauer et al., 2005) and lock-in for customers (Baines et al., 2007; 2008; Grant, 2013). The third category is about the development of a customer-centric approach, which leads to a better understanding of customers and to closer relationships with them (Mont, 2002; Oliva and Kallenberg, 2003; Wong, 2004).

The fourth driver, on the other hand, is related to the technological development. Kowalkowski et al.'s research (2013), for instance, explains how Information and Communications Technologies (ICT) are key enablers for the servitization, as their development and diffusion can allow the creation of new PSS, that might lead companies to develop new, profitable opportunities (Manyika et al., 2015). Nowadays, with "smart" components, products can be the object of advanced analytics and multi-functional dashboards, providing the manufacturer an ongoing visibility on the performance (Masson, 2016), as well as the chance of triggering new services components (Allmendinger and Lombreglia, 2005; Ontario, 2015). In particular, the recent development of the Internet of Things (IoT), has offered manufacturers revolutionary ways for both optimizing operations and developing innovative value propositions based on products *and* services (Thoben et al., 2017; Forrester Consulting, 2015).

Despite all the advantages and drivers, implementing PSS involves also challenges, including the risk of facing the so-called Service Paradox, which explains the situation in which the manufacturer heavily invests in service businesses, incurring in higher costs related to a more complex offering, without yielding the expected higher return from services (Gebauer et al., 2005). The source of this problem might be found in the definition of "service". Given the intangibility and the contextual production and consumption, characteristics that define the term (Zeithaml, 2013), it might be argued that companies which are willing to compete via services strongly need to stay as close as possible to the end customers, developing a customer-centric approach. Having a strong connection with customers implies understanding them, building a relation with them and keeping track of their usage patterns and needs, to design and deliver better offers. In fact, only by satisfying these requirements, it might be possible to successfully servitize the offer (Mathieu, 2001; Baines et al., 2007; Vandermerwe and Rada, 1988) and overcome the Paradox (Gebauer et al. 2005).

IoT might possibly help many manufacturing companies that normally would struggle to create and maintain a strong connection with customers. It is defined as "a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies" (ITU, 2015). When the terms servitization and PSS were coined (1988 and 1999), this newness was not already disposable. Now that it is diffused and quite widely available, it might be argued that it is likely to "both undermine old business models and require further development of new business models specific to particular applications" (Dutton, 2014, p. 15). In other words, in accordance with Torsten and May (2016), it might represent a feasible and promising track for the shift toward the servitization and implementation of PSS offerings.

IoT components, for instance, allow a rapid, scalable and cost-effective deployment of remote monitoring solutions. Therefore, products that have been sold can be stably connected and analyzed remotely, allowing the producer to keep an ongoing visibility into their performance and utilization (Masson, 2016; Lightfoot, 2016; Sassanelli et al., 2016). This means that IoT, that has been incredibly spread and developed by many companies from all over the industries, changing also the competition dynamics (Porter and Heppelmann, 2014), might offer relevant bases thanks to which manufacturers can possibly create the bridge to connect them to the final customer, adopting the customer-centric approach needed for the success of PSS.

However, according to a recent study by SaS, half of US manufacturing companies acknowledged the deployment of IoT solutions to improve their operations, but only the 44% collected data from sensors in their products, while just one third of them reported to have a specific strategy based on IoT (SaS, 2015).

As a matter of fact, generally speaking, organizations tend to identify IoT as more of an operational efficiency enhancer (Thoben et al., 2017), rather than a catalyst for the development and implementation of new offerings and value propositions (Forrester Consulting, 2015). In line with this result, a research by Whitmore et al. (2015) found that, despite the exponential growth of scientific contributions on technical aspects of IoT, there is still a lack of a relevant academic body regarding IoT applications in a business perspective. Indeed, the way through which IoT might affect the offering portfolio of a firm and the methods through which it generates customer value remain still unclear (Torsten and May, 2016).

The absence of guides or tools for manufacturers toward the implementation of PSS on the one hand, and the grey area which surrounds IoT applications in the offering portfolio, on the other hand, together represent the starting point of this work.

1.2. Purpose and research question of the thesis

It is in the purpose of this master thesis to explore and evaluate the possibilities offered by IoT to the product offering portfolios of manufacturers. In particular, it is in the interest of the author to drill down both the servitization and the PSS concepts to find if, in such a wide and promising area, there might be room for this innovative technology. Indeed, it might be both theoretically and empirically relevant to detect if and how IoT relates to servitization and to PSS, as well as to understand how companies, under this perspective, are employing it.

Therefore, the purpose of this research is to understand if and how IoT might be relevant for offering *bundles* of product and services, to which, from an academic point of view, are associated relevant advantages. Moreover, it might be interesting to analyze the implications of its employment, in terms of opportunities and challenges for the manufacturer, as well as possible modifications for its business model.

Hence, the general research question of this paper is:

What kind of role can IoT play for the Product-Service Systems of manufacturers?

In particular, the present research aims at addressing the research question by answering to the followings:

1. **How is IoT employed in the offers of servitizing companies?**
2. **What are the opportunities, delivered by IoT, for their PSS?**
3. **What are the main challenges associated with its implementation?**
4. **How can IoT enhance the servitization process for non-servitizing, manufacturing firms?**

The first three sub-questions refer to companies that have already servitized their own offer, aiming at understanding if and how IoT is employed by them, and at inquiring the opportunities, challenges and outcomes of its utilization. The fourth one, on the other hand, investigates the possibility for manufacturing firms, that have not already servitized their offer (i.e. that still have to approach the servitization shift), to make use of these innovative tools in order to enhance the shift toward services in their own offering portfolio. This means to understand the possible opportunities and challenges provided by IoT (sub questions 1, 2, 3) to be applied to non-current-users (sub question 4).

It is relevant to warn the reader that inquiring the technical aspects of the aforementioned technology, or going too deeply in its functioning, is not in the purpose of this study. The following will be a research paper willing to explore and explain if and how IoT can be applied theoretically, still keeping the focus on its business and managerial related aspects, rather than on the technical and engineering ones.

1.3. Value of the research

The usefulness of this research is twofold. Firstly, addressing the research question(s) would potentially lead to a further and relevant step in the academic knowledge regarding popular topics as servitization and PSS. In particular, given the lenses through which the concepts will be analyzed – the role played by IoT, opportunities and challenges implied –, these themes would be connected with other subjects undergoing intense studies and interests such as the world of connected (or "smart") products. Therefore, the aim is to develop a general understanding of broad and current topics and explore a new field of research by combining two widely known areas. This way, it is possible to give light to a previously rather grey zone that combines high potential modern technologies - according to some research, IoT has a total impact, economically speaking, of 3.9 up to 11.1 trillion per year in 2025, that corresponds to the 11% of the total 2025 world economy (Manyika et al., 2015) - with the business strategy macrocosm.

Secondly, an empirical contribution will follow. It is in the possible answer(s) to the research question(s) that manufacturing companies might find interesting opportunities to be handled, as well as managerial recommendations which can eventually help them to make a step ahead from the competition via evolving their offers. The goal can be reached by understanding if and how they can integrate IoT in their products portfolio to approach the servitization shift, by implementing and developing PSS.

1.4. Thesis disposition

The thesis begins with an *Introduction* which provides general background information and the reasons which have led to the formulation of the research question(s). The purpose, research question and value of the research are also presented in the chapter.

The *Literature Review* is presented in Chapter 2. This section describes the theoretical framework and provides an overview of the relevant theories and models. The main topics researched and mentioned are Servitization, Product-Service Systems and IoT. A particular focus is dedicated to how these concepts relate to each other, also through the utilization of empirical examples.

The 3rd chapter encloses the *Methodology,* which describes, in details, the way selected by the researcher to address the research question(s). Moreover, it contains information about how empirical data have been gathered, and later analyzed, together with the theory.

The primary data gathered from the cases selected for this multiple case study are identified in Chapter 4, which presents the *Empirical findings*. Its purpose is to present, through the use of tables, the outcome of the interviews, modelled around the interview guideline shown in Appendix 2.

The *Analysis of the findings* is shown in Chapter 5. The section explains the primary gathered information and compares differences and commonalities between the studied cases. The chapter aims at providing an understanding of the empirics and at integrating the *theory*, developed in Chapter 2, with the *practice,* presented in Chapter 4.

The thesis ends with the *Conclusions*, which draw the main results of the research. After a brief summary, Chapter 6 exhibits the answer(s) to the research question(s), explains the theoretical contribution of the research and suggests some related managerial recommendations. The paper concludes by advising some future research, basing on its observed limits.

2. Theoretical framework: Servitization, PSS and IoT

This chapter provides a general understanding of different theories and frameworks which represent the theoretical base of the present research. The literature review gives a comprehensive overview on the topics of Servitization, Product Service Systems, Internet of Things and its integration in business offering portfolios; these are concepts that will be recalled throughout the whole paper.

2.1. The concept of Servitization

During the last decades, the term "servitization" has been used by academia to capture the attitude of firms, previously known as pure manufacturers, which are increasingly bundling (or integrating) services with the goods they produce and sell (Roger, 2009). Although it is often referred as an innovative trend, in his research on the history of US manufacturing, Schmenner (2009) suggested that this "servitization shift" has antecedents that go back at least 150 years. However, the term was firstly coined by Vandermerve and Rada not earlier than in 1988. Its meaning goes beyond the mere adding of ancillary services to the offer of products, since it rather indicates the tendency of manufacturers of getting closer to customers and to their underlying needs (Roger, 2009). Mitchell refers to this phenomenon as innovations in the business models of manufacturing firms, given their willingness to innovate the offer by adding complementary services on what already provided, via combining solutions to help customers (Mitchell, 2004). Essentially, companies still offer the same products (that are certainly evolving as the time goes by), but, with different business models, these can be commercialized in different ways yielding to different returns. Nevertheless, servitization might also be defined as a strategy focused on the embracing of a service orientation, to satisfy customer's needs, to achieve competitive advantages and to enhance the performance of the firm (Ren and Gregory, 2007).

There exists a relevant and increasing amount of academic contributions about the subject, suggesting a growing interest for service-led strategies for both businesses, governments and, of course, academia. This is probably because the servitization shift is an approach that has important implications under an economic perspective. It is often associated to activities for creating additional value and developing distinctive competences and capabilities, which might lead to competitive advantages in economies previously just based on cost (Baines et al., 2009).

Servitizing firms, indeed, deliver capabilities to the customer in order to differentiate and get to a new competitive edge (Jacob and Ulaga, 2008). Their goal, therefore, is not anymore to sell "just" products but, rather, to offer solutions to customers (Baines et al., 2007), by integrating services with the products, creating a *bundle* (Vandermerwe and Rada, 1988).

There is a multitude of practical examples of offers implemented by servitizing manufacturing firms. Goedkoop already identified almost 150 different ones in 1999. Without going into details, it suffices here to mention the probably most quoted examples of Rolls-Royce "TotalCare", that shows the company´s shift from "just" selling engines to provide customers the availability of them, by getting paid "fixed dollar per flying hour" (Neely, 2008; 2013), and Xerox "pay per click" scanning, printing and copying (Baines, 2013). These examples (analyzed later in the text), together with many others – including the notorious Hilti "Tool Fleet Managing Services" (Hilti, 2017) - are a very relevant body to be studied in order to detect how an important consequence of the servitization is represented by the tendency of delivering customers "value in use" (Baines et al., 2009). This means offering capabilities to solve directly users' own problems, rather than selling products that can be then used by them independently to eventually reach the same result.

2.2. Product Service Systems: the "servitized" offers

Within the servitization theory, many authors including Goedkoop (1999), Manzini et al. (2001), Mont (2002), Tukker (2004) and Baines et al. (2007) decided to focus their attention on how the concept concretizes in terms of offerings of manufacturers. Indeed, as already said, under the perspective of the servitization, manufacturers do not offer anymore just brick-and-mortar goods but, contrarily, *bundles* of products and services, called by academia as "Product-Service Systems" (Tukker, 2004; Baines et al. 2007).

Product-Service Systems (henceforth referred as PSS) are systems of products, services, networks of different actors and infrastructures which strive to be competitive by satisfying customers' needs while having lower environmental impacts than traditional innovation models (Goedkoop et al., 1999). They are also referred as solutions offered for sale, involving both product and service elements, in order to deliver the required functionality (Wong, 2004). In few words, paraphrasing the contributions of Goedkoop (1999), Mont (2002), Manzini et al. (2001), Tukker (2004) and Baines (2007), PSS can be considered as offers provided by manufacturers that are approaching the servitization shift, or, to put it simpler, as "servitized" offers.

These *bundles* of products and services have some special features. In particular, Baines explained how PSS not only include the integration of services with products, but also envisages the "sale of use" rather than the "sale of a product" (Baines et al., 2007). Therefore, under this perspective, with PSS offerings (but not in all the cases, as explained later in the text) customers pay for the usage or for the result of using a determined asset, rather than for the ownership of it.
The following example about the already mentioned case of Rolls-Royce might be useful to better comprehend the main characteristics of offers developed under the servitization perspective (PSS).

In the past, Rolls Royce (RR) used to sell engines such as gas turbines for its airline customers. Its transactions with the customer ended as the product was sold. If RR integrated in its offer, for instance, the installation of the engine, trainings for the operators and other kinds of support activities such as the maintenance, it would have been possible to talk about a general servitization of the RR offer. However, with its Total-Care package, RR does not transfer the ownership of the gas turbines to the airline customer. Rather, the company keeps the direct access to the asset, bearing the responsibilities associated, ensuring to the customer the effective and continue functioning of the engine via collecting data on its performance and usage. This way, the customer does not pay for the object, but for the *effective* usage of it, that is "power-by-the-hour" (Baines, 2013; Baines et al., 2007; Neely, 2008; 2013). With Total-Care, therefore, Rolls-Royce servitized its offer by implementing a PSS, as described by Baines et al. (2007).

2.3. The different options for PSS offerings

After the introduction of the PSS concept, it is necessary for the scope of this research to deepen its understanding. The example of RR, indeed, represents just one case of PSS. There are, in fact, many kinds of PSS and, although different authors used to classify and label them in different ways, they might be commonly grouped into three main categories. These are, according to the aim of the services surrounding the physical product, using Manzini et al. (2001), Tukker (2004) and Baines et al. (2007) taxonomies, Product-oriented, Use-oriented and Result-oriented, PSS. These alternatives, explained extensively in the following paragraphs, are intended to represent different shades of the spectrum that goes from pure products to pure services. The self-explanatory Figure 1, adapted from Tukker (2004), shows these different kinds of categories, identifying also eight concrete examples of PSS, divided by category. In addition to the model presented by Tukker (2004), Figure 1 specifies in what cases the ownership of the product component of the

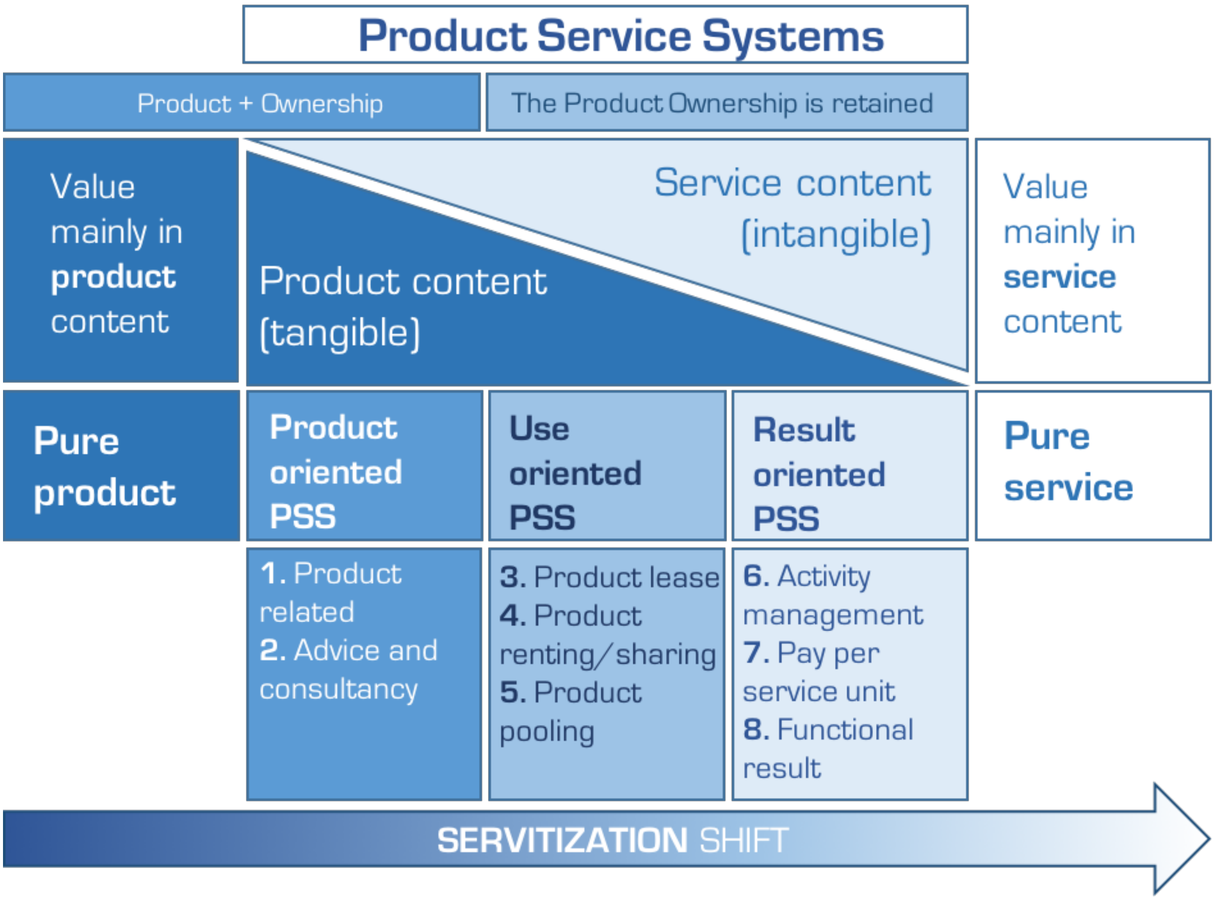

Figure 1. Product-Service-Systems (adapted from Tukker, 2004)

offer is transmitted to the customer and when, as suggested by Baines et al. (2007) for PSS offerings, it is not. Moreover, to clarify the distinction between PSS and servitization, the bottom of the figure displays the servitization shift continuum, highlighting how PSS are special cases of the wider former concept (Baines et al. 2007).

2.3.1. Product oriented PSS (PoPSS)

The so called Product oriented PSS (PoPSS) refer to offers that are mainly represented by physical products surrounded by some services, product-related, whose aim is to improve the functionalities, performance and/or to manage the life cycle of the former (Manzini et al., 2001; Baines et al., 2007).

Differently from the two other PSS presented later, PoPSS is the only case that foresees the transfer of the property right on the product from the company to customers. This can be explained by the fact that, in these product-service *bundles,* the offer is mostly represented by the "pure product" and to a lesser extent by its related services. Indeed, this category of PSS is the closest one to the traditional selling mode of "pure products" (Tukker, 2004). Nevertheless, PoPSS also envisage for the integration of some services as advices and consultancy for improving customer's applications of the product, or of features for enhancing its maintenance, repair, reuse and or recycling. These activities are directed at improving the availability, durability and performance of the product (Tukker, 2004; Baines et al., 2007).

Allegrini "Casa Quick" home delivery of detergents, which combined the selling of products with the support of experts that provided advices for their usage (UNEP., 2002), is a case of Advice and consultancy PoPSS. Moreover, the home delivery with parcel tracking services of manufacturers (Torsten and May, 2016), Ralph Lauren "Polo Tech Shirt", Babolat "Play Pure Drive" and Philips "hue lightbulb" (Porter and Heppelman, 2014), analyzed later in the text, represent other possible examples of Product related PoPSS.

2.3.2. Use oriented PSS (UoPSS)

Identified at the midway of the spectrum between pure products and pure services by authors as Tukker (2004) and Manzini et al. (2001), there are the Use oriented PSS. These are the cases in which the value delivered by a company is approximately equally shared between the intangible and tangible components of its offer.

UoPSS are aimed at offering the maximum possible availability of the underlying product, in order to sell its effective usage rather than its property right (Baines et al., 2007). Hence, contrarily to PoPSS, the ownership of the product is not transferred to the customer, but is retained by the firm (as it happens also with RoPSS, explained in the next paragraph). They are a sort of "pay-as-you-go" or "spend-when-you-use" applications, in which, following Tukker (2004), the product might be leased, shared, rented or pooled between different users. To this category belongs, for instance, Hilti "Total Fleet Management" offer (Hilti, 2017), which is about renting – instead of selling - all the tools necessary for many applications in the construction industry, ensuring their availability, functioning and maintenance. Car2Go, Zipcar and Eni-Enjoy PSS, analyzed later in the text, represent further examples of UoPSS.

2.3.3. Result oriented PSS (RoPSS)

Result oriented PSS are the offers made by companies which directly deliver capabilities and solutions to customers (Baines et al., 2007), rather than means through which make them solve their problem by themselves. This might mean, according to Tukker (2004), selling the whole management of some activities (idea that goes very close to the concept of outsourcing), let customers pay per service unit (e.g. per washed dress, instead of per washing machine sold) or per functional result (e.g. for transporting efficaciously customer from point A to point B, regardless the time and fuel involved). Obviously, also in these cases the ownership over the product component of the offer is retained by the company.

Xerox and Canon offers represent successful examples for their "pay per copy" lease and take back programs (Baines et al. 2007). Rolls-Royce "TotalCare" (explained earlier in the text) is a case of RoPSS, since, without giving away the ownership, the company gets paid "fixed dollar per flying hour", in a way that appears very similar to the "pay per copy" or "pay per service unit" concepts. Other examples include food catering services as well as some offers of transportation companies, for instance.

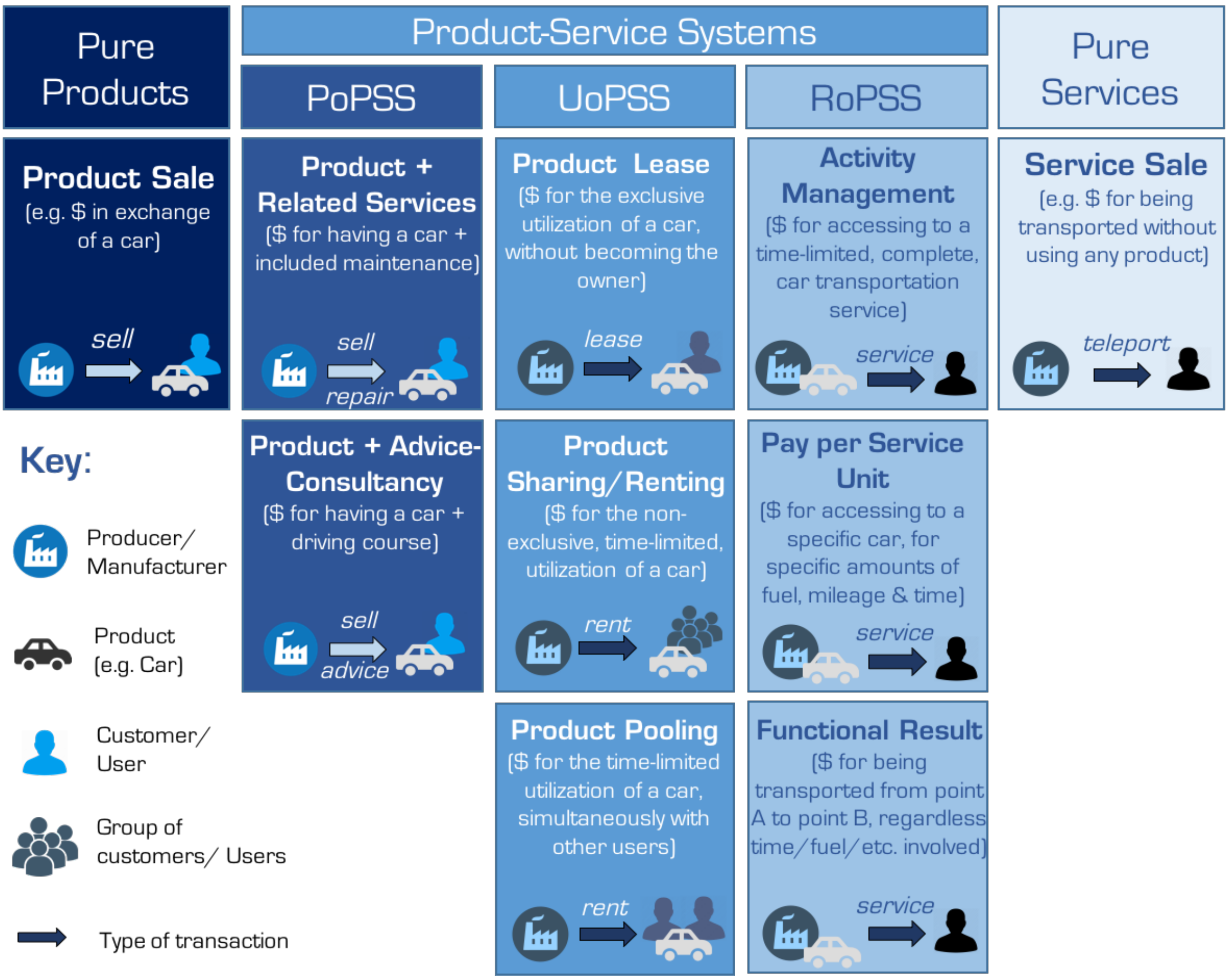

Figure 1b. PSS exemplification (adapted from Tukker, 2004)

The Figure 1b summarizes the concepts discussed in the previous paragraphs, applying Tukker's PSS theory (2004) to an example regarding a car manufacturer. The figure represents all the possible combinations for car and services *bundles*, providing examples for every kind of identified offer. This should facilitate the understanding of the different PSS, which will be proposed again throughout the whole paper.

2.4. Why PSS?

At this stage, after having explored the possible options academia delivers to companies willing to develop their own servitized offers, it might be relevant to understand the rationales laying behind the choice of implementing them. By scrolling the existing literature, it is possible to group up and distinguish previous contributions in four main categories that summarize reasons, benefits and drivers connected to the choice of triggering PSS. In this research, they will be distinguished between Environmental, Economical, Customer-related and Technological.

2.4.1. Environmental rationales

This first category refers to the PSS associated benefits in terms of a more sustainable consumption, increasing in the deployment of underutilized assets and less environmental impact. Certainly, if the ownership of the offered good is not transferred to the customer, not only a same asset can be utilized more times from different users, but also, in the long run, less products can be produced, thus leading to a decrease in the environmental footprint of the manufacturer (Goedkoop, 1999; Manzini et al., 2001; Oman, 2003; Baines et al., 2007). Moreover, by offering PSS, companies are incentivized to manage effectively the life cycle of every product, to reduce their own costs (Baines et al., 2007; UNEP, 2002). This implies reusing, repairing and recycling (especially in PoPSS), rearranging and re-managing for next users (especially in UoPSS) and making products as more efficient and less consuming - at least economically speaking - as possible (especially in RoPSS).

All these expedients lead to increases in the efficiency of resources and optimization in the utilization of assets, as well as to decreases in wastes and potential pollution (Goedkoop, 1999; Manzini et al., 2001; Oman, 2003; Baines et al., 2007), delivering benefits not only to the producer and customer, but also to the government and to the environment (Mont, 2002).

2.4.2. Economic rationales

Although, very often, scholars tend to emphasize the environmental rationale as the main driver for the PSS, arguably, without economic incentives, their implementation would not be so widespread in the business world.

First of all, as stated by Baines et al. (2007, p.9), "the fundamental business benefit of a PSS is an improvement of total value for the customer through increasing service elements"; and to a higher value in most of the cases correspond higher revenue streams. It suffices here to consider that, in some sectors, the revenues associated to services might be up to two orders of magnitude superior than to the sale of new products, suggesting to manufacturers to go downstream in their value chain, closer to end customers (Wise and Baumgartner, 1999). According to a 2013 IDC study, moreover, North American equipment manufacturers are moving towards maximizing aftermarket service revenue: without it, only 9% expected increased revenues in coming years (ICD manufacturing Insights, 2013). In a sense, these concepts appear really consistent with the idea at the base of the widely known Stan Shih's smiling curve[1], shown in Figure 2. Indeed, it is possible to display the servitization shift as the progressive advancement of a manufacturer from the center to the right of the value chain (Jian, 2011), to which correspond higher value-adding activities.

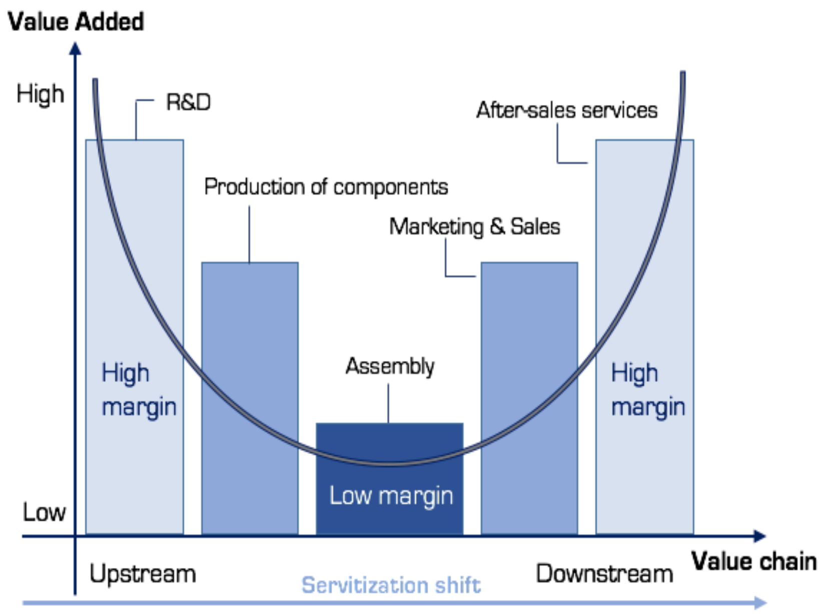

Figure 2. The smiling curve in a servitization perspective

Under the point of view of the manufacturer, "service components" deliver alternatives to standardization and mass production (Baines et al., 2007), offering more strategic choices and options to differentiate from competitors (Manzini et al. 2001; Mont, 2002). Gebauer et al. (2005) suggested also how, by increasing the intangible component of an offer, it is possible to increase its inimitability, thus enhancing the durability of the competitive advantage of the company (Grant, 2013). On the other hand, getting closer to customers by operating services, as already mentioned in 1988 by Vandermerwe and Rada, translates in a lock-out effect for competitors and lock-in for customers, whose side effects might consist in a securing or even increasing of existing market share and revenues for the company (Grant, 2013).

What deserves to be analyzed, moreover, is the consequence of making use of the product installed base of the company as a platform for activating services, particularly in the cases of PoPSS and UoPSS.

[1] This framework was originally dedicated to an understanding of how the value is averagely added across the different phases of the value chain. To put it simple, the smiling curve shows that to the very upstream or downstream phases are generally associated a higher value added and higher margins. In this research, the curve has been employed to interpret the servitization shift as the attempt of manufacturers of moving downstream, to internalize high value and margin activities.

The UK-based Ellen MacArthur Foundation, in 2012, calculated that a circular economy could help European manufacturers saving around 630 USD billion a year in 2025 (Lovins et al., 2014). Although going deeper in the topic of circular economy is not in the purpose of this research, it might be stated that in some of its applications, PSS concept goes quite close to the former, questionably allowing to sate that its implementation would lead to relevant decreases in production costs for the manufacturer, boosting its margins (as foreseen by the smiling curve). Moreover, substantial long-lasting revenues might be captured from an installed base with a long life cycle, as suggested by Oliva and Kallenberg (2003).

These strategic options have been further confirmed by Baines et al. (2007; 2009), which highlights how the potential loss of sales caused by the increasing in services (because of the higher products life cycle and utilization of the installed base, as explained earlier), is more than offset by higher profit margins and by an increased stability in the income. Nevertheless, product-service sales tend to be countercyclical and to resist more to economic cycles affecting good purchases and investments in general (Oliva and Kallenberg, 2003).

2.4.3. Customer-driven rationales

One of the main reasons that pushed manufacturers to advance beyond the production of pure physical goods, is the idea that customers are demanding more services (Oliva and Kallenberg, 2003). For them, PSS might deliver an improved customization and higher quality because of the flexible characteristic that are implicit in the service component of the offer (Baines et al., 2007).
Considering that, according to Prahald (2004), the kind of relation to be established with customers should not be anymore just transition-based and passive, and not anymore happening just during what marketing literature names "moments of truth", as they are demanding for more voice, information (Grant, 2013; Prahald, 2004) and customization (Grant, 2013; Oliva and Kallenberg, 2003; Vanderverme and Rada, 1988), it is clear how a customer centric approach is needed.

Mathieu (2001) suggested how PSS might be developed primarily around the product or around the customer, using the latter case as an example in which this customer-centricity has to be reached and improved. His contribution, together with Mont's one (2002), represent a basis that allows to state that PSS, in comparison with traditional offers of pure physical products, better enhance the involvement demanded by customers. This means, recalling Oliva and Kallenberg, that customers themselves have indirectly asked for PSS and contributed to their development, while enjoying the benefits of flexibility, customization and better relationship with producer (Baines et al., 2007).

Another aspect to be considered is whether to acknowledge the not-ownership of the product by customers as a benefit for them or not. Of course, it is impossible to generalize, considering the multitude of factors that might influence the possible answer, including the type of product, manufacturer, customer, industry, environment and social status. Suffices here to state that, without the property right over the good, the customer gives back to the producer the burden represented by monitoring, maintaining and undertaking administrative tasks (Baines et al., 2007), while having in most of the cases an improved availability, durability and performance of the product (Tukker, 2004).

2.4.4. Technological drivers

The fourth driver for the PSS diffusion is related to the technological development that might have paved the way to the integration of product with services. Roger (2009) highlighted how the evolution in transportation and communication technologies contributed to accelerate the trend toward the combination between manufacturing and service functions. Moreover, Kowalkowski et al. (2013) narrowed down the focus explaining how Information and Communications Technologies (ICT) have been key enabler for servitization, stating that their development and diffusion allowed the creation of new PSS. Nevertheless, the ICT diffusion allowed the widespread of manufacturer-controlled activities close to the end customer such as marketing, sales, financing and purchasing. Before that, manufacturers tended to be rather independent wholesalers or jobbers (Roger, 2009).

Under this perspective, the technological evolution delivered many innovative technological tools, used both for transforming production processes and implementing new business models (Manyika et al., 2015). Arguably, the mobile phone diffusion, for instance, facilitated the implementations of PoPSS, as, thanks to the device, customers were able to get in contact with the manufacturer for receiving real time assistance from everywhere. Also, the more recent development of the Internet of Things (IoT), offered revolutionary ways for both optimizing operations and developing innovative offers for manufacturers (Thoben et al., 2017; Forrester Consulting, 2015). Nowadays, formerly offline tools can be easily connected and interconnected, services can be moved from reactive up to predictive (Masson, 2016). These are evolving conditions which might have progressively led manufacturers to make an increasing employment of ICT to servitize their offers.

Additionally, in the latest years, incredible progresses have been achieved on the quality, size, potential and price of sensing systems, that nowadays promise great and affordable service opportunities (Thoben et al., 2017). Furthermore, a research from Goldman Sachs highlighted how, in the last decade, sensors prices dropped to 60% on average, processing costs declined by nearly 60X and the overall wireless connectivity become available for free or at a very low cost (Goldman Sachs Global Investment Research, 2014).
These are opportunities that might enable and push manufacturers to apply in the offering portfolio the advantages delivered by technological applications. These latter could potentially provide the former with the possibility of making use of their existing installed base, while enjoying a physical distance from the customers, still keeping the track of their utilization patterns, in order to trigger service components (Shah et al., 2006; Tamburini, 2016).

2.5. The arduous journey toward the implementation of PSS

Given all the drivers, benefits and facilitators associated, the next move would be trying to detect a step-by-step guide for the manufacturers implementation of PSS. Unfortunately, according to the academia, the task is not that simple.

In Gaiardelli's opinion (2014), different organizations are trying to approach the servitization shift in an "unstructured fashion", probably because of the insufficient understanding by them of the different kinds of PSS. Generally speaking, companies attempt to attach value-adding experiences around their products (LaSalle, 2003), through an incremental service infusion adopted via small steps, with no directed efforts dedicated (Kowalkowski, 2012). This is, according Kowalkowski, the so called "agile incrementalism" approach, that conceives the service strategy as a way characterized by continuous modifications, adaptations, *ad hoc* innovations and recalibrations of opportunities and goals (Kowalkowski, 2012).
Chen (2010), on the other hand, suggests the TRIZ design methodology to support the creation of PSS: the Altshuller's method developed in the former Soviet Union based on the analysis of 400'000 patents and suggesting 40 principles and obstacles in a matrix. Also, Kim (2015) proposes four different steps to be followed for designing a PSS offering, namely strategic planning, idea generation and selection, service design and product development. However, here the perspective is the one of a service company aiming at offering a PSS, rather than the one of a servitizing manufacturer. A different option is the one delivered by the MEPSS Handbook (2004), which introduces a methodology and toolkit for the development of a PSS model (Baines et al., 2007). The first who tried to define a way, however, is again Tukker, who intended to write down a manual for allowing companies to identify a PSS offer in 2003.

Unfortunately, as emerges from this brief review, a widely recognized common framework to be followed to activate PSS offers does not seem to exist. Also, there is a lack of critical evaluations for the aforementioned methods, limiting their possible applicability. After all, it might be argued whether a common approach is needed, considering that "PSS must be designed, made and delivered on a case by case basis and viewed from the client perspective" (Baines et al., 2007, p.11). Nevertheless, the many different business-related contributions seem to be mostly dedicated to the idea generation of PSS or to general ways for PSS definition and design, rather than at the identification of generally applicable tools to leverage on for their implementation.

With no paved ways ahead, therefore, it might be useful to figure out what are the major challenges that might impede a PSS implementation, aiming at finding these solver, enabler tools. In fact, once identified the "threats", then it might be possible to detect a possible facilitator which might help to overcome them.

2.6. PSS implementation: obstacles and challenges

Most of the authors who showed interest for PSS, including Goedkoop (1999), Manzini et al. (2001), Mont (2002) and UNEP (2002), tend to identify the cultural shift needed by the customer as the main challenge for the PSS implementation. In their opinion, the greatest problem is making the customer perceive and capture the value for having a need satisfied, rather than for owning a new product.

However, it should be noticed that during the almost two decades which separate their contributions from the present one, this perspective might have changed. In particular, it is possible to find in the academia a multitude of more recent studies which focus on the development and success of the sharing economy or on the changes in the customers' consumption patterns and preferences, including the recent research of Zervas et al. (2014) and the one of Hamari (2015). Therefore, without exploring the topic, it might suffice here to state that, in the present paper, the "cultural change needed by the customer" is not considered as a main challenge to be overcome. This because its research and analysis would bring the focus far from the research question, revealing a too wide and distinct area of research.

Contrarily, one major general concern related to the implementation of PSS, whose analysis could be relevant for the given focus of the topic, is related to the risk of incurring in the so called Service Paradox (Gebauer et al., 2005), introduced in the next paragraph.

2.6.1. The Service Paradox

Gebauer et al. (2005), following also Oliva and Kallenberg (2003), identified a transition line that describes the continuum that goes from Product Manufacturers to Service Providers, as shown in Figure 3. On one side there is the pure manufacturer, whose income mainly derives from pure products and to a way lesser extent by some add-on, product-related., services. The opposite side identifies the Service Provider which, oppositely, creates value especially through services: products only represent support factors for its service offer, contributing with a minor share in the overall turnover.

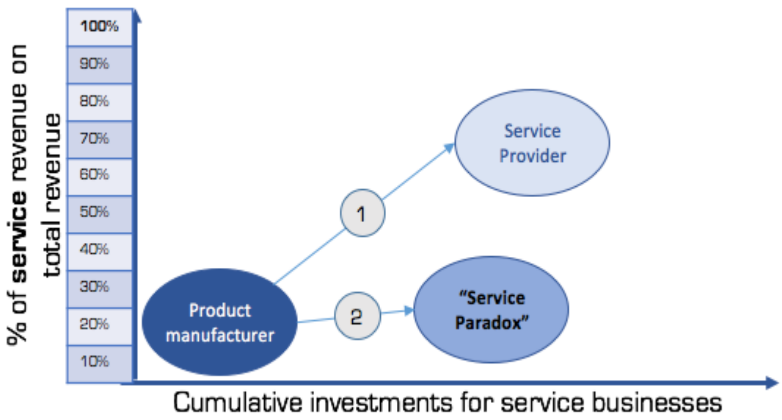

Figure 3. The Service Paradox (from Gebauer et al., 2005)

The Service Paradox describes the situation in which a product manufacturer fails to become a Service Provider, by shifting on the line "1". This happens when the former follows instead the line "2", investing great amounts in service businesses, incurring in higher costs related to a more complex offering, without yielding the expected higher return from services (Gebauer et al., 2005).

This situation is also presented by the extensive quantitative study of Neely (2008), which demonstrated the difficulty of manufacturers to succeed through the servitization shift, given the higher costs to be incurred and the uncertainty in the returns, after the modification of the offer.

Incurring in the Service Paradox can be extremely detrimental for a servitizing company, since it would translate in a progressive erosion of its margins and income, leading in some cases to bankruptcy (Neely, 2008).

2.7. Overcoming the paradox

Gebauer et al. (2005) identified six general recommendations to be followed in order not to take the wrong path identified by the line 2 of Figure 3. Without naming and analyzing all of them, it shall be noteworthy to mention here the first three, that are about: establishing a market-oriented and clearly defined service development process; focusing service offers on the value proposition to the customer; initiating relationship marketing. At a first glance, the just mentioned suggestions - which represent half of the body of all the solutions identified by Gebauer et al. (2005) for overcoming the Service Paradox – seem to be all related to a common topic. In particular, they refer to the role the company has to play towards its external environment and market, that is mainly represented by its customers. It might be questioned, therefore, if the connection with the customer might represent a major concern – at least one of the most problematic – to overcome the Service Paradox and approach the servitization shift successfully.

Baines et al. (2007) agrees with this idea, by stressing the key role the relationship between customers and the company has to play in the design and implementation of effective PSS. Also Oliva and Kallenberg (2003) highlight this point, recommending that PSS require new business models based on relationships rather than transactions. Nevertheless, a problem that might arise for companies willing to move toward services lays exactly in the definition of "service". Given the intangibility and the contextual production and consumption, characteristics that define the term (Zeithaml, 2013), it might be argued that companies which are willing to compete via services strongly need to stay as close as possible to the end customers, developing a customer-centric, relation-based approach.

For instance, Vandermerwe and Rada warn manufacturers that "when customers don't use services to their full potential because they don't know how or why, the manufacturer becomes vulnerable. Hence the need to create a service-centered business philosophy" (Vandermerwe and Rada, 1988, p.323). Likewise, Baines et al. explained that "to be both effective and efficient, manufacturers need, for example, to be able to understand how their customers will value their services. Similarly, they will need to be able to configure their products, technologies, operations, and supply chain to support this value offering" (Baines et al., 2008, p.563).

What aforementioned suggests that one of the biggest challenges for a PSS implementation is understanding customers, building a relation with them and keeping track of their needs and usage patterns, in order to offer specific solutions (Mathieu, 2001, Baines et al., 2007).

2.7.1. The importance of the contact with customers

As already mentioned, the focus of this section is more on the main challenges related to the implementation of PSS, rather than to the design, creation and/or definition. This also by considering the multitude of existing frameworks (introduced in paragraph 2.5.) for the fuzzy-front end stage of development, but still the difficulty in finding some effective and generally applicable.

According to what emerged from the previous section, one main problem for the implementation of PSS seems to be establishing and retaining contacts with customers. This plausibly means, again, continuously understanding them, maintaining a relation and keeping track of their usage patterns, in order to offer individual-based solutions.

The problem, mentioning Magnusson (2000), lies on the operational efficiency combined with the potential cost of the contact. Closer contacts lead to higher costs, given the more personnel, time and effort involved. That is why low cost providers use to minimize the contact to maximize the efficiency, lowering costs. Nevertheless, a high level of contact with the customer undoubtedly produces many benefits (Magnusson, 2000). A fast, individual, customer-centric and cost-effective response to customers' needs, is crucial for the success of a service strategy, especially for actors that are striving for getting closer to the figure of Service Provider, as shown in Figure 3. This is important also by virtue of the risk of incurring in unexpected rivalry with suppliers, customers or distributors, when moving outside the former value chain position (Vandermerwe and Rada, 1988; Oliva and Kallenberg, 2003; Mathieu, 2001).

One possible solution that could solve these concerns might arguably be represented by the Internet of Things, or, more precisely, by the opportunities delivered from its implementation.
Before explaining the possible relation between IoT and services, however, it is firstly necessary to explain what is the IoT. The next paragraph, therefore, is dedicated to its presentation and understanding.

2.8. "That Internet of Things thing"

The "Internet of Things" term was coined almost twenty years ago, by the founders of the MIT Auto-ID Center, with a particular mention to Kevin Ashton, who, in 1999, used the denomination in the context of supply chain management (Ashton, 2009; Jayavardhana et al., 2013). "Auto-ID" expression "refers to any broad class of identification technologies used in industry to automate, reduce errors, and increase efficiency. These technologies include bar codes, smart cards, sensors, voice recognition, and biometrics" (Vermesan et al., 2009 p.12). Starting from this basis, the concept of IoT has deeply developed, and it has been identified as a network infrastructure with the self-configuring abilities that are based on standard communication protocols in which the "things" have an identification and attributes and can communicate between each other (Vermesan et al., 2009). A more recent, less technical, explanation of the term is provided by the International Telecommunication Union (ITU), which defines IoT as "a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies" (ITU, 2015).

Under this perspective, a "thing" in the context of IoT can "sense" its environment (mainly through sensors), can perform some computations (usually via an embedded software that makes it "intelligent" or "smart"), is connected via the internet to other "things", with which it exchanges information and commands (Tamburini, 2015).

These connectable "things" are described by Porter and Heppelmann as products with three main dimensions: physical components, "smart" components and connectivity components. While the first elements refer to the mechanical and electric parts of the product (e.g. for a car, the engine, the tires, batteries…), the "smart" components are the sensors, microprocessors, software and an embedded operating systems. These are elements that enhance and amplify the capabilities of physical components (e.g. anti-lock braking system, automatic wipers, touch screen display…). The third dimension, on the other hand, is the one that enables IoT to take the field. Connectivity components are represented by ports, antennae and protocols able to trigger connections – one-to-one, one-to-many or many-to-many; wired or wireless – with the product (Porter and Heppelman, 2014).

In consonance with a study undertaken by Goldman Sachs, IoT has the potential of rearranging the technological landscape. Again. It has key attributes that differentiate from the "usual" Internet, that can be captured by the S-E-N-S-E framework: Sensing, Efficient, Networked, Specialized, Everywhere. These are attributes that might lead to a shift in the direction of technology development, diffusion and adoption

S-E-N-S-E	What IoT does	How IoT differs from the Internet
Sensing	Leverages sensors attached to things (e.g. temperature, speed, pressure, acceleration…)	More data is generated by things with sensors than by people
Efficient	Adds intelligence to manual processes (e.g. reduce power usage during hot days)	Extends Internet's productivity gains to things, not just to people
Networked	Connect objects to the network (e.g. cars, watches, thermostats…)	Some of the intelligence shifts from the cloud to the network's edge
Specialized	Customizes technology and processes to specific verticals (e.g. retail, healthcare, oil…)	Unlike the broad horizontal reach of PCs and smartphones, IoT is very fragmented
Everywhere	Deployed pervasively (e.g. on the human body, cars, cities, factories, homes…)	Ubiquitous presence, resulting in an order of magnitude more devices and even greater security concerns.

Figure 4. S-E-N-S-E framework (Goldman Sachs Global Investment Research, 2014)

(Goldman Sachs Global Investment Research, 2014). Figure 4 shows the framework, summarizing IoT functions and the differences with the Internet.

IoT development and diffusion have very important implications in the business world. Its applications in the past decade covered an incredible range of fields, including utilities, healthcare, transport, manufacturing and many others, across different industries (Jayavardhana et al., 2013). Agreeing with many authors, including Thoben et al. (2017), IoT represented the main catalyst for the fourth industrial revolution, also called Industry 4.0. As reported by Manyika et al. (2015) also, IoT has a total impact, economically speaking, of 3.9 up to 11.1 trillion per year in 2025, that corresponds to the 11% of the total 2025 world economy.

By virtue of what aforementioned, it might be interesting to consider that, according to a research conducted by SaS in 2015, half of US manufacturing companies acknowledged that they deployed IoT to improve their operations. However, only the 44% collected data from sensors in their products, while only one third of them reported to have a specific strategy based on IoT (SaS, 2015).

This finding sums up, by some means, the current business scenario for IoT: although it is deeply transforming business operations and enabling new offers, nowadays organizations tend to identify it as more of an operational efficiency-enhancer (mainly at the factory floor, the area of influence and development of the Industry 4.0; Thoben et al., 2017), rather than a catalyst for the development and implementation of new offerings and value propositions (Forrester Consulting, 2015). In line with this result, a research by Whitmore et al. (2015) explains that, despite the exponential growth of scientific contributions on technical aspects of IoT, there is still a lack of a relevant academic body regarding IoT applications in a business perspective. The contribution of Gigli (2011) about IoT possible applications, for instance, although widely understandable, is extremely relevant only for developers and for whoever is interested in technical aspects, rather than for business managers.

One of the few research papers that addresses the integration of IoT in a business portfolio, however, is the one of Torsten and May (2016), which introduces a framework to classify the opportunities IoT is able to deliver to the firm transactions. It goes beyond the general overview provided by both Manyika et al. (2015) and Forrester Consulting (2015), which presents two functions or applications IoT might interpret in a business perspective, namely transforming processes or enabling new business models. On the other hand, the model by Torsten and May (2016), which analyzes more in depth the possible applications of IoT, is discussed in the next section.

2.9. The roles of IoT in an offering portfolio

Torsten and May (2016) - who have slightly modified the previously elaborated model by Cusuano et al. (2015), in order to apply it specifically to IoT - suggest a framework which presents three possible roles IoT is able to interpret for a "firm's offering portfolio" (Torsten and May, 2016).

Figure 5 shows their model, and, aiming at delivering a more thorough understanding, integrates the original version with some additional examples analyzed later in the text.

	COMPLEMENT		REPLACE
Role of IoT	**Smoothing** (Enabler)	**Adaptation** (adjunct service/product)	**Innovation** (core service/product)
Role Characteristics "The IoT component..."	• Is pivotal to *initiate* the transaction • Potentially *reduces* transaction costs • Is *not* a part of the core offer	• Significantly *increases* value • Is *not* the main value driver • Enables *additional functionalities* to an otherwise standalone product/service	• Is the main value driver of the product/service • Creates product/service features not available previously
Examples	• Amazon dash button • Car2Go and Eni-Enjoy • Bigbelly	• Parcel tracking • Philips hue lightingbulbs	• Domotics – home automation • Ralph Lauren's Polo Tech Shirt

Figure 5. The roles of IoT in offering portfolios (adapted from Torsten and May, 2016)

The framework presents three IoT functions, that can be grouped in two different categories, depending on their type of application in an offer. The first category is the one in which IoT *complements* a value proposition, meaning that it does not represent the main value driver, but it improves or adds something to the existing offer. In this case, the roles IoT can perform are two: it can Smooth (in the figure Smoothing) or Adapt (Adaptation) the offering portfolio. However, according to the model, IoT is also capable of *replacing* existing value propositions, by creating features not previously available, performing a third role, namely Innovation. These roles will be analyzed in details, one by one, in the following paragraphs.

2.9.1. Smoothing (Enabler):

Having a smoothing function means acting as an enabler. This signifies being pivotal to start transactions, without changing the basic functionality of an already existing offer (Cusumano et al., 2015).

One explanatory example, also mentioned by Torsten and May (2016), is the one of the Amazon dash button. It allows users to order house related goods (e.g. detergents, bottles of water…) by just pressing a branded wireless button that can be anchored anywhere in the dwelling. The items ordered in this way are then delivered through the standard distribution channels of the company (Economist, 2015). In this example, the service is still mainly represented by the sale and home delivery of goods, but the ordering method is smoothened by the IoT-enabled button, which makes the purchase simpler for the users (Torsten and May, 2016).

Similarly, Bigbelly offers "smart, self-powered waste management & recycling solutions", supported by "smart" waste stations which, thanks to sensors, automatically alert when they have to be emptied as too full (Bigbelly, 2017). This is a simple solution that enables (or smoothens) the waste collection service in a more effective way, thanks to IoT (Bigbelly, 2017). Other examples might be represented by the international offer of Car2Go or the one of Eni-Enjoy for the Italian market. Both offerings are about rental cars. However, in these cases the overall process of renting its smoothened by IoT, which allows customers to interact with the cars – that are spread randomly around the city according to where the previous user parked – thanks to their smartphones, from which it is possible to find, book and activate the closest available "smart car", as well as paying for the service via credit card, automatically (Car2Go, 2017; ENI-Enjoy, 2017).

2.9.2. Adaptation

The second *complement* role IoT can undertake is the so-called Adaptation role. Again, it does not imply an alteration of the main functionality of the related product or service. Contrarily, it rather aims at enriching it, via adding capabilities. Torsten and May (2016) report the example of the tracking and tracing systems of logistic companies for the shipments of goods. It is the case of the offers of many companies including Amazon, JustEat or Foodora (Sassanelli et al., 2016). Their value proposition still concerns the movement of materials or products, but thanks to the possibility - delivered by IoT - for both the sender and recipient to track the shipment location, the value of the service significantly increases.

An additional example of IoT Adaptation role is provided by the Philips Lighting hue lightbulbs. They are light bulbs controllable via smartphone, for switching them on or off, as well as for programming them for blinking if someone gets closer to them or for dimming if it is time to sleep, for instance (Porter and Heppelman, 2014).

2.9.3. Innovation

IoT is also able to completely change determined value propositions, creating previously unknown offerings, that are only possible through its implementation (Torsten and May, 2016). These opportunities are part of the second category, labelled *replacement* (instead of *complement*), which presents IoT Innovation role.

By performing the Innovation role, IoT triggers new product or service offerings, replacing the non-IoT-enabled ones (Torsten and May, 2016). It is possible to find examples in the *domotics*, the field of home automation systems. Indeed, there are many companies operating in the industry, which produce smart devices performing automated functions as regulation of temperature or remote monitoring and responsive readjustment of the energy consumption (Torsten and May, 2016). These are services that, without IoT components, could only be fulfilled via time-consuming, manual, interventions. Another case is the one of Ralph Lauren, which through its "Polo Tech Shirt", offers to runners the possibility of collecting and analyzing data on their mobile devices about their running session, including distance covered, calories burned and heart rate. The information is directly streamed from IoT components embedded in the T-shirt (Porter and Heppelman, 2014). Here the main value is not represented by the sole T-Shirt, but rather by the capabilities it is able to deliver thanks to IoT. Similarly, Nike FuelBand provides a wearable device through which customers can keep track of their progresses in trainings via the complementary app (Torsten and May, 2016; Nike, 2015). A further example for this category is the Babolat "Play Pure Drive" system, which, via sensors, connects the racket handle to the user's smartphone via a branded app. This way, the company can provide a service to help tennis players to improve their skills, by monitoring and tracking the ball speed, impact zone and spin, and by giving advices and suggestions basing on these data (Porter and Heppelman, 2014).

2.10. Why IoT for PSS?

Once having introduced and analyzed the different applications IoT is capable to offer to the offering portfolio of a company, for the purpose of this research, it might be relevant to give light to the rather unexplored area about how IoT might be related to the implementation of PSS. However, even before exploring what kind role IoT might play, under this perspective, it is necessary to provide reasons about why IoT, Servitization and PSS are concepts that might be connected between each others.

Torsten and May (2016) stated that, from the perspective of a manufacturer, IoT elements promote and enable servitization possibilities. Generally speaking, the adoption of digital technologies such as microprocessors and sensors may trigger the provision of additional services to an integrated product-service offer (Porter and Heppelman, 2014). By developing smart products, indeed, the company can "attach" additional intangible services to physical assets, providing more value or allowing its delivery.

As suggested from paragraphs 2.7 and 2.8, however, relevant challenges of servitizing manufacturers for implementing PSS are represented by their needs of establishing connections with customers, understanding them, maintaining a relation and keeping track of their usage patterns, aiming at offering individual-based solutions.

Nevertheless, it might be questioned whether IoT "brings" "smart things" closer to customer. In the case of *domotics*, for instance, IoT "brings" the oven, air conditioned, heating, lighting system, fridge and coffee machine right in the smartphone or remote controller of the user (Porter and Heppelman, 2014). Their functionalities, performances and conditions might be, this way, activated and/or monitored, for instance. At least theoretically speaking, these same possibilities can be applied to the smart products sold by firms and used by customers. This arguably means that, following the same thought, via IoT, "smart" products can be brought closer (not physically) to the owner of their "remote controller", that might possibly be also their producer. This does not necessarily imply the latter to remotely *control* customers' products and their usage. Contrarily, bringing what offered (product) closer to whom produced and offered (manufacturer), inevitably brings whomever purchased (customers) closer – without any effort – to whomever sold (manufacturer). This is also consistent with the fact that, in the most of the cases - in a PSS perspective - this latter is also the owner of the product, as it retains the property right in order to offer the capability (the "value in use"; Baines et al., 2007).

In other words, via IoT, at least theoretically speaking, it is possible to continuously monitor the functionalities, status and performance of the sold products, together with the usage patterns of the user, thus developing a deep customer understanding. This connection would then possibly lead the manufacturer toward a customer-centric approach without the need of deeply changing its structure, governance, functions and/or personnel.

Lightfoot (2016), agrees with this perspective, stressing how the relationship with customers is changing because companies – by employing IoT – can now maintain a contact with the product after its sale. Thanks to technologies like the Cloud and the deployment of remote monitoring solutions, products can be the object of advanced analytics and multi-functional dashboards, providing the manufacturer an ongoing visibility on the performance (Masson, 2016). Nevertheless, IoT solutions convey the possibility of leveraging on the installed base (Sassanelli et al., 2016), confirming this scenario.

To sum up, the contact established with products in the market enables the transfer of information and insights about customers' behavior and product utilization, thus allowing the company to understand the product performance and its specific usage patterns. This way, on the one hand, marketing capabilities of the company can sharply improve, because the latter has the chance to improve segmentation and develop more targeted pricing models, for instance. Also, on the other hand, it is possible to deliver new added services by understanding current customer needs and anticipate future ones (Lightfoot, 2016).

Last but not least, the "smart" components allow the company to remotely monitor, locate and somehow handle the installed base, thus reducing the risks associated with the retaining of the ownership, increasing the responsiveness to eventual problems, defects or unforeseen situations, and, as mentioned, permitting new services (Allmendinger and Lombreglia, 2005; Ontario, 2015; Lightfoot, 2016).

As a result, IoT seems to be tailor made to solve the PSS-related challenges of establishing connections with customers aiming at offering individual-based solutions. These include the profitable after sales services manufacturers are increasingly trying to focus on, to add value to their offers and drive new revenue streams (ICD manufacturing Insights, 2013).

Therefore, quoting Sassanelli et al. (2016), "IoT is surely an enabler of PSS" (p.36), since it allows not only to offer richer experiences for customers (Forrester Consulting, 2015), but also to collect, analyze and share relevant amount of information, along all the life cycle of the "solution" (Sassanelli et al., 2016), enabling reactive service opportunities (Lightfoot, 2016).

2.11. IoT opportunities for the implementation of PSS: empirical evidences

Considering that IoT seems able to solve some challenges associated to the PSS implementation, the next step of this study would be trying to define and analyze what are the real opportunities it can provide to PSS offerings. For this purpose, some companies' best practices have been identified, in order to evaluate the potential of IoT functions on practical cases.

It is possible to start from the three roles IoT can play, as defined earlier in the text: Smoothing, Adaptation and Innovation (Torsten and May, 2016). Also, the eight PSS identified by Tukker (2004), that might help in the categorization, are recalled. These are Product related and Advice and consultancy, PoPSS; Product lease, Product renting/sharing and Product pooling, UoPSS; Activity management, Pay per service unit and Functional result, RoPSS.

It is noteworthy to state that, in section 2.11, the offers of the manufacturers have been analyzed through the lenses of two different models (Tukker 2004 and Torsten and May, 2016). Therefore, although everything is motivated and/or based on solid theoretical findings, it is clear that in some cases the author has made some assumptions for their classification.

2.11.1. Opportunities from Smoothing

For what concerns Smoothing, some empirical evidences from secondary sources confirm the point of view of Sassanelli et al. (2016). In particular, the previous cases of Car2Go and Eni-Enjoy might suggest how IoT can enable the implementation of UoPSS. Indeed, in those cases, the possibility of customers to connect their smartphones to the car to search, book, activate and pay for the rental service, led to the implementation of "Product renting/sharing" PSS as identified by Tukker (2004). Indeed, the car manufacturer, by making its cars "smarter" and connected, has the possibility to implement a different business model based on a "pay-as-you-go" or "on demand" concept, that does not imply the sale of the ownership of the product. Also Zipcar, the offer of the American car-sharing company, subsidiary of the Group of Avis Budget, works exactly in the same way. As its motto says, "Own the trip, not the car" (Zipcar, 2017).
Arguably, in these cases, by enabling manufacturers to remotely monitor their products and by allowing customers to do the same, IoT endowed the former with the possibility of delivering value in use. This happened without the need of having intermediaries, that otherwise would have necessitated to "stay close" to the end user to start - *smooth* or *enable* – the transaction.

Philips "Lighting-as-a-service" provides a different example (Philip, 2017). In Washington, DC, the company delivered to the Capital 13'000 lighting installations with no upfront cost, in a 10-year contract. The installed bulbs are able to autonomously alert the company in real time about when and where maintenance is needed, while the company can remotely control them and monitor their utilization. Philip revenues derive from the savings LEDs are expected to provide each year, thus offering at the same time a lighting and saving solution to the customer, without transferring the ownership of the product (Tamburini, 2016).
In this case IoT, which makes the connection between bulbs and the company happen, arguably enabled (or smoothened) the implementation of RoPSS, namely an Activity management (Tukker, 2004). Indeed, the offer concerns the complete management of the installed base of bulbs to provide light, rather than the mere delivering of bulbs (that is why RoPSS). However, a same value proposition - providing illumination to an

area - might have been delivered even without the support of IoT, but here its components have triggered the way trough which the solution is supplied, namely through a RoPSS. This is why it might be asserted that IoT played a Smoothing role, in this case.

2.11.2. Opportunities from Adaptation

One same manufacturer can also deliver different PSS by commercializing a same product while letting IoT play different roles in different offers. It is again the case of Philips, which, with its "Lighting hue lightbulbs", leveraged on IoT in a completely different way compared to its "Lighting-as-a-service", implementing also a different business model. In the case of Lighting hue lightbulbs, as mentioned in Paragraph 2.9.2, IoT has been utilized to enrich the value of the product, via adding related capabilities, but still maintaining a quite traditional transitional business model based on the sale of the ownership (Torsten and May, 2016; Porter and Heppelman, 2014). Therefore, in this case, with IoT Adaptation function, following Tukker (2004), it might be stated that Philips implemented a Product related PoPSS.

Lightfoot's contribution (2016), also, presents Tesla Motor Automobiles cars as smart products with a maintenance system that autonomously alert the company for any issue that can be solved quickly by automatic corrective software downloads. Considering that the offer of Tesla is still about "selling cars", arguably here IoT plays an Adaptation role, since it ameliorates an offer without deeply altering it (Torsten ad May, 2016). However, via IoT components, Tesla can remotely offer integrated services (responsive corrective software downloads) together with the physical asset, in Product related, PoPSS. A very similar case is the one of the "Expert-on-Alert" system in GE devices, which allows a condition based maintenance thanks to a centralized, remote, real-time monitoring over the status and performance (GE, 2017).

Another interesting example is the one provided by LEGO Mindstorms. The company offer a robot kit that not only can be freely assembled (usual function of the notorious LEGO bricks), but can also be freely programmable and controlled by smartphones. Thanks to the sensors and microprocessors and a branded, open source, software interface offered with the kit, the robot can be easily programmed for doing both basic and advanced functions (e.g. move, walk, up to shoot, run, rotate, talk, answer…). Via the forums on the LEGO website, also, it is possible to be part of users' communities to gather ideas and suggestions for potential utilizations or assemblies of the robot, enabling further support services to happen (LEGO Mindstorms, 2017). Therefore, the connection between the CPU of LEGO Mindstorms robot and the mobile phone of the user, via IoT, allows LEGO to offer more than just an assembled toy, adding a great value to the usual offer, without altering its main value proposition, in a Product related PoPSS.

2.11.3. Opportunities from Innovation

Recalling Torsten and May (2016), by performing the Innovation role, IoT intends to trigger new product or service offerings, replacing non-IoT-enabled ones.

This is the case of the already mentioned cases of Ralph Lauren “Polo Tech Shirt”, Nike “FuelBand” and Babolat “Play Pure Drive”. IoT allows the three corresponding companies to sell, together with the products, additional relevant innovative support services. Considering that these aim at helping customers to understand their own behavior in use, as well as at giving suggestions for them to improve (e.g. to improve the spin of the ball with the Babolat racket), the overall offers of the companies can possibly be referred as Advice and consultancy, PoPSS.

In the field of *domotics*, on the other hand, smart devices that autonomously perform automated services, including regulation of temperature and responsive readjustment of the energy consumption (Torsten and May, 2016), are part of the PSS offers of the corresponding manufacturers. In this case, however, the capabilities of the connected products permit devices to offer automated and combined house-related solutions to customers, thus probably enabling sort of Activity management PSS, if analyzed through the Tukker’s lenses (2004): kinds of RoPSS offerings. This is also the case of the GE “Trip Optimizer”, which is a cruise control for locomotives employed for optimizing the fuel consumption, which autonomously can set the optimal speed taking into account the train characteristic and route topography (GE, 2017).

2.12. The IoT-PSS Matrix

In the last paragraphs clearly emerged how the roles IoT is able to play in the offering portfolio are connected with the type of offers delivered by the corresponding firm, and might imply or enable it to implement different PSS.

The present research, aiming at further integrating the two concepts of IoT and PSS, by trying to detect the opportunities the former can deliver to the latter, proceeds by introducing a new framework based on the combination of the efforts of Torsten and May (2016) and Tukker (2004). This model aims at facilitating the understanding of the relation between IoT and PSS, while offering a structure in which is possible to collocate, classify and analyze different best practices of servitizing manufacturers.

The IoT-PSS Matrix, shown in Figure 6, presents on the horizontal axis the different kinds of PSS, as conceived by Manzini et al. (2001), Tukker (2004) and Baines et al. (2007): PoPSS, UoPSS and RoPSS. On the vertical axis, instead, are collocated the possible different roles IoT might play, as introduced earlier, from Torsten and May (2016): Smoothing, Adaptation and Innovation. To these three there, the case in which IoT has no role at all - or a not relevant or specified one - in the offer has been added, in order to present all the possible alternatives.

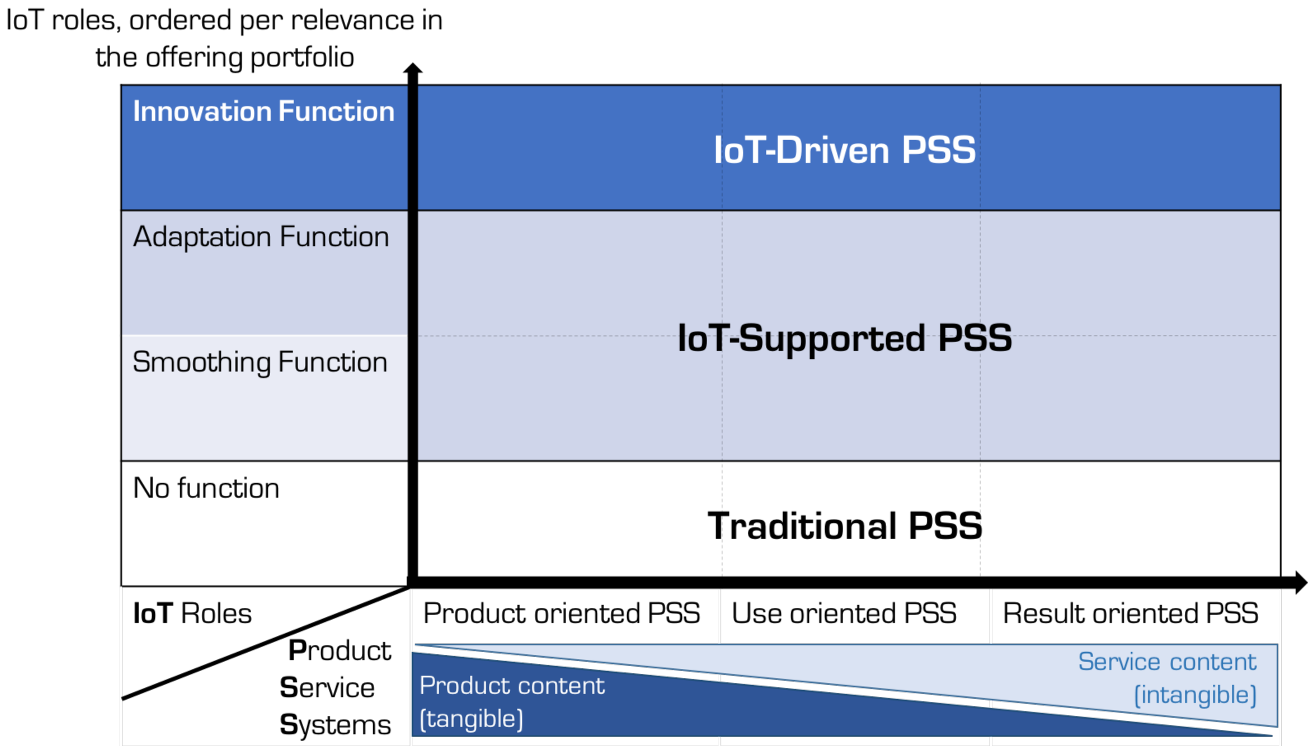

Figure 6. The IoT-PSS Matrix

As analyzed earlier, IoT employment influences the offer, delivering manufacturers different possibilities to implement PSS. One single role of IoT, furthermore, can enable different kinds of PSS, according to its usage. This is why the matrix presents twelve different alternatives, divided in three groups. The first group, at the bottom, is represented by the Traditional PSS: these are the ones that do not envisage any support from IoT components, or in which their function is completely unknown.

The second group, in the center, is the one to which correspond the roles of Smoothing and Adaptation. In other words, these are PSS in which IoT might play two different functions:

The first one is the one in which it plays a pivotal role for starting the transaction intended in the PSS. Playing a Smoothing function means that it is crucial for enabling the PSS, but still does not represent or it is not strictly necessary for the main value driver of the offer. For instance, a company (e.g. a common car rental provider), could rent cars even without IoT support, but its implementation might trigger PSS offerings (e.g. Car2Go, Eni-Enjoy, Zipcar), that envisage a similar value proposition (i.e. rental cars) in a different way (e.g. IoT allows the whole process of renting a car only through connected devices, without the need of human intermediaries).

The other function is the one of Adapting PSS. This means that IoT is not crucial for starting the transaction nor for creating the value driver, but rather for contributing to ameliorate the it, offering new, additional opportunities via IoT components.

In this central area are collocated the different IoT-Supported PSS, namely PSS that are assisted and/or improved by the capabilities provided by IoT.

The last part, at the top of the matrix, is composed by the three possible PSS implemented through IoT Innovation function. These are the IoT-Driven PSS, given the crucial role IoT plays for the delivering of offers that would not be available without its components. In a sense, these are PSS in which the opportunities provided by IoT do represent the main value driver of the offer. In other words, for this latter case, what customers are paying for is exactly something for which IoT is a precondition.

The matrix is utilized in chapter 5 for analyzing the empirics, but it is also applied in the next paragraph for summarizing and categorizing the wide body of examples mentioned throughout this chapter.

2.13. Summary of the theory

The literature review has put light on the servitization trend manufacturing companies have been approaching in the last decades. Many companies have developed offers which imply the combination of product and services, that can be categorized in Product oriented, Use oriented or Result oriented, Product Service Systems (Manzini et al., 2001; Tukker, 2004). This overall tendency toward the offering of PSS has been pushed by many factors, that can be summed up in three rationales, namely Environmental, Economic and Customer-related, and in Technological drivers.

Given the advantages PSS are able to deliver to manufacturers, one aim of the review has been to define a step-by-step model for their implementation, but scholars failed to provide a common, reliable guide or widely recognized tools that might assist PSS applications.

Aiming at finding a facilitator, the research has tried to detect some major challenges associated with the PSS implementation, to then identify a possible "solver". The Service Paradox has showed how, without a close relationship with customers and a deep understanding of their needs and usage patterns, a product manufacturer would struggle to become a successful service provider (Gebauer et al., 2005).

Here is where the Internet of Things has come into play. Indeed, the functions it is able to perform in a business portfolio offering, namely Smoothing, Adaptation and Innovation (Torsten and May, 2016), can support the company in the development of the needed customer-centric approach. Nevertheless, many empirical cases and studies have showed how IoT might allow companies to trigger a connection with customers. Moreover, the theory has suggested how IoT is strongly connected with PSS, being the former a possible "catalyst" or "enabler" of the latter (Sassanelli et al., 2016).

Paragraph 2.11 has presented many secondary-gathered empirical evidences of how IoT, via its different roles, is able to provide opportunities for the PSS implementations of manufacturers.

Once having introduced the IoT-PSS Matrix, it might be useful for the reader to apply it, by making use of the examples previously analyzed in the text, before going forward into the research. Indeed, this should not only facilitate an understanding of the model, before applying it in the analysis of the empirical findings in Chapter 5, but it can also deliver a summary of the topics and examples mentioned previously.

In Figure 7, therefore, the different offers analyzed in the theoretical review have been collected, classified and collocated in the matrix, according to what suggested in Chapter 2.

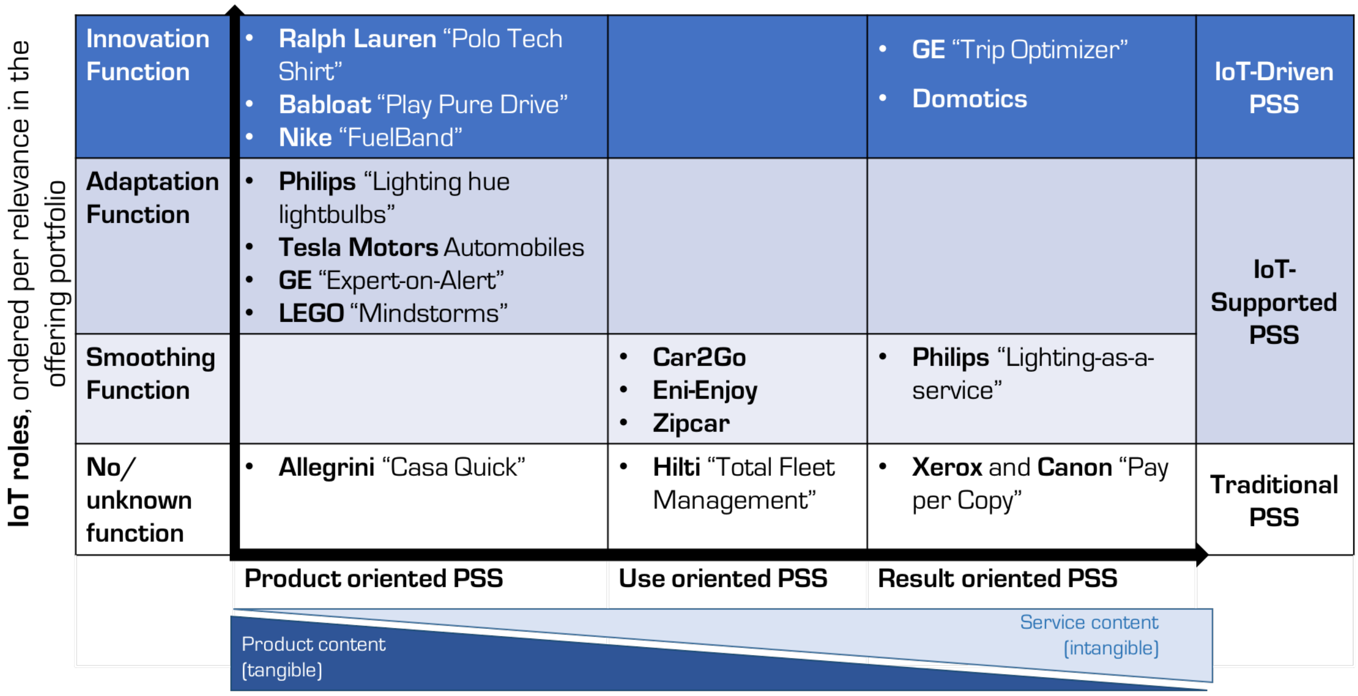

Figure 7. Application of the IoT-PSS Matrix on secondary gathered empirics

3. Research Methodology

This section analyzes the research type, strategy, design, approach and methodology that have been chosen by the researcher for addressing the research question(s). Moreover, it provides the settings for the sample selection, interviews and presentation of the empirics. Last but not least, it evaluates the research quality.

3.1. Research Strategy

The present paper employs a qualitative research strategy in order to address the research question(s). This approach provides the researcher with a potentially broad and comprehensive picture of the individual settings of the interviewed companies. Its purpose, indeed, is to generate theory by analyzing empirical findings, rather than by testing hypotheses (Flick, 2009). This is why it ha been undertaken an iterative approach based on the interpretation, contextualization and conceptualization of data, a narrowing of the questions to be answered and collection of further data, up to the identification of findings and conclusions (Bryman & Bell, 2015). Nevertheless, the use of the qualitative strategy opens up for flexibility in the research, leaving room for adjustments *in itinere*, according to the different people interviewed, questions asked and kinds of answers received.

Furthermore, the present research is to be considered explorative, as it aims at obtaining data with the use of different cases and qualitative interviews (Flick, 2009). This approach has been selected due to the originality of the topic, and to the lack of relevant amounts of strictly related theories.

Being this strategy strongly dependent on the researcher's interpretations of the findings, there might be present the risk of bias, as well as the difficulty in generalizing the outcomes. However, the mentioned drawbacks are unfortunately intrinsic characteristics of every qualitative study (Bryman & Bell, 2015). Also, it is not in the purpose of this paper to generalize the findings across different organizations. Contrarily, it aims at making an in-depth, context-dependent interpretation of the interviewed companies, in order to understand their general settings, offers and their development, with a particular focus on their potential employment of IoT-driven capabilities.

Hence, given the research question(s) and the selected strategy, this paper adopts an inductive approach, aiming at generating theory from the observations. Thus, the following study is open for not expected or not predetermined data. Nonetheless, also inductive approaches imply some deductive elements (Bryman & Bell, 2015). Indeed, the outcome of the literature review, explained in the theoretical framework in the Paragraph 2.12 (Figure 6; the IoT-PSS Matrix) has been tested on the different settings of the cases. This choice is justified by the possibility of better understanding, categorizing and then analyzing the empirical findings gathered.

3.2. Research Design

The design that has been chosen for this research is the multiple case study, as it entails the most suitable alternative for this master thesis. As a matter of fact, to understand if, why and how IoT is employed by servitizing manufacturing firms, there is the need of analyzing more than one case, receiving many different inputs from various sources. The design is also consistent with the choice of combining two different topics in a new framework - PSS and IoT -. More cases can provide a wider breadth and a better understanding of different points of view about the topic, that are absolutely needed, considering the lack of extensive academic research in the subject. Multiple case studies are widely undertaken for the purpose of comparing the different cases included and, therefore, they allow the differences between the cases to emerge (Bryman & Bell, 2015). Notwithstanding, the focus has been kept on the cases and their unique context, as this should favor the addressing of the research question(s), in the most comprehensive way possible. Indeed, the purpose of this multiple case study is to identify the different "best practices", as well as the distinctive opportunities and challenges recognized by the selected cases.

It is noteworthy to mention that the present work has been conduced within the Double Degree Program between LUISS Guido Carli and Gothenburg University, School of Business and Law. Hence, some characteristics of its design (e.g. its length), are due to different requirements from the different universities.

3.3. Research Method

Primary data have been gathered by conducing semi-structured interviews. These generally allow researchers to interview more than once the same people, to ask again for relevant topic or to go deeper in some matters as the conversation proceeded (Bryman & Bell, 2015). Indeed, this choice has delivered more flexibility the author, and has allowed him to obtain rich and detailed information from the interviewees: for their iterative nature, semi-structured interviews endow the key people in the selected multiple cases with the freedom to touch all the relevant topics related to the demanded themes. These latter are the pivotal elements around which the interview guideline (shown in Appendix 2) was developed. The guideline is an important factor because, although it allows a certain extent of flexibility to both the interviewer and the interviewee, it makes sure to keep the focus on relevant topics and to cover certain issues related to the research question (Bryman & Bell, 2015).

The amount and type of interviews, as well as the number, name and roles of the questioned interviewees, are shown in figure 8. It displays the name and logos of the companies, the corresponding interviewee's names and positions, the dates, places and durations of the interviews, as well as other settings that would permit a certain extent of repeatability to other researchers.

The interviews took place at the respondents' offices in all cases except two. For one case, indeed, the interviewees were questioned via Skype, Skype for Businesses and GoToMeeting, since it has not been possible to meet them physically (Autodesk), given the author's limited time and resources (they are located, indeed, in a different continent). For another case, an interview has been partially undertaken via email, for having access to preliminary information (Stavdal).

Company	Respondent(s) Name	Respondent(s) Position	Location(s)	Date(s)	Type(s)	Duration	Language
AUTODESK.	• Diego Tamburini • Lona Dalessandro • Leslie Bull	• Senior Industry strategist • Senior Product manager, IoT • IoT Sales executive	• Seattle • Minneapolis • San Francisco	• 14/03/2017 20/03/2017 • 23/03/2017 • 24/03/2017	• Skype • Skype for Business • GoToMeeting	• 60 min 60 min • 60 min • 45 min	• English • English • English
Stavdal	• Mikael Olsson	• CEO	• Gothenburg	• 08/03/2017 10/03/2017	• Email Face to face	• - 90 min	• English
SKF	• Carlos García Timón	• Business Analysis manager	• Gothenburg	• 06/03/2017 17/03/2017	• Face to face Face to face	• 50 min 70 min	• English
VOLVO	• Helena Sundqvist • Kristoffer Hjelm	• Uptime & Service sales manager • Product manager for Uptime and Service contracts	• Gothenburg • Gothenburg	• 06/04/2017 • 20/04/2017	• Face to face • Face to face (Focus group with Mrs. Sundqvist)	• 120 min • 130 min	• English • English

Figure 8. Interviews settings.

It is noteworthy to mention that, during every interview, leading questions were avoided in order not to bias interviewees' answers. Also, to reduce errors, all the recorded interviews were transcribed in detail right after the meeting, in order to ensure a proper assessment of the interviewees' answers, reducing at the minimum any memory limitation and personal re-elaboration.

In all the cases, during the very firsts meetings, the interviewees were briefly introduced via a Power Point presentation to the master thesis project and to its main themes, as well as briefed on the concepts of servitization, PSS and IoT, when needed.

3.4. Data Collection

The data that have been employed in the present research derive from both primary and secondary sources. All the information obtained via the semi-structured interviews, emails, company reports, documents and presentations have been considered as primary data. Secondary data, on the other hand, have been gathered from books, newspaper, academic journals, articles and research, as well as from many internet websites of companies and magazines. Databases that have been employed include Google Scholars, Science Direct, Orbis and EmeraldInsight. The Bibliography and Sitography sections present the complete list of the sources that have been consulted and utilized. These have been extremely useful especially for understanding and designing the theoretical framework, that provides an overview on the relevant topics, facilitating the introduction and understanding of the empirics presented in the next chapter. Moreover, many best practices or offers of companies, publicly available from their corresponding corporate website, have been researched and presented. This is, in order to have practical examples providing a more comprehensive understanding of theoretical topics presented in Chapter 2.

Obviously, the source criticism aspect has been a crucial factor for examining and using secondary sources. Under this perspective, when choosing a source, not only the relevance of its content has been taken into account, but also the quality of the publication – and of the publisher -, as well as, for articles, the number of citations and the date of publication (more recent contributions have been preferred to elder ones). Highly ranked journals and universities have been considered as reliable sources.

3.5. Case Selection

The sample group for this research has been selected via a purposive sampling. In fact, both the companies and the interviewees have direct reference to the research question (Flick, 2009). This not only means that the selected companies deal with the concepts introduced in the theoretical framework, but also that the role of the interviewed employees, shown by Figure 8, have granted them with the ability and authority to address precisely and reliably the questions. This result has been reached also thanks to a snowball sampling of the interviewees (Flick, 2009; Bryman & Bell, 2015). In particular, this happened in certain cases, when the first interviewee was not able to address all the relevant topics, and/or if it was possible to be introduced to further available colleagues more specialized in the matter, for some specific questions. This way, for certain companies, more than one person has been interviewed, in order to access to all the relevant information.

The interviewed companies, to comply with the requirement of a purposive sampling (i.e. being perfectly consistent with the research question), have been selected by following some specific criteria. In particular, being the aim of this work detecting both the role played, and potential opportunities and challenges implied by IoT for PSS, the need of choosing a relevant sample group, composed by subjects which somehow relate to manufacturing industries, PSS offerings and IoT implementation, is evident.

Therefore, in order to select the right cases able to provide relevant information to address the research question(s), the preference has been set on companies which can satisfy at least one out of the two requirements presented below.

1. The company has a business model which employs PSS offering, in which IoT plays a role.
2. The company has a relevant experience about IoT implementation in the offering portfolio of manufacturers.

With the terms "PSS", and "IoT" is intended what extensively explained and analyzed in Chapter 2.

3.5.1. Sample composition

The sample group, which fulfill the criterion explained above, is still to be somehow considered a convenience group. This choice was due to the limited time and resources available to the author. In particular, The ( ) Space - an organization whose aim is to provide students with connections with companies for their research - provided support with its network for the case selection. Therefore, the case possibilities were limited according to the existing contacts of the organization. Indeed, in all the cases but Autodesk, The ( ) Space endowed the researcher with the possibility to establish the very first contacts with the companies. Once having precisely defined the subject of the research, The ( ) Space provided the author with a pool of potentially interested partners, all operating in Gothenburg. These companies have been filtered according to the selection criteria mentioned in the previous paragraph, and contacted with a preliminary email from the organization, to check their general interest. In all the cases the feedback received was positive. Therefore, both Stavdal AB, SKF, Volvo Trucks and a fourth company have been directly approached by the researcher to arrange a meeting for presenting the research project and defining the terms of the collaboration. Only the fourth company has not been available to disclose sensible information regarding a not-already-launched product, that represented the researcher's area of interest. In this latter case, after a first positive meeting, the company has decided not to participate in the project.

One particular case is the one of Autodesk. The company has been selected because the literature review put light on two articles by Mr. Tamburini (Tamburini, 2015; 2016) concerning specifically the subject of the present paper. In order to have access to his very relevant knowledge, the Senior Industry Strategist has been contacted via Linkedin, and thanks to his availability and interest in the topic, it has been possible to involve in the project him, his colleagues and the company he works for.

The following sections are dedicated to a very brief introduction of the companies, together with the reasons that encouraged the researcher to choose them.

3.5.1.1. *AUTODESK:*

Autodesk, Inc. operates as a design software and services company worldwide (Autodesk, 2017). Thanks to its relevant expertise in the IT-world and software development, the company has started to apply its competences and capabilities toward many industries. In particular, it recently started to provide software solutions for manufacturing companies. Fusion Connect is a service for manufacturing firms willing to integrate and connect their products through an IoT implementation (Fusion Connect, 2017). Aiming at accessing to some of its knowledge about IoT and its possible implementations and applications, especially by manufacturers, Autodesk has been chosen in the sample of this multiple case study. It is not a manufacturing firm which offers PSS, but it is rather a software and services provider with relevant experience about IoT implementation of manufacturers.

3.5.1.2. *STAVDAL AB:*

The company has been chosen for its business model, which foresees the rent of physical products integrated with support services. In particular, it offers rental solutions for construction companies in need of providers of worksites components (Stavdal, 2017). It is not a manufacturer, since it does purchase the equipment from other manufacturing companies, but it might be agreed that eventual IoT applications in its offer could be possibly implemented by other manufacturing companies competing via similar PSS. Nevertheless, its business model is very similar to the one of Hilti, whose example has been mentioned earlier, which is, indeed, a manufacturer. Moreover, since 2010, the company has started investing in new technological components for the newly purchased equipment - to be rented out -, which has started to be “smart” and “connected” (Stavdal, 2017). For these reasons, the company seemed perfect to be analyzed for addressing the research question.

3.5.1.3. *SKF:*

The Swedish multinational enterprise has been chosen for its relevant inclusion of services in its wide offering portfolio, which includes products, solutions and services in the rolling bearing and seal business (SKF, 2017). Nevertheless, the manufacturing company has always shown a deep interest in technological solutions and in IoT applications. Its great background as a world-class servitizing manufacturer qualifies it as a manufacturing company with a business model which employs PSS offering, in which IoT plays a role.

3.5.1.4. *VOLVO TRUCKS:*

The Swedish leading truck manufacturer has been selected for the way through which it markets its own products. Under this perspective, the company does not claim to sell trucks, but rather, to offer “*transport solutions*” (Volvo Trucks, 2017). Therefore, it does not only sale trucks traditionally, but also rent or even deliver them to customer via monthly-based contracts that include also assistance, maintenance and, generally speaking, complementary services (Volvo Trucks, 2017). Moreover, the Volvo AB subsidiary has definitely shown in last decades an interest in technological applications, and by visiting the webpage or by reading articles about Volvo in general, immediately emerges its interest for smart, connected products. For these reasons, it can be asserted that the company is a manufacturer which fulfills the criterion of implementing PSS offers in which IoT plays a role.

3.6. Empirics settings

Chapter 4 highlights the most relevant outcomes of the semi-structured interviews. For the sake of simplicity, efficiency and clarity, the chapter is divided into different relevant topics by virtue of the research question(s) areas, with every sub-paragraph introducing an explanatory table regarding the situations of all the companies for that specific topic. Through tables and via developing the chapter per topic (instead of per company), the different settings for every case are more likely to emerge and comparisons are easier implementable. This way, the analysis process has been facilitated.

Therefore, the Chapter 4, after a brief introduction of the cases, develops around the following topics:

- Identification of both the value proposition and offer development of every case;
- Assessment of how IoT is applied from each case;
- Evaluation of the opportunities IoT implementation delivered to each case;
- Definition of the possible implications in the business model provided by IoT implementation, for each case;
- Identification of the challenges associated to IoT implementation, for each case.

While both SKF, Stavdal and Volvo Trucks can be compared according the aforementioned lenses, as both of them make use of IoT for improving their product offering portfolio, the case of Autodesk is different. Autodesk Fusion Connect, in particular, provides companies with IoT solutions, offering support for its customers' "*IoT implementation journey*" (Leslie Bull, personal interview, 24 March 2017). This means, in a nutshell, that part of Autodesk offer is based on supporting companies for their implementation of IoT solutions. Therefore, for the purpose of this research, it might be relevant to compare Autodesk customers to the other cases (Stavdal, SKF and Volvo), rather than Autodesk by itself, as the latter is incompatible with the other cases (it also had a specific interview guideline, as reported in Appendix 2). Nevertheless, as explained earlier, the company has been selected for its great expertise in the topic, and not for being a manufacturer with a PSS offer in which IoT plays a role. These latter case is, contrarily, the one of the customers of Autodesk. Hence, throughout the interviews with the company, interviewees have answered by making use of the examples of three different customers, that are comparable with the other cases. These are Griswold Water System (GWS), TSM Controls Systems (TSM) and the "*Spray technology manufacturer*"[2] (Lona Dalessandro, personal interview, 23 March 2017).

Therefore, after having introduced Autodesk – its background and its offer, Fusion Connect – in the next chapter, it will not be present anymore in the tables about the topics concerning the IoT, mentioned earlier in the list: it will be substituted by its customers. However, other relevant information provided that does not affect them directly, will be reported separately, in other "focus" sections.
The purpose of this division is to describe the empirics in the most consistent, understandable and straight-forwarded way as possible.

3.7. Analysis settings

The empirics gathered and presented in Chapter 4 are analyzed in Chapter 5, with the intention of understanding the role of IoT in the offering portfolio of the studied cases. For this reason, the IoT-PSS matrix, shown in Figures 6 and 7, has been re-utilized, aiming at classifying the findings and at providing a clearer understanding of the empirical results. To represent the offers of the cases in the matrix, therefore, it had been necessary in Chapter 5 to firstly identify the corresponding PSS, as well as the role played by the IoT.

Nevertheless, another important part of the analysis concerns the identification of the main challenges that are entailed with IoT implementation. Therefore, in this sense, the outcome of the interviews regarding the

[2] For this latter, the name has been disclosed to the researcher, in order to allow the gathering of general information that enabled the introduction of the case. However, the name will not be presented in the study. This because some of the company IoT applications and innovations in the business model are not already publicly available, as they are still in an introductory phase.

challenges has been coded in order to understand if a particular challenge had been faced by to two or more cases.

Indeed, the purpose is not to provide a comprehensive understanding of all the possible challenges, but rather to understand what are the main and most common challenges faced by companies willing to implement the IoT. Therefore, Chapter 4 analyzes only these common challenges.

3.8. Research Quality

This paragraph is focused on the evaluation of the quality of the present research, via analyzing its two main dimensions, namely reliability and validity.

3.8.1. Reliability

The reliability is a criterion employed to assess the possible replicability of the study by another researcher (Bryman & Bell, 2015). Generally speaking, it is a very difficult requirement to be met by qualitative research, as it is impossible to freeze a social context and circumstances as well as exactly replicate all the settings, that are, indeed, unique in every case (Flick, 2009; Bryman & Bell, 2015). The present research relies on a qualitative multiple case study, which implies a great amount of uncontrollable variables that might affect its outcome, whose exact replication would be impossible. However, the Bibliography and Sitography, together with the interview guidelines and the IoT-PSS matrix should provide a common basis that would probably allow another researcher, who uses the same means, to get to very similar findings. Moreover, not only the ones of the companies, but also all the names of the interviewees are reported, together with their role, enhancing a great transparency that would potentially enable anyone else to ask exactly the same questions to exactly the same people. Figure 8 shows also the duration, the language and type of each interview conducted, enabling a completely precise replication at least in the modality. Therefore, it is possible to say that, for being a qualitative research, the reliability is met satisfactorily.

3.8.2. Validity

The validity of a study should be assessed by analyzing both its internal and external components (Bryman & Bell, 2015).

The internal one is met by the studies whose observations match with the theoretical ideas developed (Bryman & Bell, 2015). This is undoubtedly a strength of a qualitative research, as it strives to emphasize the cases and to induce results right from the observations themselves. Therefore, considering its qualitative characteristic, its mainly inductive approach and its matching between empirical data and conclusions, the present study can be evaluated as internally valid.

When it comes to the external validity, it is difficult to achieve the same result. In particular, for a study, meeting the external component of the validity would imply a possible reliable generalization of its finding (Flick, 2009; Bryman & Bell, 2015). Being the present research qualitative, it is very hard to generalize its results, mainly because of its small - still quite heterogenic - sample. Nevertheless, it is not in the purpose of the researcher to prove its generalizability, as it aims at giving light to a rather unexplored field regarding IoT implementation in a servitizing offering portfolio. It does not demand for a generally applicable and complete "truth". The scope is rather to provide a general understanding of the matter and some suggestions to companies, individually and idiosyncratically applicable. Therefore, the task of proving the external validity of the results would be left to future research, preferably quantitative.

4. Empirical findings

The following chapter displays the gathered empirics. It is divided into sections, according to the lenses trough witch the different cases are analyzed. It begins with an overview of the interviewed companies, and proceeds with the identification of their offers and IoT utilizations, opportunities and challenges, ordered by themes. This should permit the reader to get a comprehensive and understandable overview of the findings via recognizing and comparing the different settings of every case. Throughout the text, meaningful interviewees' quotes are reported in italics between "reverted commas".

4.1. General background information

This paragraph aims at introducing the different cases, highlighting their main identifying characteristics. Via Figure 9, the reader should get a general overview of the companies, in order to better understand their particular settings, to be connected with the content of the following paragraphs.

Company	General background information (*source: Orbis, 2017)
AUTODESK.	Autodesk, Inc. is an American multinational enterprise specialized in software and services for infrastructure projects, civil and industrial constructions. It also develops multimedia applications for entertaining and for mechanic and manufacturing projects, for which it develops PLM (Product Lifecycle Management) systems. From its first widely known and successful AutoCAD software, developed in 1982, the company has deeply evolved its offer, also operating in the manufacturing industry, via leveraging on its core business concerning software developments. Its motto, indeed, is "*we make software for people who make things*". Recently, Autodesk developed its **Fusion Connect** offer, for manufacturing firms, which leverages on its core competences in the software and IT-related fields. **Year of incorporation:** 1994* **N° employees (2016):** 9'000* **Operating Revenue (2016):** 2'031'000 th. USD*
GWS GRISWOLD WATER SYSTEMS (customer 1) AUTODESK® FUSION CONNECT	Griswold Water Systems is an American company which manufactures a complete line of water treatment products featuring chemical-free water treatments that allow cooling systems ("Water Towers") to enjoy long-term stability and operate in a consistent and reliable way. Instead of using chemicals, the company uses electrodynamic field generation. It prevents the corrosion and the growth of bacteria, while allowing businesses to recycle or safely dispose of the gallons of water that don't evaporate. Their products are used in HVAC, Industrial, Commercial and Institutional water treatment applications. **Year of incorporation:** 1936 (source: GWC, 2017) **N° employees:** 33 (estimated, source: Owler)

Operating Revenue: 2'800 th. USD (estimated, source: Owler)

Stavdal

Stavdal AB is a Swedish, B2B, specialist rental company for the access and construction equipment. It has developed its offer with a "*one stop shop*" (Mikael Olsson) concept, in which customers can rent everything needed for starting constructions, including tools, machineries of any kind and temporary living spaces, fully furnished with heating, water access and electrical systems. Stavdal AB offers therefore the "*whole package*": all the capabilities, instruments, equipment and documents needed not only for building constructions and for "*living the workplace*", but also for having no kind of problems with administrative tasks.

Year of incorporation: 2001*

N° employees (2015): 203*

Operating Revenue (2015): 54'393,5 th. USD*

SKF

Svenska Kullagerfabriken AB is a Swedish multinational enterprise which develops, produces and markets products, solutions and services in the rolling bearing and seal business. It is the largest bearings manufacturer all over the world. Its offer includes ball and roller bearings, specialty bearings, sealing systems, linear motion products, tools for mounting and dismounting bearings, and measuring and monitoring instruments. To these products SKF adds services components including consulting, training (especially for distributors) and remanufacturing.

Year of incorporation: 1907*

N° employees (2016): 44'868*

Operating Revenue (2016): 8'064'708 th. USD*

Spray technology manufacturer

(customer 2)

AUTODESK® FUSION CONNECT

"*The American company is a leading manufacturer of spray technologies that has invented an IoT-enabled machine that generates environmentally friendly cleaning and disinfecting solutions in an on-demand model*" (Lona Dalessandro). It provides customers in the food, paper, chemical, petrochemical, steel and biologics and pharma industries with equipment including spray nozzles and accessories, as well as automated spray control systems. The company offers its products through local representatives in the United States, Canada, and internationally.

Year of incorporation: 1937*

N° employees (2016): 1500*

Operating Revenue (2016): 175'000 th. USD*

TSM

(customer 3)

AUTODESK® FUSION CONNECT

TSM-Controls Systems is an Irish, multinational, B2B, manufacturer which supplies process control solutions for plastic production processes. It provides blending and control systems that enable companies to improve the level of precision of their production processes in 60 different countries across a wide variety of industries.

	Year of incorporation: 1976 (source: TSM, 2017) **N° employees:** 26 (estimated, source: Owler) **Operating Revenue:** 1'000 th. USD (estimated, source: Owler)
	Volvo Trucks Corporation is a subsidiary of the Swedish AB Volvo. It is a world leading manufacturer of heavy trucks and tractors, engines, and accessories in more than 140 countries, all over the world. It engages transportations, leasing, contract maintenances, vehicle and fleet managements, training, and used trucks. Rather than a truck manufacturer and seller, Volvo Trucks "*has started its journey from manufacturer to transport solutions provider*" (Helena Sundqvist), as stated also in the company vision. Its offering portfolio includes direct sales as well as rental solutions, complemented by services regarding maintenance, training, consulting and technical supports (h24, 7/7). Its goal is to become, through its widely spread workshops (96 just in Sweden), an "*one stop service provider*" for anything related to trucks, including products and all the related "*soft offers*". **Year of incorporation:** 1927* **N° employees (2015):** 5'064* ("the entire Volvo Group has about 100'000") **Operating Revenue (2015):** 9'226'195 th. USD*

Figure 9. Cases' general background information

4.2. Offer development and definition

Figure 10 introduces to the reader the value propositions of the cases, by focusing on the offers they propose to customers and by summarizing their development.

Company	Offer development and definition
AUTODESK	**Autodesk Fusion Connect** is an Internet of Things Cloud Service Platform to connect, analyze and manage products remotely. It is mainly dedicated to customers whose products are highly capital intensive (e.g. industrial machinery, specialty vehicles) and whose downtime is very expensive. Autodesk solution allows companies to connect "*things*" (essentially anything that sends data, including sensors, gateways, computers) and collect and process data streams. It does so by software adapters that translate the message from whatever protocol to a common data model. "*Every product with sensors connected to a CPU* [that can be installed if not provided, in most of the cases] *has some sort of embedded software or operating system and networking capability. Thanks to, for example, Bluetooth, Wi-Fi, 3G or 4G, the thing can connect to the Internet and send packaged information using some standard and communication protocol. This is basically how IoT works"* (Diego Tamburini).

One problem is that a standard "*is like a toothbrush: everyone has to use one, but nobody wants to use the same one*". Fusion Connect, therefore, "*grabs*" the many different coded information deriving from connected products, converts them in a common protocol ("*in a common toothbrush*"), and packages it in an industry standard, understandable from customers via the Fusion Connect platform. This way, the company and its products/assets are connected and, via the platform, the former can *act* with the data from the latter. Acting with data means not only capturing relevant information from products usage and functioning, but also creating "*business rules*" for enabling automated responses to determined situations: from computational "*if…then*" rules (e.g. raise an alarm if a parameter goes above a certain level) up to complex analyses using Artificial Intelligence and Machine Learning. In the factory floor, this would translate in opportunities for automating and optimizing the production processes, "*triggering the effects of the so called Industry 4.0".* On the after-market side, if a company wants to deliver a service, "*it just needs to understand the relevant data needed for offering it*". Autodesk Fusion Connect provides the manufacturer with the possibility to "*listen to their product data*", providing all the information needed for "*keeping things up and running optimally*".

Autodesk solution allows the customer, therefore, to outsource the "*connection and translation*" process for already connected or connectable products, delivering a ready-to-use IoT software platform for manufacturers to manage, in an understandable way, their IoT network.

(customer 1)

GWS used to manufacture product lines including full complement of centrifugal separators, sand filters and pot feeders. These are products for water treatments, whose aim is to provide customers with water and energy efficient, cost-effective, chemical free water treatments for cooling systems. In particular, it developed an innovative method for treating cooling towers by generating electrodynamic fields, instead of using chemicals. However, chemicals provider competitors tried in an aggressive way to keep GWS solution out of the market, also via sabotaging the towers. Here arose the need of developing monitoring solutions, in order to have transparency in the operations, and to understand, in case of problems, whether a tower failed or there were issues not related to GWS systems. Autodesk Fusion Connect endowed the company with an IoT solution that not only solved their monitoring problem, but also delivered opportunities to improve the value proposition of the company (Condon, 2017).

Nowadays the company rather than a pure manufacturer, after IoT implementation, claims to be a provider of solutions for helping customers to maximize their cooling water utilization and reutilization, being closer to them, as "*All GWS Water Treatment Includes Built-in Remote Monitoring*" (GWS, 2017).

Originally, Stavdal started by renting machineries and tools. It has always had a B2B business, delivering its products to construction companies. "*More or less immediately*" (Mikael Olsson), however, the company understood that its customers were willing to find a "*single partner that would have been able to provide and/or equip the full worksite*". That was the moment in which Stavdal became an "*one stop shop*", able to **rent** everything - "*for a day up to for months*" - that is needed for starting a construction workplace. Also, it understood that "*it was easier to grow by offering also other complementary services*". Therefore, it eventually started to supply also temporary spaces like cabins used for meetings and for providing hygiene services, as well as other services including temporary heating, water installations, electrical systems and hoists services. Moreover, it included in the offer also training sessions for teaching how to use machineries. Also, understanding the need of its customer to comply with the very great amount of regulations and laws regarding the workplace security and machinery characteristics and usage, the company decided to offer the "*whole package*".

The solution provided by the rental company delivers flexibility, since it allows customers to undertake different construction projects that require specific equipment, without incurring in regulation-related concerns.

From 2010 on, the company started to modernize its "*heavy machineries*" fleet, via installing a TrackUnit system and an ID Card reader. This was both to keep track of the most expensive equipment, as well as to trigger additional service components, in order to improve the overall value proposition.

SKF has had for a long time a "***transactional business model***", meaning that the company used to "*sell its products on the markets in a traditional way*" (Carlos García Timón). However, given its great expertise in the field, the company used to add to the products complementary services including training, maintenance and consulting.

Nowadays, "*especially in the Industrial-related market*", SKF is implementing an additional type of value proposition, opposed to the traditional, transactional business model. This is a "***performance-based business model***", that is not based on the transferring of the ownership of a product, but rather on providing the maximum possible availability of it, selling it "***as-a-service***". For example, the printing industry (within the industrial-related market) employs very large and costly machines, which operate through large-volume standardized tasks. *"[Here,] One small problem can compromise the entire line, causing huge economical losses"*. This is why some customers of this market started preferring and demanding, rather than the ownership, "*the 99% or 100% availability of SKF products*" for a determined period of time.

This pushed the company to open up for service-based, performance-driven business models that leverage on remote monitoring functions and big data analysis. IoT and Big Data development delivered SKF great possibilities to be pursued to access to new competitive advantage sources. In particular, "*IoT is absolutely an enabler for performance-based business models*", although its "*extremely important*" integration process in the offering portfolio is still in a "*developing process*".

Spray technology manufacturer (customer 2) AUTODESK® FUSION CONNECT	The offer of the company envisages spray technology solutions. It delivers spray nozzles, air control nozzles, tank washers, accessories, automated systems, and other fabricated products. It also provides customers with automated spray control systems, including modular, antimicrobial spray, mold inhibitor spray, tissue lamination, gas conditioning, and lubrication systems. In addition, the company offers a collection of tools, resources and services to assist nozzle selection and spray system optimization. Recently, the company developed *"an IoT-enabled machine"* for cleaning and disinfecting solutions in an ***"on-demand model"*** used, for instance, for dosing and dispensing food-related chemicals, according to customers' specific needs. Also, thanks to the support of Autodesk Fusion Connect, the company managed to activate a connection with customers (thanks to the embedded IoT components in the machines), which triggered the implementations of a different business model. By monitoring customers' chemical utilization via the Autodesk software platform, the company has been able to promptly furnish customers with the right amount of chemicals needed, when needed, charging them just for what they use.
TSM (customer 3) AUTODESK® FUSION CONNECT	TSM Control Systems markets processing equipment for mixing the plastic in different forms. In particular, it supplies gravimetric blending/mixing and return control for applications whose efficiency and measurable returns on investment are crucial (TSM, 2017). The manufacturing company used to sell its blending and control systems, before having innovated its business model via employing the IoT, whose deployment has been facilitated by the support of Autodesk Fusion Connect. The connection between the products fleet and the company, enabled by IoT

implementation, has allowed TSM to keep close contacts with its customer in order to optimize their plastic related production processes. Under this perspective, the company has recently started to rent out its products, through **subscriptions**, ensuring their maximum availability and functioning.

Right now, they promote themselves as operations improvers, cost reducers and throughput boosters, rather than pure plastic-related products manufacturers.

The Volvo Trucks offering portfolio has always rotated around its core business, that has developed during the time according to customers' needs, and has ameliorated by integrating services in the offer or even by marketing product as services.

Its current product portfolio, although very wide, can be categorized according to three different areas.

1. **Truck Sales**: New trucks are built and sold "*on order*", following customers' specifications. However, also used trucks are available for sale. Truck sales can be further distinguished according to the kind of contact through which the transaction happen:
    - *Dealer* Sales: the majority of the truck sales is done by the retail network of Volvo.
    - *Direct* Sales: large customers have direct contact with the company for the sales of the trucks. The trucks delivery and the services are done by the dealers.
2. **Spare parts sales**: The offer is represented by the sale of spare parts, mainly demanded as part of a service or repairs in the workshop but, in some cases, they are also sold over the counter.
3. **Related services** these include Trucks Rental, Leasing, Service Contracts and Fleet management systems.
    - **Truck Rental:** Customers can get temporary access to many different kinds of ready-made trucks, paying the product on a daily basis, up to three months, for a rental truck.
    - **Leasing:** "*Operational leasing is a goal contract based on a payment plan [...] it enables many small truck companies to access to the transport solution*" (Kristoffer Hjelm). Through leasing contracts, thanks to the financial business unit of Volvo, it is possible to "*purchase trucks but also get a service contract*".
    - **Service Contracts:** This kind of offer is becoming nowadays very common for accessing to a truck. **"***From 2008 to 2017, the service contract penetration rose from 20% up to over 60%*"

(Helena Sundqvist). The offer includes the sale of the product plus complementary services that are needed by the product during its life cycle. The overall price is based on the "*cost history for similar trucks*". Volvo has a program for the dealers to calculate the amount and average cost of services expected to be needed during the contract duration. This is computed according to the type and quantity of services demanded to be included in the offer, to the type of truck and to its expected utilization, as well as to other specifications agreed with the customer. It is like an "*insurance thinking*": instead of paying for each service and repair occasion, customers pay, on a monthly basis, a total amount that is equal to the sum of all the expected costs that they are supposed to spend in workshops, sooner or later. In exchange, they get the possibility of having all the demanded services, anytime, for a pre-determined monthly amount, during all the duration of the contract (averagely, it lasts 5 years). It is possible to distinguish three different standardized types of service contracts:

- **Blue:** This is the basic offer, which includes all the services related to the *"preventive maintenance of the vehicle",* including oil and filters changes, in order to prevent common breakdowns to happen.
- **Silver:** The offer includes the preventive maintenance plus "*the repairs of expensive components*" such as the drive line of the truck, in case of damages.
- **Gold:** This is the "*all inclusive*" offer, which adds to the Silver one also repairs for "*wear and tear",* (e.g. brake pads) and, since 2012, the "*Uptime Promise".* In particular, it foresees the wear of some components and, in case of a breakdown, "*Volvo offers a replacement truck or monetary compensation*". For instance, if a breakdown occurs, within 4 hours either Volvo replaces the truck with a similar one, or pays an economic reimbursement to compensate the period of unavailability of the product. "*It is like a health plan, in which* [the transport solution] *has to be always available and functioning".*

- **Fleet management system:** With a monthly based subscription,

	customers can accede to a software system that connects them with the Volvo server, enabling them to gather all the stats regarding their Volvo trucks fleet. This offer is often bundled with Truck sales, especially for big orders, when the customer owns a transport company and "*wants to monitor the performance of the drivers*" (Kristoffer Hjelm). The main focus that drives the sales is the customers' profitability, and "*Uptime is probably the most important key for their productivity and profitability*" (Helena Sundqvist).

Figure 10. Cases' offer development and definition

4.3. IoT applications

The present paragraph highlights how IoT is utilized in the offer of each case, by detecting its main areas of application and by also delivering practical examples, when available.

Company	**IoT applications**
GWS GRISWOLD WATER SYSTEMS (customer 1) AUTODESK® FUSION CONNECT	Through the software IoT platform (Fusion Connect), sensors and microprocessors in cooling systems ("Water Towers") are used for: • Remote monitoring the installed base: capture data about running time, performance trends and flows within the systems. • Remote activating electrodynamic fields in the Towers for the water treatments.
Stavdal	Since 2010, the company installed on the heavy machines (to be rented): • A TrackUnit system used for localizing in real time the machine and monitoring its effective usage, by laptop or mobile, via an app. • An ID card reader employed for "*identifying the workers who are going to use it*" (Mikael Olsson; by Swedish law, everyone in worksites must possess a particular ID card to prove her authorization).
SKF	IoT is employed for triggering data flows from customers. • IoT "*is a precondition for connecting the supplier to the user*" (Carlos García Timón), to keep track of the utilization patterns. • Sensors and microprocessor are employed for connecting products with a central server, to continuously monitor their functioning (e.g. of printers, mining machines, lubrication systems).

Spray technology manufacturer (customer 2) AUTODESK® FUSION CONNECT	Through the software IoT platform (Fusion Connect), sensors and microprocessors in the chemical dispensers are used for: • Remotely monitoring the customers' utilization of chemicals. • Detecting the "*residual availability of chemicals in IoT enabled machine*" (Lona Dalessandro).
TSM (customer 3) AUTODESK® FUSION CONNECT	Thanks to the software IoT platform (Fusion Connect), sensors and microprocessors in their plastic processing machines are used for: • Monitoring the utilization, the functioning and performance of the products. • Keeping products updated via remote cloud software installations.
VOLVO	IoT connects the company to the trucks sold through **Gold service contracts**, or the customer to its Volvo trucks fleet, trough the **Fleet management system**. A telematic gateway in the trucks plus the GSM network (*"there is a Sim card in each truck";* Helena Sundqvist) and the GPS positioning sensor endow trucks with communicative capabilities. They can send data to a central server, allowing workshops or customers who can accede to the server to: • "*Monitor driving distance, speed, fuel consumption, engine hour, topography, weight, battery status and fault codes* (these latter are available just to Volvo)". This does not happen constantly but "*at least once a week*", when data is sent to the server. • Evaluate graphs and figures deriving from data flows to check remotely and in real time the status of the truck.

Figure 11. Cases' IoT applications

4.4. Opportunities delivered by IoT implementation

The following section presents the opportunities pursued by each case, that would not be available without an IoT implementation (i.e. the opportunities that derive from IoT applications explained in Figure 11). Below the Figure 12, there is a focus on the general opportunities IoT delivers, that have not been coupled with specific empirical examples, but that are still relevant for the purpose of the research.

Company	Opportunities delivered by IoT implementation
GWS GRISWOLD WATER SYSTEMS (customer 1) AUTODESK® FUSION CONNECT	Responsive and remote maintenance, remote intervention, sabotages detection: • An instant notification, if any problem occurs in the "Water Towers", triggers responsive maintenance even before customers realize anything was wrong. • Promptly purification of the water in the water towers, without employing

	chemicals, via remotely activated electric fields. • Optimization of the installed base functioning, reducing in customers' water consumption. • Detection of possible sabotages/dysfunctions not due to GWS systems.
Stavdal	Responsive maintenance, remote user identification, effective monitoring: • If serious problems occur to the rented equipment, "*an automatic email makes possible for operators to go straight to the worksite"* (Mikael Olsson), to fix the issue. • The ID card reader, with the support of the keypad, identifies the user and activates the machine only if the former is authorized to do so. • The TrackUnit system allows to understand the effective utilization of the equipment ("*when, where, how long*"). If products are utilized during non-agreed periods of time, as during weekends, the responsible site "*would automatically receive an email on Monday morning* ".
SKF	Predictive and proactive maintenance, installed base optimization: • *"By analyzing data flows from lubrication systems it is possible to understand if problems are about to occur"* (Carols García Timón). Automatic notifications to customers or to SKF make possible to solve problems aforetime (basing on contracts). Same for customers in the printing or mining industries: "*where very small problems can cause huge losses"*. • PRM programs (Proactive Reliability Maintenance) are data-driven services which aim at identifying the root cause of failures of physical assets, prescribing possible measures to be taken to prevent future likely reoccurrences, "*enabling patterns and scenarios analyses*". • Remote monitoring possibilities enable performance analyses and the consequent potential optimization of the installed base. • By monitoring and ensuring the product functioning, warranty costs decrease.
Spray technology manufacturer (customer 2) AUTODESK® FUSION CONNECT	Remote monitoring of customers' chemical consumption and predictive services: • Automatic alerts when dispensers are about to run out of chemicals. • Predictive placing of orders*: "*[customers] *do not need to make the call anymore"* (Lona Dalessandro), the company acts with just in time proactive refills, according to customers' utilization. • Understanding of customers' usage patterns and consumption trends through data analysis. • *"Optimization and smoothing"* of operations.

- Opportunities for supporting customers and for "*Ad-selling*" (Diego Tamburini): by understanding customers' insights, the company can suggest utilization methods and promote targeted offers.

(customer 3)

Installed base functioning optimization:

- Responsive and/or predictive maintenance of the machines through product data analyses.
- Just-in-time service delivery (e.g. automatic software updates when available, or responsive physical reparations of the machine when needed).
- Maximization of product utility for customers: "[thanks to the IoT] *products are always functioning and updated*" (Lona Dalessandro).
- Consequent "*decreases in warranty costs"* (Leslie Bull).

"Better availability of products, few breaks, few and shorter stops" (Helena Sundqvist): Responsive, predictive and proactive maintenance, product functioning optimization.

- Thanks to the remote monitoring it is possible to understand immediately what kind of problem is occurring to the truck, and what kind of spare parts and personnel the correspondent workshop (according to the area) will need for repairing. "*We can prepare the workshop visit by assigning the right technician and the right spare parts and put the truck back on the road quickly"*.
- "*Automatic warnings or pre-warnings*" are communicated to the workshop responsible for the area, that can evaluate just in time or even foretime the status of the truck, and eventually contact the driver to arrange an extra visit to the workshop.
- By analyzing the combination of different kinds of data about the truck and its current utilization, it is possible to activate the "*predictive component changes"* service: it is about "*risk calculations",* based on real time information, analyzed through statistics and compared with historical data, that allows to predict scenarios. Through the system, it might be possible to estimate that, for example, "*the truck is likely to have a breakdown in the next 670 km at the 37% of possibility".* With this kind of information, then, it is possible to act via predictive maintenance, in order to avoid breakdowns proactively.
- By understanding customers' utilization patterns and real time occurrences, the company can suggest them new service options and promote targeted offers, enhancing opportunities "*for better uptime and to offer more services for improving the product performance".*

- For the customers of the **fleet management system** offer, it is possible to monitor and evaluate drivers' performance and the truck fleet status, to optimize operations.
- "[IoT might enable to offer] *in the future, a fleet pool, to offer different choices to customers for different days, according to their needs*" (Kristoffer Hjelm).

Figure 12. Cases' opportunities delivered by IoT implementation

4.4.1. Focus: some general opportunities delivered by IoT for the offering portfolio

Mr. Tamburini (Autodesk), without referring to any specific case, explained how, for a company implementing IoT in its product offerings, the data deriving from the utilization of a connected product – so, from the usage of the installed base – provide meaningful insights for three main applications.

The first one is related to the *Design* function: the real time feedback received from the customers' usage of the existing product lines gives opportunities to "*close the design loop*", allowing the department to better design new products to be more suitable and adapted to customers. Moreover, with a good data management, it is also possible to run simulations, to test new designs even before building them.

The second application is for the *Marketing* function: understanding when, how and for how long customers make use of the product can be extremely valuable for targeting customers more precisely and creating offers for new segments. Moreover, it can trigger targeted, automated, ad-selling opportunities and dynamic pricings.

The third application of these data is for providing attached *Services*. For instance, as reported by the Senior Industry Strategist, if a pump manufacturer knows that if the temperature of its product goes up to a certain level its functioning is likely to be compromised, via IoT it is possible to send automated alerts to the manufacturer, who can directly fix the problem with precise instructions. Also, through this system also the user can be automatically alerted via a signal (e.g. a red light which turns on or a message on a software platform), and with very little efforts the problem can be promptly solved. The mentioned applications can be done by setting simple computational functions (*If* X happens in x, *then* do automatically Y on y) in a IoT software platform (e.g. Fusion Connect). These may enable, for IoT platform user, a post-sale service based on the product optimization that undoubtedly increases the value of the product itself, since it enhances its functioning and life cycle.

By delivering the information derived from data flows to an Artificial Intelligence (A.I.), moreover, it is possible to gather more sophisticated predictions, without the need of computational "*if...then*" functions. An A.I. understands patterns in the information flows, detecting "*what is normal, acceptable and what it is not*" (Diego Tamburini). Eventually, it might allow scenario analyses with different percentages of likelihood for different situations to happen, suggesting therefore the best alternatives. The partnership between Autodesk and Neutonian is devoted to the exploration of the opportunities related to prescriptive data analyses, through A.I.

4.5. Implications for the Business Model

This section is dedicated to the effects on the business model of each company due to IoT implementation, highlighting potential changes in it or possible exploitable possibilities, as reported by the interviewees. Indeed, the opportunities mentioned in the previous paragraph led, in most of the cases, to changes in the offers, as explained in Figure 13. Moreover, at the end of the paragraph, there is a focus on the potential of IoT as intended by some interviewees. Its content, even tough did not find application to practical cases, is still relevant for the purpose of the research.

Company	Business Model implications (*from IoT implementation*)
GWS GRISWOLD WATER SYSTEMS (customer 1) AUTODESK FUSION CONNECT	• Embedding IoT solutions as core parts of every water treatment system offered: "***product evolution***", chance of charging extra price. • From just selling water treatment products to offering mainly services thanks to and through the IoT. • Possibility of charging customers for extra services related to the product maintenance or optimization ("*that they would ask for anyway, sometimes from third parties*"; Lona Dalessandro).
Stavdal	• Chance of charging customers per hours of utilization rather than per days. • Possibility to charge customers when using equipment during weekends or national holidays (when normally they are not charged, as workplaces are supposed to be closed). • Higher value delivered through renting contract foreseeing warranty and maintenance.
SKF	• New business model opportunity: *"from traditional, transaction-based to **performance-based**"* (Carlos García Timón). • Implementation of *"**Service Level Agreements**"* (SLAs): contracts foreseeing the definition of some Key Performance Indicator (KPIs), agreed with customers, to be reached by the offered asset. • In case of SLAs, revenue streams derive from the fulfilment of KPIs, rather than from the products sales. • The possibility of monitoring the performance of products endows the manufacturer to sell, for instance, "*the 99% of availability of a determined product for a certain period of time, rather than its ownership".*

Spray technology manufacturer (customer 2) AUTODESK FUSION CONNECT	• IoT enabled a "*new, **on-demand** model for dispensing chemicals to customers"* (Diego Tamburini): instead of products sales, customers subscribe on a monthly basis for accessing the product and just *"pay for what* [chemicals] *they use"* through the machines. • Stabilization of revenue streams, given by the IoT-enabled business model based on subscriptions. • The placing of orders became company-pushed, rather than customer pulled: "*from reactive* [to customers' demand] *to predictive"* (Lona Dalessandro).
TSM (customer 3) AUTODESK FUSION CONNECT	• New business model: from selling machines and delivering additional, after-sale services to a **subscription model**: "*you rent a machine that is continuously updated with just in time services"* (Lona Dalessandro). • Company retains the ownership over the product. • Customer, in exchange, always gets "*the most evolved product"*.
VOLVO	• Possibility of selling extra services based on IoT data flows, aimed at optimizing trucks functioning and performance, as *"predictive component changes"* (Helena Sundqvist) for the *"gold"* offer. • Opportunity to sell to organizations **fleet management** capabilities together with trucks, to let them remotely monitor their fleet functioning and the drivers' performance, in order to optimize all the operations. • Chance of exploring even more the service contracts option to sell trucks (e.g. *"mileage based, tires contracts..."*), thanks to an accurate, IoT based monitoring: through it, it is possible to check in real time if the agreed terms of the service contract are respected (e.g. the mileage, weight, countries crossed...).

Figure 13. Cases' implications for the Business Model (from IoT implementation)

4.5.1. Focus: IoT can transform your business

Leslie Bull, IoT Sales Executive for Autodesk, without referring to any specific example, explained how IoT is potentially able to transform the business of a company. In particular, agreeing with Mr. Tamburini, she stated that IoT offers opportunities both for lowering costs and increase revenues for manufacturers.

Costs might be lowered, generally speaking, thanks to the possibility of reducing, via remote solutions, the ones incurred for offering services. Moreover, by continuously monitoring products after sales, it is possible to minimize the warranty costs. This concept has been further scrutinized by Mrs. Dalessandro, who explained that, with data from machines, it is possible to understand how products are performing on the field, thus the time and money devoted to warranty claims can be consequently decreased, by leveraging on the IoT.

On the factory floor, on the other hand, under the perspective of the effects of the Industry 4.0, IoT enables relevant savings, as the production can be optimized and repairs or maintenances can be undertaken responsively or even proactively, thanks to automatic alerts or pre-warnings. These factors, considering also the possible smart automation of the machines, lead to relevant decreases in the overall downtime of the production process, reducing the operating costs significantly.

On the revenues side, following Mrs. Bull's words, by grasping information about the products functioning and utilization by customers, it is possible to promptly understand customers' needs and act with complementary services. It is the case of maintenance and spare parts selling, for instance, that according to her colleague, can be get "*directly from you, as opposed to some third party*" (Lona Dalessandro). For many customers, in fact, it might make way more sense to purchase an "*all-in solution"* which includes product, maintenance, services, spare parts and so on, in a subscription-style model, that enables predictable revenues. Additionally, via embedding sensors in the product, it is possible to enhance its performance via leveraging on its communicative capabilities, that might lead to a higher selling price.
Last but not least, with products which are always available and functioning, thanks to the complementary services, the brand image can be significantly improved, both in IoT sales executive's and the senior product manager's opinions.

4.6. Challenges for IoT implementation

This paragraph is devoted to the challenges faced or that are being faced by each case in the implementation of IoT in the corresponding offering portfolio.

Company	Challenges for IoT implementation
GWS GRISWOLD WATER SYSTEMS (customer 1) AUTODESK FUSION CONNECT	• Difficulty in developing IoT solutions internally and autonomously. It would have been a very slow and not necessarily cost efficient process. • Complexity in finding the right vendors for technological components. • Need for more than one partner for the overall IoT implementation (not only Autodesk).
Stavdal	• High costs implied for an IoT upgrade of the equipment. • As some products become obsolete fast or can be interchangeable with disposable, throwaway, cheaper alternatives, it is not always cost-effective to make the equipment "smart". • IoT solutions are not always available: "*RFID tags would become dirty after the utilization of the equipment, and the reader could not recognize them"* (Mikael Olsson). • Need for accessing the right managerial capabilities: "*not all the people of the current generation know exactly how to implement and deal with IT*

	solutions in this industry, right now".
SKF	• Need for managerial capabilities: "*It is not easy to find people with the right capabilities and with a deep understanding of the business and of the industry*" (Carlos García Timón). • Complexity in developing competitive offers and processes according to technological opportunities, as, by itself, "*accessing the technology is not a problem".* • Need for specialized personnel, including "*data scientists, integration experts and business developers*". • Necessity of testing and piloting, need to partner with key companies or innovative business actors, to quickly catch up with the state-of-art in the matter and develop cutting-edge offerings. • Exigency but difficulty in determining the right KPIs: *"what exactly to look for and how".*
Spray technology manufacturer (customer 2) AUTODESK® FUSION CONNECT	• Initial underestimation of costs implied for the overall IoT implementation, it was a difficult and quite long process before the effective change in the business model. • Need of a perfect understanding of "*how you want to get started, where to start focusing on"* (Lona Dalessandro): what information, drivers and indicators are needed and how to make use of them to fulfill the designed business object. • Not all the assets can be connected. • Need for more than one partner for IoT implementation, including hardware and software IoT vendors.
TSM (customer 3) AUTODESK® FUSION CONNECT	• Difficulty of making products package the information in the same way. Different assets are semantically different ("*some communicates with binary codes, others with commands that are different according to their producers' decisions"* –Diego Tamburini). Need for developing adaptors to make them effectively communicate. • Need for more than one partner for IoT implementation, including hardware and software IoT vendors. • Not all the assets can be connected, especially old products and legacy machineries.

- Necessity for starting small, need for *"pilots"* to understand business opportunities deriving from the IoT: *"It is a matter of maturity that still has to be reached"* (Kristoffer Hjelm).
- *"It's always a challenge to have good data quality"* (Helena Sundqvist). Need for understanding and gathering relevant and reliable data that can be used to act, rather than just monitor. Also, when high quality data are available, it could be difficult to handle and decide what to do with them.
- Difficult to change service types from reactive to proactive. With all the possibilities for monitoring, it is possible to gather lot of data and pre-warnings. The point is *"should I act or not? When?"*. Moreover, *"there are a lot of niches, sometimes it is difficult to provide specific services they really need, according to the specific data" (Kristoffer Hjelm).*
- Need to *"constantly strive for the development by all the network"* (Helena Sundqvist, referring to workshops). Driving the change management, it is not always an easy task: need for communicating the value of the change to the *"dealers' business men, to make them become salesmen of the service,* (...) [to make them spontaneously say to potential customers] *Hey, I can help you, I have this"*. Only if they understand the benefits and implications of opportunities it is possible to implement them successfully.
- A concern is represented by the reliability of the forecasts, for predictive or proactive repairs: *"need for developing better algorithms to make sure that forecasts work"* (Kristoffer Hjelm).
- According to data privacy regulations, remote monitoring and data gathering is possible only if customers completely agree that *"we* (Volvo) *can download data*". If customers do not accept it, IoT implementation might be useless and its applications limited.
- Sometimes it is difficult or even not possible to connect products (including trucks superstructures), as some of them are old or have different communication capabilities. With the modern ones, it is easier.

Figure 14. Cases' challenges for IoT implementation

5. Analysis of the findings

The analysis is based on the findings of the previous chapter and is divided in four parts:

the first one is dedicated to the analysis of the cases offers, for the identification of eventual PSS;

it follows the analysis of IoT employment by the cases, in order to detect which role IoT played in each offering;

the third and main section is dedicated to the overall analysis of the main findings and aims at understanding IoT role within the perspective of PSS. This section leverages on the IoT-PSS Matrix, that is designed according to the information analyzed in the first two parts.

The fourth part concludes the analysis, by identifying the main challenges related to IoT implementation.

5.1. PSS identification

This first part of the analysis aims at defining the PSS offers of every case, in order to assess the main characteristics of the corresponding offer and explain what the servitization process led to, in terms of PSS. For every case, a brief summary of its servitized offer is presented, as emerged in the empirics, that is to be compared with the model of Tukker (2004), in order to define the corresponding PSS.

5.1.1. GWS

The company offers water treatment products and methods for treating cooling towers via electrodynamic fields. It claims to be a solutions provider for maximizing customers' water utilization and reutilization, and reducing waste. It does this by offering connected products together with complementary services, as responsive and, in some cases, predictive, remote maintenance and remote interventions through water-purifying electrodynamic fields. Considering these as bundles of products and activities directed at improving product availability, durability and performance, by following Tukker (2004), it is possible to identify GWS offer as a Product related, Product oriented PSS.

Company	Offer	Corresponding PSS
GWS GRISWOLD WATER SYSTEMS	**Water treatment**	**PoPSS**

Figure 15. GWS PSS identification

5.1.2. STAVDAL AB

Stavdal offers rental solutions including machineries, tools and living spaces (including the related services needed), "*for a day up to for months*" (Mikael Olsson), for starting worksites, through a "*one stop shop*" concept. It offers the effective utilization of its product fleet, rather than the ownership, charging customers accordingly. This is the classical Product renting identified by Tukker (2004) and Manzini et al. (2001), that is a form of Use oriented PSS.

Company	Offer	Corresponding PSS
Stavdal	**Construction solutions rental**	**UoPSS**

Figure 16. Stavdal PSS identification

5.1.3. SKF

For what concerns the case of SKF, its traditional, "*Transactional business model"* (Carlos García Timón) should be distinguished from its "*Performance based"* one. The former envisages the sale of products and related services regarding its core business of rolling bearings. Services are mainly about maintenance, being it responsive, predictive (thanks to the remote monitoring and data analysis) or proactive (PRM programs, through "*patterns and scenarios analyses*"). Other services concern product optimizations for customers. It might be said, however, that in this case the tangible and intangible components of the offer remain quite separated, as the latter regards the offering of additional, optional, product related, services that are not bounded with product offers. Therefore, it is possible to assert that, although services aim at improving the product durability and performance, they belong to different, separated, service-based, offers. This arguably means that the company, with the traditional business model, differently from GWS, sells services and products separately, without offering *bundled* Product-Service Systems.

On the other hand, the "*Performance based business model*" bases its value proposition on the delivery of capabilities, rather than of products. It is about selling products "*as-a-service"*, trough Service Level Agreements (SLAs) that foresee the definition of some KPIs to be reached by the underlying asset. Customers pay, for instance, for "*the 99% of availability of a determined product"* rather than for the product itself. If the latter does not work properly or if the agreed KPI level is not reached, then the customer is reimbursed according to the contract clauses. Therefore, the offer concerns the fulfillment of a Functional result, as explained by Tukker (2004), as SKF directly delivers capabilities to customers (Baines et al., 2007), rather than means through which getting to them by themselves. This kind of offers might be identified, following Tukker (2004), among the Result oriented PSS.

Company	Offer	Corresponding PSS
SKF	• **Transactional BM** • **Performance based BM**	• **None** • **RoPSS**

Figure 17. SKF PSS identification

5.1.4. Spray Technology Manufacturer

Likewise for SKF, this manufacturer also presents two different offers. In particular, the company innovated its own business model after the implementation of the Autodesk Fusion Connect IoT platform. Originally, the company offered spray technology solutions: spray products and a collection of tools, resources and services for assisting the selection and optimization of its offered cleaning and disinfecting solutions. As it has been said for SKF, despite the aim of the services was at improving product functionalities and/or managing its life cycle, they were not coupled with it, as they used to belong to separate, service based, offers. Therefore, agreeing with Baines et al. (2007) and Manzini et al. (2001), this is not a case of Product oriented PSS, but rather a case of traditional, independent, product and service offers.

After IoT implementation, also thanks to the support of Autodesk, the company has started offering IoT enabled machines through which using chemicals provided "*in an on demand model*" (Lona Dalessandro). Customers can subscribe, on a monthly basis, to access the preventively supplied, needed, chemicals. Then, they pay just for what they use effectively, as they are refurnished automatically by the company. The whole management of the chemicals provision activity, for the customer, is therefore outsourced to the spray manufacturer, whose offer consists in delivering "*just in time*" what it will be used via IoT enabled machine, for the period of time covered by the subscription.

Using Tukkers' taxonomy, this offer can be traced back to Activity management, Result oriented PSS (Tukker, 2004).

Company	Offer	Corresponding PSS
Spray Technology Manufacturer	• Spray solutions • On-demand model	• None • RoPSS

Figure 18. Spray technology manufacturer PSS identification

5.1.5. TSM

TSM, exactly as the Spray Technology Manufacturer, has changed its offer after IoT implementation supported by Autodesk Fusion Connect. Before being a customer of Autodesk, TSM Control Systems used to sell processing equipment for mixing plastic in different forms, as well as additional services aimed at optimizing their production processes. This case is very similar to the "Spray solutions" offer of the previous example and it might be argued that TSM original offer, regarding blending and control systems, foresees both the offer of services and products that are not bundled to each others. Therefore, according Tukker (2004) and Baines et al. (2007), it is not possible to consider TSM "Blending & control systems" offer among the PSS.

On the other hand, with Fusion Connect, the company has started to market its products through a subscription model, bounding the intangible and tangible components of its offer. This way, TSM retains the ownership of its installed base, offering in exchange, during the subscription duration, "*the most evolved product*" (Lona Dalessandro), to which are associated a higher availability and an improved performance, thanks to responsive or predictive maintenances and remotely activated software updates. Using Mrs. Dalessandro words, with the subscription model, "*You rent a machine that is continuously updated with just in time services*". Considering that the main value proposition of UoPSS concerns the offering of the maximum possible availability of products, in order to sell their effective usage, rather than the ownership (Manzini et al., 2001; Tukker, 2004; Baines et al., 2007), it is possible to consider the offer of TSM as a Product renting, Use oriented PSS (Tukker, 2004).

Company	Offer	Corresponding PSS
TSM	• Blending & control systems • Subscription model	• None • UoPSS

Figure 19. TSM PSS identification

5.1.6. VOLVO TRUCKS

As shown in the previous chapter, the offering portfolio of Volvo Trucks is very wide and includes both product and service sales, as well as different kinds of combinations of them. For the sake of simplicity, the different offers will be analyzed following the same order presented in Figure 10.

Truck Sales, both Dealer and Direct, concern the simple selling of readymade, used, or built on order, new, trucks. The offer by itself does not include complementary services which, on the other hand, might be purchased in the workshops when needed, separately. This offer, therefore, according to the definition of Wong (2004) and Baines et al. (2007), is not possible to be evaluated among the PSS.

Spare parts sales, on the other hand, is about the selling of spare parts, that are mainly demanded as part of services in workshops. When a repair is needed, therefore, workshops charge customers with the price of the spare parts, together with the cost of labor needed for completing the work. Only in few cases spare parts are sold over the counter. This means that spare parts are usually associated with services aimed at repairing, through the spare parts, the mean of transport. Therefore, similarly to SKF performance based BM, the offer concerns the fulfillment of a task, namely repairing or substitute broken components to make the truck functioning again, rather than selling brick-and-mortar spare parts by their own. Therefore, as it happened with the second SKF offer, also in this case it is possible to evaluate the Volvo offer as a Functional result, Result oriented PSS (Tukker, 2004).

Truck Rental foresees exactly the same value proposition of Stavdal, with the difference that the one of Volvo deals with trucks, rather than with construction-related equipment. Its corresponding PSS, therefore, according to Tukker (2004), is a Product renting, Use oriented PSS.

For what concerns the **Leasing**, Tukker (2004) identified a specific category, that is the Product lease, Use oriented PSS. Indeed, operational leasing is often associated to the sales of trucks (either direct or dealer based) as a complementary service to re-design the payment plan. During the leasing, the ownership of the product is retained by the company, until the latter is released in front of the payment of the agreed ransom.

Therefore, this offer of product plus financial service, that does not transfer the ownership of the former, can be surely classified among the UoPSS.

Service Contracts, on the other hand, envisage the offer of a product which is strictly bundled with product-related, after-sale, services devoted to its maintenance and performance optimization, throughout its lifecycle. Arguably, considering their nature, Service Contracts might be considered among the Tukker's Product oriented PSS (Tukker, 2004), similarly to the GWS "water treatment".

Nevertheless, the **Gold** type gets closer to the concept of Result oriented PSS. Indeed, following the empirics, by selling trucks with connecting capabilities, Volvo trucks intended to provide an "always working", "all inclusive", solution, together with all the services, to ensure that the uptime of the transport solution is kept at its maximum level. This means that predictive maintenance services, automatic notification systems, proactive repairs and so on, are all activities that are finalized to let customers think about anything but driving. All the ancillary, needed, support activities are implemented by the workshops of the manufacturer, in some cases automatically. With Gold Service Contracts therefore, rather than a truck, Volvo offers an always available and functioning, all inclusive, transport solution, close to functional result, Result oriented PSS, as explained by Tukker (2004). However, for service contracts, the ownership of the truck is not retained by the company which, on the other hand, transfers the property via a subscription model. This is why also the gold service contract cannot be considered among the RoPSS, following Manzini et al. (2001), Tukker (2004), and Baines et al. (2007), but rather among Product oriented PSS, like the blue and silver ones. Indeed, PoPSS are the only particular cases, among PSS, that foresees the transfer of ownership to the customers.

Nevertheless, there are cases in which the ownership of the truck is retained by the company, at least legally speaking, until the payment of the ransom: it is the case of trucks offered through operating **leasing** contracts. Hence, considering that it is possible to arrange a leasing plan "*also for a Service Contract"* (Kristoffer Hjelm), then, the particular cases of gold service contracts offered through an operating leasing can conceivably be appraised as functional result, RoPSS, according to what foresaid.

Fleet management is, by its very nature, a pure service, as it enables the owners of a truck fleet to remotely monitor the performance and functioning of their products, through a software that connects customers with the central server of the company. However, for big orders, the company uses to include this service in the offer, adding an extra fee to the monthly payment due to the trucks purchasing. Hence, this combination includes the product bundled with an innovative, product related, support service. Considering that this latter aims at helping customers to understand their own behavior in use, as well as at providing them with suggestions to evaluate the functioning or improve the performance, the offer of the company might be classified among the Product oriented PSS. Nevertheless, this goes very close to the examples provided in Chapter 2 regarding the associated software of Nike FuelBand (Torsten and May, 2016; Nike, 2015), Babolat

"Play Pure Drive" and Ralph Lauren "Polo Tech Shirt" (Porter and Heppelman, 2014), that have been identified among the Advice and consultancy, Product oriented PSS (Tukker, 2004).

Company	Offer	Corresponding PSS
	• Trucks Sales	• None
	• Spare part sales (+ labor)	• RoPSS
	• Truck Rental	• UoPSS
	• Product leasing	• UoPSS
	• Blue/Silver/Gold Service Contracts	• PoPSS
	• Gold S.C. + leasing	• RoPSS
	• Fleet management	• None
	• Fleet management + Trucks Sales	• PoPSS

Figure 20. Volvo Trucks PSS identification

5.2. IoT role definition

This second section is dedicated to understanding what role IoT plays in the offering portfolio of each case. This should also allow to detect the opportunities it delivers to the offerings. IoT applications, as reported in the empirics, are analyzed through the lenses of the model of Torsten and May (2016), that allows an understanding and a classification of the different cases.

5.2.1. GWS

The main value driver for this company is represented by its innovative method for treating the water: the generation of electrodynamic fields. However, the threat of sabotages from competitors incentivized the company to resort to an IoT solution. Fusion Connect has provided GWS with a connection with its water towers, that allowed the company to remotely monitor the cooling systems while activating the electrodynamic fields. Moreover, IoT platform has permitted to capture data about the running time, performance trends and flows within the systems. By analyzing these data and by setting computational functions ("*if…then*"; Diego Tamburini), the company has managed to activate automatic warning setups that have triggered the possibility of responsive maintenance services. Moreover, by understanding the product functioning and the customers' utilization patterns, now GWS is also able to offer support for optimizing the performance of its installed base, thus reducing water waste and delivering higher value to customers. Using Mrs. Dalessandro words, IoT has enhanced a "*product evolution*", as it increased its functionalities and performance. In this case GWS, thanks to the IoT, enriched the functioning of its products, rather than altering it, thus increasing their value throughout the lifecycle. Therefore, according to the model of Torsten and May (2016), in the author's opinion this function of IoT is ascribable to the Adaptation role.

Company	Opportunities from IoT	Corresponding role
GWS GRISWOLD WATER SYSTEMS	• Remote monitoring of performance: o Responsive maintenance; o Sabotages detection; o Performance optimization. • Remote activation of electrodynamic fields.	**ADAPTATION**

Figure 21. GWS IoT role identification

In this case, it might be argued that it is IoT that enabled GWS to implement a PSS offering, as some of the opportunities listed in Figure 21 are, indeed, exactly the services components that made the GWS offer a PoPSS (e.g. responsive maintenance, performance optimization, remote activation of electrodynamic fields).

5.2.2. STAVDAL

According to the CEO, the company, together with other actors within the industry, is still at the very early stages of the "IoT journey" as IoT applications are quite limited. However, from 2010 on, the company has started to embed in the newly purchased heavy machines a Track Unit system with a ID card reader which has triggered some IoT functions. The system, indeed, has made possible for the company to understand products performance as well as when, where, for how long and by whom they are utilized. These features have not only allowed the company to make extra profits, as it can charge customers for their effective utilization of products (e.g. also during weekends), or charge them on hourly basis, but also enriched its value proposition. In fact, the user identification feature allows customers to have less regulation problems, as only authorized workers can turn the machine on. Moreover, an automatic notification system, deriving from the electric system of the heavy products, has made possible to offer responsive maintenance services, in case of relevant problems, even before customers can realize them. This possibility potentially increases the availability, performance and value of the product fleet, without modifying the original functioning of the Stavdal offer. Therefore, using the nomenclatures of Torsten and May (2016), IoT played, in this case, an Adaptation role.

Company	Opportunities from IoT	Corresponding role
Stavdal	• Remote monitoring of heavy products: o Responsive maintenance; o Effective utilization detection. • Remote user identification and activation: o Decreases in red tape concerns.	**ADAPTATION**

Figure 22. Stavdal IoT role identification

It is noteworthy to say that, in this case, differently from GWS, the company would have had a PSS offer even without IoT implementation. Before 2010, indeed, Stavdal had exactly the same business model. For

Stavdal, IoT provided some service opportunities that have only enriched an already existing PSS offer, without altering it.

5.2.3. SKF

In Mr. García Timón opinion, IoT represents the connecting channel between the "*supplier and the user*", as it is able to trigger customers' data inflows from the product utilization. Through these data it is possible to understand usage patterns, evaluate the products functioning and performance, as well as conduce scenario analyses. These features have provided the company with the possibility of supplying extra services. Both the automatic notification system for solving problems responsively (or even aforetime) and the pattern analyses aimed at prescribing measures to be taken to prevent future likely reoccurrences are potential service sources, enabled by the IoT. They, indeed, have led to both the responsive or preventive maintenance and Proactive Reliability Maintenance (PRM) services, that are part of the offering portfolio of the company. This means, according to the framework of Torsten and May (2016), that for the transactional business model it is arguably possible to consider that IoT played an Adaptation role, as it *complemented* an already existing business model by enriching it with new services possibilities.

However, for the purpose of this research, it is even more interesting to understand to what the remote monitoring possibility led to, in terms of PSS offerings. In the case of SKF, IoT has been "*the enabler for the Performance-based Business Model*", as it has allowed the implementation of new product-service offerings that would not have been available without it. As stated by the manager, by remotely monitoring and preventively repairing the installed base, it is possible to sell "*the 99% of availability of a determined product*" instead of the product itself. Arguably, the same can be done with many other different KPIs that can be continuously monitored and improved to reach their agreed level according to the corresponding SLA. This is in line with what explained by Manyika et al. (2015), and Forrester Consulting (2015), that stated that IoT might enable completely new business models. Following Torsten and May (2016), it is possible to assert that IoT played an Innovation role, in the case of the Performance based business model, as it led to *replace,* rather than *complement,* the previous, transactional one, creating previously unknown offerings, that are only possible through its implementation.

Company	Opportunities from IoT	Corresponding role
SKF	Remote monitoring of performance: • Responsive/Predictive maintenance; • Proactive maintenance (PRM); • Installed base optimization; • SLA implementation; • Chance of exploring more service options for already existing offers; • Decreases in warranty costs.	• **ADAPTATION** (Transactional BM) • **INNOVATION** (Performance based BM)

Figure 23. SKF IoT role identification

5.2.4. Spray Technology Manufacturer

Before the support of Autodesk, with its Fusion Connect IoT platform, and of other IoT hardware vendors, the company had no kinds of IoT applications in its offering portfolio, likewise GWS. After and through IoT implementation, however, the Spray manufacturer decided to change its own business model. In particular, according to the empirical findings, IoT has allowed the company to embed connecting capabilities in its "*IoT enabled machines*" (Lona Dalessandro, referring to chemical dispensers). This way, for the manufacturer it has been possible to continuously monitor their functioning, as well as the chemicals utilization patterns of customers and residual availability. By understanding and analyzing these insights, the company has been able to promote targeted offers accordingly, as well as to provide customers with chemicals "*in an on demand model". They just have to pay for what they use, and during the subscription period, thanks to the newly acquired capabilities of the company, they can receive the needed chemicals "*just in time*". IoT has allowed the analyses of data flows and the consequent possibility of placing orders automatically, making the *on demand* model possible.

In order to understand IoT function, it is noteworthy to consider that, although this business model is undoubtedly enabled by the IoT, the offer is arguably still the same, concerning the sale of chemicals. Nevertheless, IoT has been pivotal for starting the "*just in time*" transactions, but it has not changed the basic functionality of an already existing offer.

This means that, under the lenses of the model of Torsten and May (2016), IoT has played a Smoothing role, as it has enabled the transactions, without representing a core part of the offer.

Company	Opportunities from IoT	Corresponding role
Spray Technology Manufacturer	Remote monitoring of chemical dispensers: • Automatic alerts when chemicals are about to finish; • Predictive and automatic placing of orders; • Optimization of operations; • Chance of Ad-selling targeted offers.	• **NONE/ UNKNOWN** (Spray solutions) • **SMOOTHING** (On-demand model)

Figure 24. Spray technology manufacturer IoT role identification

5.2.5. TSM

The case of TSM is similar to the one of GWS and of the Spray Technology Manufacturer. Before becoming a customer of Autodesk, the company used to sell its products in a similar way to the one of the SKF "Transactional BM". Fusion Connect, however, has granted TSM with a stable connection with its installed base, allowing the remote monitoring of the products utilization, functioning and performance. This capability has given to the company the possibility of responsively or preventively detecting the occurrence of problems. Therefore, by analyzing data flows from products, it is possible to understand if, when and where maintenance is needed, to trigger just in time, tailor made services, including responsive and predictive maintenance. Moreover, through this connection, also thanks to the Cloud, it is possible for the company to install and update software components of products when newer ones become available, remotely and automatically (similarly to the example of Tesla Motors Automobiles; Tesla, 2017). This way, TSM guarantees that "[thanks to IoT] *products are always functioning and updated*" and that customers always have "*the most evolved product*" (Lona Dalessandro).

In this case, IoT has enabled both the monitoring and the software updates, triggering service possibilities that have undoubtedly increased the performance and the value of products that are part of the TSM offer. However, again, it might be argued that it has not altered its functioning or scope. Therefore, as it has been for GWS or Stavdal, in author's opinion, IoT role has not implied an alteration of the main functionalities of the related product or service. Contrarily, it has rather added capabilities, ameliorating the offer, interpreting what Torsten and May (2016) would have called Adaptation role.

Company	Opportunities from IoT	Corresponding role
TSM	Remote monitoring of plastic processing machine and software updates: • Responsive and/or predictive maintenance; • Automatic software updates when available; • Decreases in warranty costs.	• **NONE/ UNKNOWN** (Blending & control systems) • **ADAPTATION** (subscription model)

Figure 25. TSM IoT role identification

In this case, similarly with the example of GWS, it might be argued that is IoT which has enabled TSM to implement a UoPSS offering. Indeed, these service opportunities that derive from the remote monitoring and software updates possibilities, have allowed TSM to implement a business model based on the use, rather than the ownership. Without the IoT, for the company it would not have been possible to monitor and act with just in time services, that make actable the value proposition of letting customers pay for what they effectively use (and only when the product works properly). This result is in accordance with what stated in the theory, namely that connected products allow companies to handle the installed base, reducing the risks associated with the retaining of the ownership, increasing the responsiveness to eventual problems, thus permitting new services (Allmendinger and Lombreglia, 2005; Ontario, 2015).

5.2.6. VOLVO TRUCKS

IoT provided Volvo Trucks with connecting capabilities that are utilized in **gold** service contracts and in the **fleet management systems**. Thanks to the telematics gateway, the GSM network and GPS positioning device, the trucks offered via the gold service contracts or together with the fleet management system are provided with communicative capabilities. In both of the cases, products are able to autonomously send data to a central server, about "*driving distance, speed, fuel consumption, engine hour, topography, weight, battery status and fault codes [...] at least once a week*" (Helena Sundqvist). This way, by accessing to the server, it is possible to monitor these figures, that are also displayed through graphs and charts.

On the one hand, by accessing to these information, it has been possible for Volvo to improve the non-IoT-supported service contracts (the blue or silver options). Indeed, by analyzing the combination of different kinds of data about the truck and its current utilization, Volvo could have activated preventive or proactive services, including maintenance or component changes, that have led to the development of the gold offer. Moreover, also general services that would have been provided without the support of IoT can be ameliorated through these kind of information. As a matter of fact, thanks to the remote monitoring, it is possible to immediately understand what kind of problem occurs or is abut to occur to the truck, and what kind of spare parts and personnel the correspondent workshop (according to the area) would need for repairing. Via automatic, data-driven, warnings or pre-warnings, communicated to the workshop or to the drivers, it has been possible to optimize operations and get to *"Better availability of products, few breaks, few and shorter stops*" (Helena Sundqvist). Therefore, similarly to both GWS, Stavdal and SKF "Transactional BM", here IoT has granted Volvo with opportunities to enrich service contracts, rather than altering them, *complementing* an already existing business model. This result has arguably been reached by leveraging on IoT to integrate the company offer with new services possibilities aimed at increasing the product value, throughout its lifecycle. Therefore, according to the framework of Torsten and May (2016), it might be possible to assert that IoT has played an Adaptation role.

On the other hand, with the fleet management system, Volvo offers the aforementioned monitoring capabilities to the customer, who, through the software, is able to detect all the information from its trucks fleet, mainly to evaluate the product functioning and the drivers' performance, as well as to optimize operations. For this kind of service, it might be arguably stated that IoT has been a precondition. Indeed, the service offer is driven by the IoT, as it has created a previously unknown offer only possible through its implementation. therefore, similarly to the SKF Performance based BM, by using the lenses of Torsten and May (2016), for the offers that include the fleet management system, it is possible to attribute IoT function to the Innovation role.

Company	Opportunities from IoT	Corresponding role
	Remote monitoring of performance and functioning: • Improved responsive maintenance; • Predictive and proactive maintenance; • Optimization of operations; • Fleet management system offer implementation; • Chance of exploring more service options for already existing offers;	• **NONE/UNKNOWN** (Truck Sales; Spare parts sales; Truck Rental; Leasing; Blue/Silver S.C.) • **ADAPTATION** (Gold S.C.) • **INNOVATION** (Fleet management system)

Figure 26. Volvo Trucks IoT role identification

5.3. A categorization of the offers with the IoT-PSS Matrix

The following table summarizes the findings, as identified in the previous paragraphs, highlighting what are the PSS offers (if any) and what role IoT has played in the corresponding value propositions, for each empirical case. In Figure 27, the identified PSS and the corresponding IoT roles appear blue and bold, while the non-PSS, that for the purpose of this study will not be further examined in the text, appear black. This is to facilitate the displaying to the reader.

Company	Offer identification	Corresponding PSS	Corresponding IoT role
GWS Griswold Water Systems	**Water treatment**	**PoPSS**	**Adaptation**
Stavdal	**Construction solution rental**	**UoPSS**	**Adaptation**
SKF	• Transactional BM • **Performance based BM**	• None • **RoPSS**	• Adaptation • **Innovation**
Spray Technology Manufacturer	• Spray solutions • **On-demand model**	• None • **RoPSS**	• None/Unknown • **Smoothing**
TSM	• Blending & control systems • **Subscription model**	• None • **UoPSS**	• None/Unknown • **Adaptation**
Volvo	• Truck Sales • **Spare part sales (+ labor)** • **Truck Rental** • **Product Leasing** • **Blue/Silver Service Contracts** • **Gold Service Contract** • **Gold Service Contract + Leasing** • Fleet management • **Fleet management + Truck Sales**	• None • **RoPSS** • **UoPSS** • **UoPSS** • **PoPSS** • **PoPSS** • **RoPSS** • None • **PoPSS**	• None/Unknown • **None/Unknown** • **None/Unknown** • **None/Unknown** • **None/Unknown** • **Adaptation** • **Adaptation** • Innovation • **Innovation**

Figure 27. Summary of the cases' PSS and IoT functions

Once identified all the PSS and the related IoT roles, the next step is to put them on a chart that can better classify the differences among the cases and, within the cases, among the different PSS detected. For this purpose, it might be useful to apply again the IoT-PSS Matrix introduced in Chapter 2, that offers an effective overview of what have been mentioned so far.

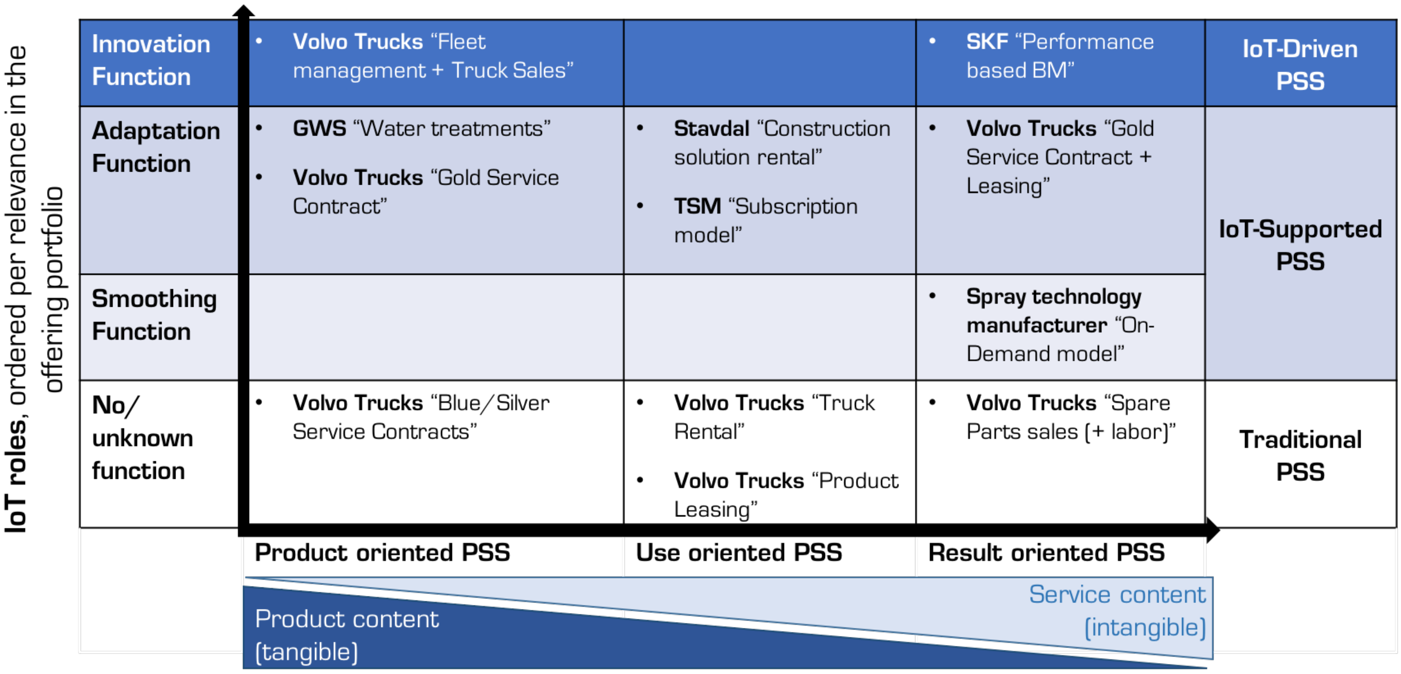

Figure 28. The IoT-PSS Matrix applied to the primary gathered data

As Figure 28 shows, the primary data analyzed have given light to twelve different PSS, that can be classified according to their underlying IoT function. Starting from the bottom, the IoT-PSS Matrix presents four Traditional PSS. Those are servitized offers in which IoT does not play any role, as explained in previous chapters, and that might be associated to the traditional PSS identified in studies as the ones of Goedkoop (1999), Manzini et al. (2001), Tukker (2004) and Baines et al. (2007).

At the center of the chart are located six different PSS, whose implementation has been assisted by the Smoothing or Adaptation functions of the IoT. In those cases, IoT has paved the way for service opportunities that have been bundled with the product component of the offer. These can be traced back to after-sales, service opportunities including specific, just in time (or even aforetime), activities for enhancing the product life cycle and its uptime. They have been driven from the data flows deriving from the product utilization by customers. In most of the cases, IoT has represented the connecting bridge between the manufacturer and its installed base, which has endowed producers with remote monitoring capabilities. These become critical when there is the willingness of the manufacturer to trigger tailor made services, or the need of keeping track of its products functioning, availability and performance, especially in cases in which it retains their ownership, as it happens in UoPSS and RoPSS.

These six are the IoT-Supported PSS, in which IoT components have played a very important role for activating services possibilities and for, generally speaking, providing reliable bases and chances for modifying the offer, as it happened with GWS, TSM and Spray Technology Manufacturer.

The last group is the one identified at the top of the figure, represented by the two IoT-Driven PSS. For these PSS, IoT is a precondition. In other words, these combinations of products and services would not be available without the capabilities provided by the IoT. For instance, SKF, thanks to the data flows from the product utilization by customers, has managed to market some of its products "as-services", deriving the revenues not from the product sale, but from the fulfillment of KPIs by the product. IoT has allowed SKF not only to monitor these KPIs, to check the outcome of contracts, but, most importantly, to understand if, when, why and how product-related support activities are needed, in order to maximize the agreed indicators. This means that, if the target KPI is "*the 99% of availability of a determined product*" (Carlos García Timón), then SKF, by monitoring the actual availability and functioning and by analyzing data, can always understand if everything is going as it was supposed. If it is not the case, data flows analyses endow the manufacturer to understand occurrences promptly or even preventively, acting accordingly, to optimize the product functioning, thus maximizing the uptime for customers. Nevertheless, *"Uptime is probably the most important key for their* [customers'] *productivity and profitability"* (Helena Sundqvist).

IoT is very often associated with optimization opportunities for operations, and it is also the case of Fleet management systems, that are very often bundled with truck sales. If, on the one hand, IoT might lead manufacturers to optimize their installed base, on the other hand, it also makes possible for them to offer this capability to customers, permitting them to monitor and optimize their own product fleet. This is exactly the case of Volvo, that combined the sale of a product fleet (Truck sales) with monitoring and optimization capabilities (Fleet management system software), available only thanks to the IoT. These undoubtedly represent very important service opportunities that contributed to create also the offers of Ralph Lauren, Babolat and Nike (Porter and Heppelman, 2013; Nike, 2015; Torsten and May, 2016), which are based on the same rationale.

5.4. IoT, an enabler for the Servitization

The empirical results confirmed what suggested by Masson (2016), Lightfoot (2016) and Sassanelli et al. (2016), whose contributions interpreted IoT as a possible mean for stably connecting to and remotely analyzing the products sold, allowing the producer to keep an ongoing visibility into the performance. Nevertheless, for most of the empirical cases, IoT represented the way through which activating data flows from customers.

According to Mr. Tamburini, the analysis of these data can provide meaningful insights for three main applications: Design, Marketing and Services. By better understanding customer needs, therefore, it is possible to develop a more customer centric approach toward different stages of the value chain: from the Design (on the product development phase, by closing the "*feedback loop*" and by running simulations), to the Marketing (pre-sales, for targeting customers more precisely and create offers for new segments – confirming what stated by Lightfoot, 2016 -, as well as for pricing them dynamically), up to Services (mainly after-sales ones). The customer centricity that, according to the theory, represents the way through which it is possible to overcome the Service Paradox (Gebauer et al., 2005), and to successfully implement PSS, as confirmed by Oliva & Kallenberg (2003) and Baines et al. (2007), can be therefore provided by the IoT. By developing this customer centricity, then, it is possible to move toward the servitization process (enabled, in accordance with Kowalkowski et al., 2013, by an ICT, in this case the IoT).

Nevertheless, suffices here to evaluate the cases of the customers of Autodesk Fusion Connect, namely GWS, Spray Technology Manufacturer and TSM. These are three manufacturers whose offer was not servitized at all, before the Autodesk – and the other IoT components vendors - IoT injection. In fact, they did not offer product and services bundled together, and the IoT-PSS Matrix would have not identified PSS for them, without the Fusion Connect intervention. Contrarily, as they accessed to the IoT-driven capabilities, they improved their offer or even changed their own business model, up to defining three different PSS. IoT has represented the turning point for the servitization of their offers, as it has enabled non-servitizing manufacturers to change their value proposition, leading them to provide both PoPSS (GWS), UoPSS (TSM) and RoPSS (Spray technology manufacturer).
The same can be asserted also for Volvo and SKF, which, trough the IoT, have managed to identify and deliver completely new, not previously available, servitized, IoT-driven, PSS: both Product oriented and Result oriented.

These findings suggest that IoT not only can offer very interesting opportunities to servitize the offer and implement PSS, but also that it might lead to the implementation of all the three different kinds of PSS (PoPSS, UoPSS and RoPSS), showing an outstanding flexibility in the way manufacturers can leverage on it for approaching the servitization shift.

5.5. IoT intermediaries

According to the empirical findings, it might be a difficult task to develop IoT capabilities *internally* and *organically.* The process requires lot of experience, time and money, especially for companies not specialized in hardware or software development - as it was for GWS, for instance -, or for small entities that might consider IoT as a not always cost-effective possibility - as Stavdal -.
Fortunately, the case of Autodesk has showed that IoT-related, specialized intermediaries that might "bootstrap" the "*IoT journey"* (Leslie Bull) do exist. These can be specific for developing and installing sensing and connecting hardware components - sensors, microprocessors, adaptors... -, or software components, as the Fusion Connect or Volvo Fleet Management System ones, used for managing the connected units. Although, according to both Mr. Tamburini, Mrs. Dalessandro and Mrs. Bull, a "*one stop shop"* for completely implementing IoT from scratches does not exist yet, intermediaries like Autodesk

might still play a relevant role for the servitization process. According to its needs and its IoT development stage, a manufacturer can turn to for them - or a combination of different vendors -, to quickly activate and/or manage precious data flows from customers.

5.6. IoT potential

The empirical findings have showed a relevant amount of opportunities delivered by IoT that go beyond the sole enabling of PSS. Indeed, they have presented the potential of IoT to create new business models and disrupt offerings, as identified by (Manyika et al., 2015). Suffices here to mention that the IoT, in most of the studied cases, has endowed manufacturers with the connection with customers, during all the lifecycle of the connected product.

To begin with, this gives the chance of developing better products thanks to customers' information, and to reduce the warranty costs after the first sales, thanks to the remote monitoring. Most importantly, however, IoT has provided the possibility of retaining customers by acting with just in time, after sales, targeted, service offers "*that they* [customers] *would ask for anyway, sometimes from third parties"* (Lona Dalessandro). Nevertheless, the manufacturer has the advantage of understanding better than anyone else how their products are supposed to work as well as their limitations. Hence, they are particularly well positioned to offer attached services.

By managing the product data, derived from IoT implementation, indeed, the manufacturer has the chance to understand problems even before the customer, thus it can ensure the maximum availability and performance of the product (by offering "*all-in"* solutions trough subscription models; Lona Dalessandro) and/or target the customer with tailor made offers.

Considering that, according to Jian (2011), to the ICD manufacturing Insights (2013) and to the smiling curve presented in Figure 2, to these service opportunities are associated a higher value added and higher margins, it might be questioned that IoT has the potential to lead to higher profits. Although the present research cannot prove this result, in accordance with Mrs. Dalessandro, Mr. Tamburini and Mrs. Bull, it can be stated that IoT is a source for both increasing revenues and decreasing costs.

The revenues can be positively affected by the service opportunities, by the product ameliorations, and by design (e.g. by closing the *"*feedback loop*"*) and marketing (e.g. by "ad-selling") applications.

On the cost side, indeed, by permitting responsive or automatic reactions, forecasts and scenario analyses (especially with the support of an A.I., in accordance with Mr. Tamburini and Mrs. Bull) based on data flows, IoT applications might be extremely valuable for automating determined functions (via "*algorithms*" (Kristoffer Hjelm) or "*if…then"* functions (Diego Tamburini), optimizing the functioning of the installed base and boosting the overall uptime of the asset.

5.7. The challenges due to IoT implementation

Until now, the research has been focused on the innovative opportunities delivered by IoT to the offering portfolio of manufacturers. However, as always, accessing to new possibilities implies facing new, corresponding challenges. Next paragraphs, therefore, dedicate their attention to the barriers related to IoT implementation and integration in the offers.

Figure 29 displays the main challenges identified by the six cases. As explained in the methodology, for the sake of simplicity and clearness, here are presented only the ones mentioned at least by two or more cases, as displayed in the following figure. Indeed, the aim is to identify the main and most common challenges to be faced by a company that is willing to implement IoT capabilities in its own business offering portfolio.

Challenge identified:	GWS	Stavdal	SKF	Spray Tech. Manuf.	TSM	VOLVO
No “one stop shop”, IoT vendors. Need for more than one partner.	✓			✓	✓	
IoT solutions are not always available.		✓		✓	✓	✓
Need for accessing to specific managerial capabilities.		✓	✓			
Difficulty in understanding and developing business implications according to IoT opportunities.			✓	✓		✓
Difficult to detect, gather, analyze and handle the right data.			✓	✓		✓
IoT implementation is not always cost-effective	✓	✓		✓		✓

Figure 29. The challenges for IoT implementation

Starting from the challenges identified by the cases and summarized in the empirics in Figure 14, the coding process of the interviews identified six main common concerns, displayed in Figure 29. The checks on the figure show which cases have faced the corresponding challenge.
The analysis proceeds by analyzing, one by one, all of them. For each challenge, a brief description as well as some examples, when available, according to the empirical evidences gathered in the interviews, follows.

5.7.1. No “one stop shop”, IoT vendors: need for more than one partner

The experience of GWS teaches how, for a non-specialized company, it is difficult to develop IoT solutions internally and autonomously. However, when the willingness is to implement the IoT, a first challenge identified by the cases is represented by the lack of a single, “one stop shop”, IoT vendor, able fully integrate IoT components and capabilities in an offering portfolio. In other words, nowadays, manufacturers would definitely struggle for completely outsourcing IoT integration process, for what concerns both the hardware and software installations and activation. Nevertheless, the text identified the existence of IoT vendors, or generally speaking, IoT intermediaries. However, these are companies that are specialized in some specific fields, that very seldom are able to entirely complete their customers' "IoT journey".

Autodesk Fusion Connect, for example, provides a software solution that works with products that are already connected (i.e. that already have connecting capabilities). Hence, both GWS, Spray technology manufacturer and TSM needed the support of other additional intermediaries to trigger the hardware deployment and make their products connected. Thus, Autodesk needed to partner up with other companies in order to provide a *complete* IoT implementation. This means that a non-specialized company which does not want to develop IoT integration internally, but still wants to fully implement IoT potential in its offer, needs to turn to for the support of more than one IoT provider.

5.7.2. IoT solutions are not always available.

In order to let IoT trigger data flows from customers' product utilization, the precondition is that the product must have connecting capabilities. However, despite the existence of IoT- hardware vendors, able to make products "smart", not all the assets can be connected. While for modern assets the connecting process is more or less easy to be applied, Volvo Trucks managers have experienced that some old machineries cannot be connected at all. Intermediaries such as Autodesk are able to translate the different information flows deriving from different assets of different year of production and producers in a common protocol, but some "*legacy assets"* (Diego Tamburini) cannot be provided at all with communicational skills and, in these cases, IoT applications are not possible. The best case scenario for IoT implementation is the one in which the product fleet is composed by modern assets from one same producer (i.e. that have a common communication standard), but this is rarely the case in real-world contexts.

Nevertheless, there are also additional practical problems that might hinder IoT functioning. In the case of Stavdal, indeed, some machineries were too small or too simple for deploying IoT components. Moreover, RFID technology, that represents a possible IoT channel, did not work as the tag got dirty or ruined during the construction activities.

These are possible impediments to be considered during the definition of a IoT strategy for an offering portfolio, as they might critically compromise the availability of IoT solutions.

5.7.3. Need for accessing to specific managerial capabilities.

IoT can potentially trigger extremely large amounts of data inflows. These data can be analyzed and managed to develop specific business opportunities. However, managing these meaningful inputs is not always an easy task. For example, if, on the one hand, for SKF "*Accessing the technology is not a problem",* on the other hand*, "It is not easy to find people with the right capabilities and with a deep understanding of the business and of the industry"* (Carlos García Timón). This means that for turning data into relevant information, prescriptions and actions, there is the need, even for large companies as SKF, of accessing to specialized personnel, including "*data scientists, integration experts and business developers*". Nevertheless, this problem might be even more challenging in some mature industries, as, according to the CEO of

Stavdal, "*not all the people of the current generation know exactly how to implement and deal with IT solutions in this industry, right now*" (Mikael Olsson).

There is therefore the need, for IoT implementers, of recruiting young talents, specialized in data analysis and with a certain experience in the corresponding industry. These might be able to read and detect very important information from data, that can be then used to define and develop business opportunities specific to the industry and viable to the company.

5.7.4. Difficulty in understanding and developing business implications according to IoT driven opportunities.

Assuming that the issues regarding both IoT availability and the need for managerial capabilities are solved, then it is all about turning the IoT-driven opportunities into actions that customers are willing to pay for. The IoT, as extensively explained throughout the text, might lead to innovative offers or even modifications in the business model (Manyika et al., 2015). However, being lost in wide sets of IoT applications and gatherable data is quite simple, thus there is the need of defining *ex ante* "*how you want to get started, where should you start to focus on*" (Lona Dalessandro). Then, there is the necessity of testing if the emerging, innovative, value proposition might be profitable, but only after both what to offer and how to leverage on IoT become clear.

Therefore, according to both SKF and Volvo Trucks, companies should start with small pilots, also by partnering up with other business actors, in order to develop and test cutting-edge applications and offerings. Indeed, all the analyzed cases are still in a "learning process" for what concerns IoT implementation and its possible implications. Nevertheless, even for renowned actors such as Volvo, the way to the full understanding and exploiting of IoT business opportunities is still to be treaded, as *"It is a matter of maturity that still has to be reached"* (Kristoffer Hjelm).

5.7.5. Difficult to detect, gather, analyze and handle the right data.

Manufacturers, after having activated the connection with the installed base, can gather, monitor, and analyze data inflows thanks to the support of a software platform. With a clear IoT-based offer designed, the next phase should be about understanding what to analyze, *"what exactly to look for and how"* (Carlos García Timón). For SKF, for instance, it is an exigency but still a major difficulty to determine the right KPIs to be audited. Nonetheless, according to the Autodesk managers Mr. Tamburini and Mrs. Dalessandro, it is absolutely crucial not only to detect what information, drivers and indicators are needed, but also how to make use of them to fulfill the designed business object. Using a metaphor, it is about finding and managing the right waves in an ocean of gatherable data. An Artificial Intelligence, in this sense, might be able to understand data patterns and endow companies to conduce scenario analyses and forecasts, helping them to understand unidentified insights. Both Autodesk and SKF mentioned its potential. However, there is still the lack of practical examples of A.I. applications. Therefore, the challenge is to understand how to work with the relevant data, by setting reliable "*If…then functions*" (Diego Tamburini) or *"algorithms"* (Kristoffer

Hjelm) that could activate automatic functions, including pre-warnings, warnings and effective automated actions.
On the same line, Helena Sundqvist (Volvo Trucks) explained how "*It's always a challenge to have good data quality*". Indeed, to succeed in a competitive scenario, it is mandatory to identify good and reliable data, to be used for acting, rather than for only passively monitoring. Only if data are reliable, in fact, it is possible to activate dependable forecasting capabilities or preventive service opportunities. Good algorithms have to use good data, and for Volvo, for example, there is always the "*Need for developing better algorithms to make sure that forecasts work"* (Kristoffer Hjelm).

5.7.6. IoT implementation is not always cost-effective.

Even though it is possible to overcome most of the IoT-related challenges by both accessing to the right managerial capabilities, having clear business ideas for IoT applications, and perfectly understanding how to manage what kind of data, at the end of the day, implementing IoT might not always be a cost-effective decision.
First of all, developing IoT solutions internally and autonomously might be a difficult, slow and very expensive process for non-specialized companies. The support of IoT intermediaries might back this process but, in some cases, the costs incurred for upgrading the equipment might not lead to the expected yield. The case of Stavdal explained how some products of the fleet might become obsolete quite fast or might be interchangeable with disposable, cheaper alternatives. Therefore, in these cases, investing to make these products "smart" might lead to unsatisfactory returns.

Financially speaking, is not even that easy to undertake a cost-benefit analysis, given the amount of hardware and software components to be implemented, the number of actors to be involved (again, there is not a "one-stop-shop", IoT vendor), and the uncertainty in the possible future profitability (hence the need of testing and piloting, as explained earlier). As a matter of fact, the Spray Technology Manufacturer underestimated the costs implied for its overall IoT implementation, mainly because it incurred in high transaction costs for searching, screening and bargaining with IoT suppliers (including Autodesk).

Last but not least, it has to be considered the institutional facet. The Volvo Truck manager Helena Sundqvist stressed the role of data privacy regulations that allow remote monitoring and information gathering only if customers agree that "*we* [Volvo] *can download data*". Needless to say, if customers do not accept it, IoT implementation might lead to very limited, not really cost-effective, business applications.

6. Conclusions

6.1. A brief review of the topic and research question(s)

The research started by analyzing the servitization trend that is affecting the offering portfolio of many manufacturers, that are willing to extend their own product-based offers with integrated services (Tukker, 2006). Under this perspective, "servitizing" companies deliver customers capabilities and solutions, rather than pure products, through the offering of *bundles* (Vandermerwe and Rada, 1988) of products and services, identified by scholars as Product Service Systems, or PSS (Mont, 2002; Tukker, 2004; Baines et al., 2007).

The theoretical framework identified different kinds of PSS, that might be classified as Product oriented (PoPSS), Use oriented (UoPSS) or Result oriented (RoPSS) according to the different possible combinations in which products and services can be marketed (Manzini et al., 2001; Tukker, 2004), as shown in Figures 1 and 1b. The rationales that lay behind the choice of a manufacturer of implementing PSS might be brought back to economic, environmental and customer related rationales, as well as incentivized by technological drivers.

Although academia widely recognized advantages for developing PSS (Oliva and Kallenberg, 2003; Baines et al., 2007), it identified also challenges manufacturers have to face in the shift toward a "servitized" offer. When it comes to deliver services, indeed, one of the main threats is represented by what Gebauer et al. (2005) called Service Paradox. A precondition to overcome this possible detrimental situation is by activating a strong connection with customers, in a customer-centric approach (Mathieu, 2001; Baines et al., 2007). For a back-end manufacturer, this might represent a very difficult task to be addressed, that, however, could possibly be facilitated by the technological drivers.

The Internet of Things (IoT) allows a rapid, scalable and cost-effective deployment of remote monitoring solutions (Masson, 2016; Sassanelli et al., 2016). It is defined as a network infrastructure, based on interoperable information and communication technologies, that enables advanced services by interconnecting things (ITU, 2015). Its implementation could potentially endow companies with the connection with their installed bases, and with remotely monitoring capabilities, thus allowing an ongoing visibility into performance and utilization (Masson, 2016; Lightfoot, 2016; Sassanelli et al., 2016). In other terms, the theory states that IoT has the potential to stably connect the producer with its products, and consequently with their users, namely the customers.

Although IoT seems to be able to play a relevant role for the PSS implementation and to solve some related challenges (as the need for customer-centricity), the way trough which it might specifically affect the "firm's offering portfolio" remains quite unclear, under a theoretical point of view (Torsten and May, 2016).

This master thesis, aiming at filling this theoretical gap and at providing practical suggestions to manufacturers willing to servitize their own offers, is intended to address the following research question:

What kind of role can IoT play for the Product-Service Systems of manufacturers?

In particular, the paper aims at answering the main question by addressing the following sub-questions:

How is IoT employed in the offers of servitizing companies?

What are the opportunities, delivered by the IoT, for their PSS?

What are the main challenges associated with its implementation?

How can IoT enhance the servitization process for non-servitizing, manufacturing firms?

6.2. Addressing the research question(s)

First of all, before analyzing the relationship between IoT and PSS, a rehash about how IoT can affect the offer of a company is required. One of the very few contributions that analyzed the role of IoT in the perspective of an offering portfolio is the research of Torsten and May (2016), which identified three different functions IoT can perform: Smoothing, Adaptation or Innovation. These are nomenclatures for explaining its potential to trigger and/or ameliorate existing offers, or even to create completely new ones, that would not be available without its implementation.

Moreover, by analyzing scholars' contributions, including the ones of Porter and Heppelman (2014), Lightfoot (2016), and Sassanelli et al. (2016), clearly appears how IoT might play a relevant role also in the specific case of PSS offerings. Hence, according to the theoretical framework, by studying some secondary-gathered empirical evidences regarding both PSS offers and IoT applications of real cases, it has been possible to assume that IoT might play the three functions explained by Torsten and May (2016) also for the delivering of PSS. Under this perspective, IoT has been supposed to be able to support PSS, or to drive them, leading to the implementation of completely new ones. This finding has been displayed through the identification of the IoT-PSS Matrix, shown in Figure 6.

Although the theory explained the possible usefulness of IoT for PSS, the nature of this possible relation remained rather unclear. Moreover, the IoT-PSS Matrix, that had helped in the understanding of the latter, surely needed to be tested. Hence the need of gathering primary data.

Through a multiple case study, four servitizing companies and one IoT intermediary – which reported examples about three additional, servitizing, manufacturers – have been questioned about the role of IoT in their PSS offer, and through an analysis of the outcome of nine semi-structured interviews, it has been possible for the author to test the framework and generate new theory, giving an answer to each of the research questions. The following paragraphs address, one by one, each of the four sub-questions, and then provide a general answer to the main research question.

6.2.1. How is IoT employed in the offers of servitizing companies?

Generally speaking, IoT components and applications are leveraged by manufacturers to create sources for valuable market differentiators. All the cases, indeed, presented at least one PSS offering that was either supported or driven by the capabilities offered by the IoT. This latter was mainly employed in two ways:

The first one is for generating data flows from the connected installed base, in order to gather information about the product performance and utilization patterns by customers. This means making use of IoT as a lasting connecting bridge between customers and producer, that enables remote monitoring capabilities.

The second envisages the leveraging of this connection to perform remotely activated actions on the installed base (e.g. software updates, TSM).

6.2.2. What are the opportunities, delivered by the IoT, for their PSS?

IoT can potentially deliver in the hands of manufacturers all the information they would like to receive from the product and from its utilization. It is like having a remote visibility on the customers' usage patterns and needs. By analyzing data flows from the installed base, therefore, it is possible to develop a customer-centric approach, by perfectly understanding, in real time, what is the status of the connected product and how it is being utilized by the user. By leveraging on this information, three different opportunities can be triggered for PSS offerings, namely developing new specific services on existing offers, enabling to market products "as-a-service", and activating completely new value drivers. These opportunities, that provide answers for the second sub-question, are analyzed below.

6.2.2.1. *Developing effective tailor-made services on existing product offers*

Understanding in real time the product status means having the potential of delivering just-in-time, specific, product-related, services. For example, if something happens to a product, its back-end manufacturer, which has the advantage of knowing perfectly how the former is supposed to work, can act with maintenance interventions even before the customer makes the call, since it has an ongoing visibility on its installed base. Moreover, these interventions might also be automated and would not even require an ever-lasting monitoring by operators. The IoT, in fact, provides the possibility of setting automatic warnings, pre-warnings or even actions, basing on designed algorithms or computational functions.

The IoT, therefore, can work as a source of precious information about customers' needs related to the product sold. It is possible to analyze these data to trigger targeted services possibilities on already existing offers. These services would provide really high value to customers and could be integrated to existing product-based or PSS offers, *de facto* leading to the implementation of new PoPSS (e.g. as it was GWS), or to the improvement of already existing PSS (e.g. as it was for Stavdal).

6.2.2.2. *Enabling to market a product as-a-service*

For a manufacturer, data flows from the installed base represent an important source to activate *responsive* service opportunities. However, by analyzing patterns in data and by comparing them with historical series, it is even possible to make forecasts and scenario analyses. Especially with the support of an A.I. (but not necessarily), producers may have the chance of developing automated systems aimed at prescribing or suggesting *preventive* service opportunities. These capabilities can deliver to a manufacturer the possibility of offering the optimization and the maximum availability or functioning of a product, rather than the ownership of it.

By keeping a continuous perceptibility on the performance and utilization, the producer is able to understand in real time or even aforetime when a problem is about to occur to its product. Hence, with targeted, data-driven interventions, it can ensure and therefore offer the maximum uptime, optimization, reliability and availability of the product, selling the latter as if it was a service. This means "lending it" and retaining the ownership, by making the customer pay only when it is working (i.e. when it functions perfectly; e.g. SKF "Performance based BM"), when it is utilized (i.e. when it is effectively employed - e.g. on an hourly basis, as suggested by Stavdal -), or for the period of its rental (i.e. on a periodic - e.g. monthly or weekly - basis, in a subscription model e.g. TSM).

Additionally, the case of the Spray Technology Manufacturer suggests another possible way to market products *as-a-service*. This can be done by making customers use disposable products (e.g. chemicals) through a connected product (e.g. chemical dispenser). By letting the embedded IoT components of the latter activate information flows about the availability and utilization of the former, it is possible for the producer to promptly and continuously replenish the customer with the disposable component of the offer. This way, instead of selling products ordered by customers, it is possible to automatically refill them according to their needs, thus activating service opportunities that envisage on-demand pricing models.

These possibilities can lead to a change in the offer toward the implementation of UoPSS (as it was for TSM) or RoPSS (as it was for Volvo trucks and for the Spray Tech. Manufacturer), implying a stabilization of revenue streams and lock-in effects for customers, which are this way stably served by a same supplier.

6.2.2.3. *Triggering completely new offers*

According to the empirical evidences, IoT has not only the potential of transforming existing offers into PSS, but also of creating totally new value propositions, that can be traced back into new servitized offers, or, according to the IoT-PSS Matrix, into IoT-driven PSS.

So far, generally speaking, the main opportunities delivered by IoT have been attributed to its ability of activating data flows to be employed by the manufacturer for keeping track of the installed base, to trigger activities finalized to its management and optimization. Nevertheless, IoT also leaves to the manufacturer the possibility to offer these capabilities to customers, to endow them with the remote monitoring capabilities on the products they purchase. This means offering a bundle of products and self-services aimed at the understanding, optimization and amelioration of what purchased (e.g. Volvo trucks "Trucks sales + Fleet management system"). These can be reached by integrating, in PSS, the hard component of the offer (e.g. the connected product) with a soft one (e.g. a software platform, similar to Autodesk Fusion Connect, or a complementary app, like Nike "FuelBand" or Babolat "Play Pure Drive"; Porter and Heppelman, 2014; Nike, 2015) that might be employed to monitor, analyze and act on the former.

6.2.3. What are the main challenges associated with its implementation?

Although IoT seems to be able to solve the problem of the customer-centricity needed for successfully activating services, as well as to provide a relevant amount of opportunities for the PSS development, its implementation entails also some challenges. The analysis of the empirics has given light to six main, commonly faced, concerns, summarized below.

- *No "one stop shop", IoT vendors. Need for more than one partner*: if IoT solutions are not developed internally, there is the need of turning to for more than one IoT intermediary to complete IoT journey from scratches.
- *IoT solutions are not always available*: some products cannot be connected at all, like very old assets. The ideal scenario is the one in which all the products are modern and from the same producer.
- *Need for accessing to specific managerial capabilities*: when it comes to activate service opportunities from the products and customers' information, there is the need for personnel experienced in the industry with the right skills for understanding and managing data.
- *Difficulty in understanding and developing business implications according to IoT opportunities:* it might be difficult to translate IoT opportunities into profitable businesses. Hence, there is the need of experimenting, by partnering and making small-scale pilots.
- *Difficult to detect, gather, analyze and handle the right data:* data quality might be a relevant issue, and within the very large amount of gatherable information, it is important to understand the right KPIs to be detected and analyzed.
- *IoT implementation is not always cost-effective:* both an internal and external IoT development might be an expensive process, considering the amount of hardware and software installations needed, the amount of partners involved and the specificities of the products.

6.2.4. How can IoT enhance the servitization process for non-servitizing, manufacturing firms?

Manufacturers willing to approach the servitization process through the implementation of PSS can resort to IoT and leverage on its capabilities in order to deliver new services that can be integrated with product-based offers. Alternatively, thanks to the IoT, they can decide to market their products as-a-service, by keeping the ongoing visibility on their availability, performance and utilization. This is to say that IoT can offer both the connection with customers and the tools for serving them, paving the way for the servitization shift of manufacturers. As a matter of fact, it suffices here to mention the cases of GWS, Spray Technology Manufacturer and TSM, which, through IoT implementation by an IoT intermediary (Autodesk Fusion Connect), managed to turn their product-based offers into servitized ones, identified as PSS.

6.2.5. What kind of role can IoT play for the Product-Service Systems of manufacturers?

According to what analyzed and stated in the previous paragraphs, in consonance with Sassanelli et al. (2016), it can be surely asserted that IoT is a catalyst for the implementation and improvement of PSS. The following chart summarizes most of the cases (both deriving from secondary and primary sources, with the latter extensively analyzed in Chapter 5) examined in the present research, and highlights the existing relationship between IoT and PSS.

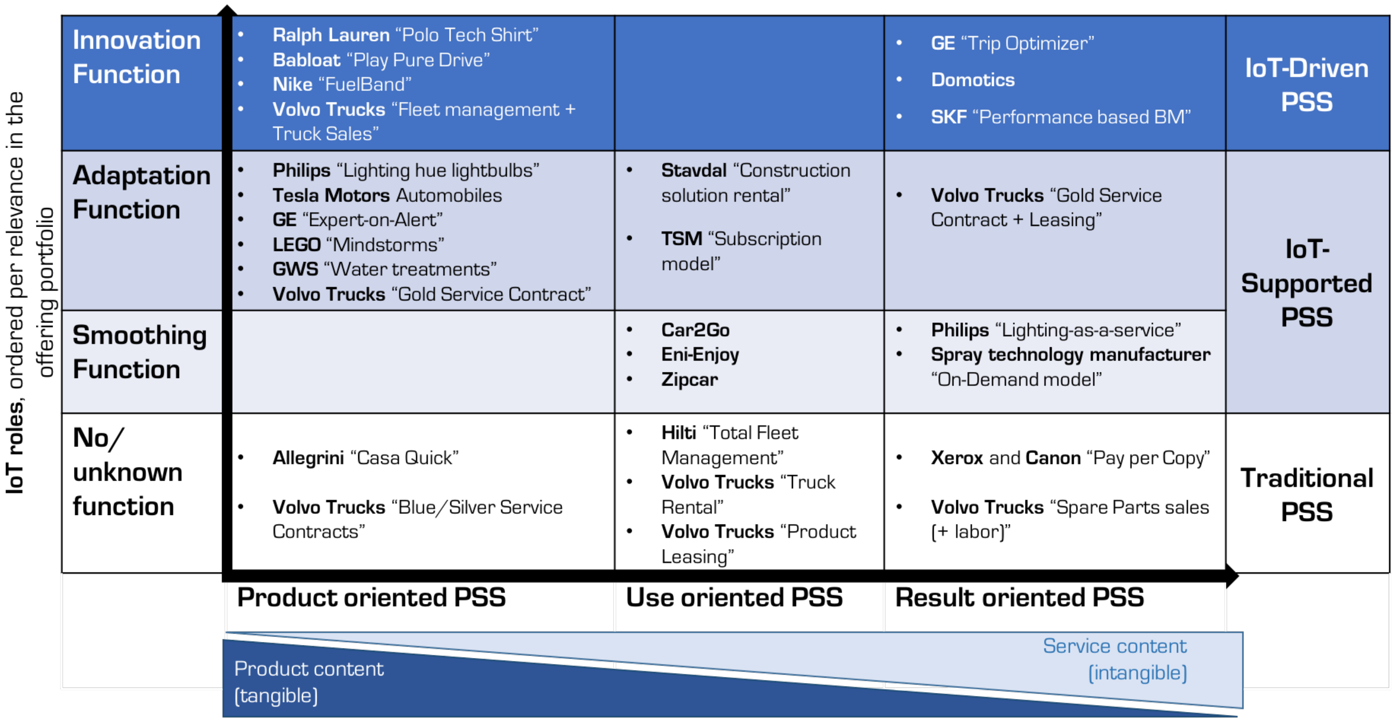

Figure 30. The IoT-PSS Matrix applied to both secondary and primary gathered data

As Figure 30 shows, the IoT-PSS Matrix presents three roles - or functions - IoT is able to play for the PSS of manufacturers.

The Internet of Things can, indeed, *Smooth* (or enable) Use oriented and Result oriented, Product Service Systems; *Adapt* (or improve) any kind of PSS; *Innovate* the Product oriented and Result oriented ones, leading to the implementation of IoT-Supported and IoT-Driven, PSS.

6.3. Theoretical contribution

The findings of this conclusive section have given light to a rather unexplored area of research regarding the impact of a notorious, modern, technology - IoT - on widely studied concepts as Servitization and PSS. The present work has not only introduced a possible solution related to some challenges associated with the two latter theories, but also explained, in detail, previously unknown opportunities and challenges related to their implementation via IoT solutions. This leads to a further step in the academic knowledge of both the fields of the Servitization, Product-Service Systems and in the one related to IoT business applications. Indeed, the research successfully integrated and analyzed a high-potential innovation under the corporate business strategy perspective. This is a contribution, considering both the paucity of relevant research on its business utilizations and implications (Torsten and May, 2016), and that IoT is, erroneously, very seldom interpreted as a catalyst for the implementation and development of offerings (Forrester Consulting, 2015).

Last but not least, this master thesis deeply examined and applied Tukker's widely known frame of reference about PSS (2004), and extended it, by combining the model with the one of Torsten and May (2016). Thus, a comprehensive, tested, ready-to-use, framework to be used to classify, understand and analyze in a systemic way any kind of product-service offers, has been delivered: the IoT-PSS Matrix. This new framework has also been applied to many real-world examples, delivering to academia a relevant pool of illustrative cases to be further mentioned and studied by future research papers.

6.4. Managerial implications

Companies can resort to the considerable amount of examples and tools mentioned, to explore strategic possibilities to gain economic, environmental and customer-related benefits.

Economically speaking, the implementation or amelioration of PSS via IoT might represent an important source to gain or retain competitive advantages, charge higher prices and improve the brand image. By leveraging on IoT, also through automated systems, it is possible to extend an offer with targeted, responsive or predictive services, to market products *as-a-service*, as well as to develop new *bundles* of product and self services. These options give into the hands of manufacturers the possibility of creating a range of critical business differentiators for their own offer and value proposition. This also by developing an improved customer-centric approach, that would possibly permit to increasingly lock-in customers and lock-out competitors. Additionally, IoT allows traditional producers to modify their business model, to access to more stable revenue streams and higher margins. As a matter of fact, in accordance to interviewees' opinions, to IoT implementations are associated high revenue sources (mainly service opportunities, product ameliorations, design and marketing applications) and possibilities for lowering costs (mainly related to the factory floor, for improving and automating operations).

The IoT-PSS Matrix might support managers to understand the possible product-service *bundles* opportunities, as well as to identify new offers and to better detect and classify existing ones.

Moreover, the research has also explained how to employ IoT, providing practical suggestions for manufacturers which are willing to servitize their own offer.

Of course, the implementation of IoT presents some challenges, as companies which want to leverage on it should be warned on the necessity of hiring talents with managerial skills related to data analysis. Indeed, it is crucial to detect the relevant information to be gathered and to properly analyze it, in order to activate determined business opportunities. However, generally speaking, for the PSS development phases, it is strongly suggested to test the feasibility and profitability through small-scale pilots, as *ex-ante* costs-benefits analyses are seldom reliable.

To conclude, the research suggests that manufacturers willing to develop new PSS with the aid of IoT should firstly think about the service they want to provide, to be integrated with their product offer. They should detect what information is needed to activate services components only when the latter is well clarified. Developing services by basing on all the possible available data is not advised: it is, indeed, very difficult to translate large amounts of data into relevant information and opportunities. Once both the service design and the data needed for its implementation are defined, then it makes sense to trigger the connection, also turning to for external IoT intermediaries. Then, it is all about analyzing data, acting with them (e.g. through computational functions and algorithms, to develop automated systems), and providing the intended combination of product and services.

6.5. Limitations of the research

One limit of the present research lays behind the initial choice, in the theoretical framework, of relying on the model and taxonomies of Tukker (2004), in concordance with Manzini et al. (2001) and Baines et al. (2007), for the identification and categorization of PSS. Indeed, different frameworks with different classifications would have probably led to different outcomes in the identification of IoT-based PSS.
Moreover, it is noteworthy to state that not all of the challenges associated to the implementation of PSS by scholars have been presented and analyzed. The focus has been set on the obstacles related to the need of establishing a connection with customers, in order to better explain the suitability of the IoT, maintaining the spotlight on main purpose of the thesis. However, this choice limits the research, as other challenges - including the cultural shift required by customers for not owning the product (Goedkoop, 1999; Manzini et al., 2001; Mont, 2002; and UNEP, 2002) – have not been adequately considered.

Another possible limitation is represented by the lack of an extensive inquiry about the relationship between servitization, PSS and IoT, and business model theories. As a matter of fact, the relevant literature of the latter (e.g. Chesbrough, 2010) has not sufficiently been taken into account, not for losing the overall focus on the pertinence of IoT for the PSS implementation.
Furthermore, given the limited time and resources available to the author, the analysis has not systemically investigated on the economic implications for the different PSS offers, nor on the impact of IoT implementation in terms of profitability. Although these are very relevant concepts strictly related to the topic, studying them would have probably required a wider sample and an additional quantitative examination, hence a different kind of analysis that, still, should have been based on key concepts clarified in the conclusions. Nevertheless, as explained in the next paragraph, a future research about this subject matter is strongly suggested.
An additional possible limit is represented by the lack of detailed explanations about the technical aspects of the IoT, whose study, however, would have probably led the focus away from the main topic.

Last but not least, it might be questioned the generalizability of the results. Indeed, the sample group, although quite variegated, is still small. Moreover, although it is composed by companies operating in different industries, some aspects of IoT and PSS might be industry-related, thus not widely applicable. However, as explained in the Chapter 3, for this paper, the generalizability is definitely not a main priority.

6.6. Suggestions for future research

It might be intriguing, in the author's opinion, to try to complete the application of the IoT-PSS Matrix, by investigating on the potential IoT functions of Smoothing PoPSS and Innovating UoPSS. Indeed, this would lead to the completion of a possibly widely applicable framework. Nonetheless, also further applications of the matrix might be interesting, through deductive research that would possibly completely test its validity. In this case, it is suggested to start focusing on one or few similar industries.

Also, as already stated, it might be extremely relevant to inquiry the economical implications of both IoT-supported and IoT-driven PSS, and quantitative research could be decisive to detect the impact of IoT implementations on the profitability of servitizing manufacturers. Moreover, quantitative studies should provide a better understanding of how IoT is mostly utilized and by whom, to identify possible correlations between some IoT functions and PSS offers, as well as between the former and certain economic results. This way, it would be possible to prescribe specific suggestions basing on financial measures.

Future qualitative studies, on the other hand, might investigate more in depth on the challenges related to IoT implementation, inquiring also the security and privacy issues that have not emerged in the studied empirics, but that in the author's opinion might represent very relevant barriers, especially in a longer-time horizon.
Lastly, academically speaking, it might be really interesting to inquire the possibility of triggering business model innovations trough the employment of the IoT, on the basis of what stated in the present work and in the ones of Mitchell (2004) and Chesbrough (2010).

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Appendix

Appendix 1: Company profile:

Stavdal AB

Sector: Industrials

Industry: Industrial Services

Sub-Industry: Industrial Distribution & Rental

Stavdal AB leases construction equipment. The Company provides lifts, construction machinery, layouts, sheds, education and related services, and safety equipment. It serves the construction industry in Sweden and Norway.

SKF

Sector: Industrials

Industry: Manufactured Goods

Sub-Industry: Fabricated Metal & Hardware

SKF AB develops, produces, and markets products, solutions, and services in the rolling bearing and seal business. The company product line includes ball and roller bearings, specialty bearings, sealing systems, linear motion products, tools for mounting and dismounting bearings, and measuring and monitoring instruments. SKF markets to industrial companies worldwide.

Volvo Trucks

Sector: Transportation

Industry: Manufactured Goods

Sub-Industry: Trucks

Volvo Trucks Corporation engages in the manufacture and distribution of heavy trucks and tractors, engines, and accessories in the world. It offers transportation, process, leasing, contract maintenance, vehicle management, fleet management, training, and used trucks. The company is based in Gothenburg, Sweden. Volvo Trucks Corporation operates as a subsidiary of AB Volvo.

Autodesk, Inc. (Fusion Connect)

Sector: Software

Industry: Software Services

Sub Industry: Software designer, producer and seller for different industries

Fusion Connect is an Internet of Things (IoT) Cloud Service to easily connect, analyze, and manage remote products. It virtualizes your physical things, links them with reporting devices and through analytics unlocks the data trapped inside to:

- Generate real-world product performance data to improve future designs.
- Predict when products might fail and perform maintenance.
- Create new service revenue and product upgrade opportunities.
- Optimize field supply chain and material replenishment costs. (Fusion connect, 2017)

Appendix 2: Interview Guideline

VOLVO, SKF, STAVDAL:

(Generally speaking)

- **Business Model**

-What is the offering/s of the company?

-Who are your customers, what is their need/pain/demand?

-How do you solve the problem i.e. what is your general offer?

- **Servitization Process**

-Have you always had this kind of offer in the past? How did you solve the problem before?

-Why and how did you change your offer?

- **PSS identification**

(*In detail)*

-Can you please explain in detail your offer? How does your product work?

-Do you maintain the ownership over the product?

-What are the services that surround the product you offer; how do they work?

-How do you deliver most of the value (i.e. via products or services)?

- **IoT**

if not already specified in previous answers

-Did your product change as (if) you changed your BM/the other way around?

-How do you handle this bundle of product and service?

-How do you keep contact with your customers and track of their usage patterns?

-What does "having a product connected" mean?

-What opportunities can the connected products deliver?

-What are the challenges associated?

If the offer includes any post-sale service on the product

-How do you manage your installed base and keep track of every unit (products already on the market)?

-How do you respond to any occurrence or problem on the functioning of your product?

-What problems do you face?

if not already specified in any previous answer

-Do you make use of IoT components for implementing your offer? How?

-What are the benefits and challenges related to their implementation?

-How would be your offer, without the support of the IoT?

AUTODESK (FUSION CONNECT):

-How does Autodesk relate to the IoT?

-How does the Business Model of Autodesk Fusion Connect work?

-What do you do, practically speaking?

-Who are your customers (generally speaking, what is their pain)?

-What is their gain, through Autodesk?

-Did they change their offer?

-What kind of benefits does the customer of your customer gain?

-What are the challenges faced by Autodesk and by its customers?

If not mentioned

-Does Autodesk Fusion Connect help customers only in their operations or also in evolving their own offer?

-Do they change their BM?

-Would it be possible for Autodesk to help them in evolving their offer rather than just optimizing their operations? In what way? How?

-What are the major opportunities and challenges for IoT “infusion”?

-Can Autodesk turn a manufacturing firm a servitizing manufacturing firm?