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WHICH SERVICES TO OFFER AND WHEN?

The role of lifecycle contexts on the performance effects of servitization.

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Preface

This report is constructed for a Business Administration master thesis with a specialization in Strategy and Organization on the Vrije Universiteit Amsterdam. The copyright rests with the author. The author is solely responsible for the content of the paper, including mistakes. Whilst writing the paper the author has been supervised by Dr. M.J. Flikkema.

In the process of writing this paper I have learned a lot on how conduct a quantitative research on an academic level. For this reason, I want to thank my supervisor for demanding high standards and for giving clear and constructive feedback along the way. I also would like to thank my family, girlfriend and friends for their mental support in the past few months.

Abstract

This thesis studies the role of industry and product lifecycles in the servitization-performance relationship. The motivation for this study is to explain the inconsistent results on servitization and firm performance in earlier articles. The study's sample consists of 96 publicly listed manufacturing firms in eleven different industries over an eight-year time period between 2011-2018. Data was acquired by integrating data from multiple secondary sources on service ratios, profitability, industry growth and patent citation lags. The results of this study yield that the performance implications of product-oriented servitization and customer-oriented servitization are dependent on industry lifecycle phase and servitization extend. Product-oriented servitization has positive performance implications in the early industry lifecycle phases when it contributes for not more than 30% to total revenues. Customer-oriented servitization has positive performance implications in the mature industry lifecycle phase when it contributes for not more than 20% to total revenues. These findings are backed by theory explaining that product-oriented services complement the product business and customer-oriented services differentiate the firm. Different from what was expected, the results shown no influence of PLC-length on the servitization-performance relationship.

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1. Introduction

Many manufacturing firms are increasing their sales from services (Cusumano, Kahl and Suarez, 2006). Neely, Benedittini and Visjnic (2011) show that already a third of the world's manufacturing firms added some services to their product offering. *Servitization is a strategy in which manufacturers include services alongside their core product in order to change their business models and/ or complement their product business*. For example, in the automotive industry, large manufactures offer services such as maintenance, repair and financial loans (Cusumano, 2010). Some of these services are sold as separate product extensions and some are included within the product's price (Mathieu, 2001). The share of revenues coming from services sold as separate product extensions within a firm's total sales revenue is the service ratio (Fang, Palmatier and Steenkamp, 2008). Although this ratio does not include all services, it is considered as a valid indicator of a firm's servitization extend.

Previously, servitization was considered as a means to escape from price-based competition within maturing industries (Cusumano et al, 2006). However, recently scholars discovered that product-oriented servitization (PO-servitization) most frequently occurs in the early phases of the industry lifecycle (Visjnic, Ringov & Arts, 2019; Cusumano Kahl and Suarez, 2015). PO-services are services that are performed on the product and aim to enhance its functioning (e.g. maintenance and repair) (Visjnic et al, 2019). On the contrary, customer-oriented servitization (CO-servitization) occurs most frequently in the mature phase of the industry lifecycle. CO-services are services that built on competences unrelated to the product and facilitate customers' processes (e.g. financing and logistics) (Visjnic et al, 2019; Mathieu 2001b).

Vandermerwe and Rada (1988) provide an explanation for the trend towards services. They argue that increased competition, advanced technology and globalization enable customers to compare product offerings. This caused a need for manufactures to differentiate themselves from competitors by offering services. Servitization is most likely to occur at firms in emergent countries, because they usually experience price pressures from emerging countries due to low labor costs (Neely, 2007). Moreover, Szasz et al (2017) explain that firms within emergent countries are better able to deliver services as they benefit from better infrastructure and a greater availability of knowledge. Both are necessities for effective servitization.

Although the motives behind the servitization trend seems to be clear, previous empirical studies on the relationship between servitization and firm performance provided inconsistent results. Benedittini, Swink and Neely (2015) conclude that servitization is negatively related to firm survival. While a meta-analysis of Wang, Lai and Shou (2018) links servitization to increased firm performance. However, these results did not last when service ratio was used as an operationalization of the construct. In contrast, a study by Crozet and Milet (2017) on more than 50.000 French manufacturing firms shows a positive relationship between service ratio and firm performance. Much of the literature has tried to find organizational factors to explain these inconsistent findings, but only a few have focused on external factors such as industry characteristics.

Fang *et al.* (2008) indicate that the servitization-performance relationship is contingent on industry growth. In that same study they report that only PO-services were likely to result in positive performance outcomes. Visnjic et al (2019) provide contradicting evidence, by showing that the adoption of PO-services and CO-services differs strongly by industry lifecycle phase. Cusumano et al (2015) extend this discussion, by explaining that the added-value of PO-services is strongly dependent on industry lifecycle context. However, none of these studies have shown what the performance implications of PO- and CO-services are within different stages of the industry lifecycle.

Further, Eggert, Thiesbrummel and Deutscher (2015) show that especially PO-services provide benefits for product innovations due to knowledge spillovers with the product business. The study of Visnjic et al (2019) had a similar outcome. It discovers that PO-services are increasingly applied within industries that have high investments in research and development (R&D). In addition, Fang et al (2008) mention that CO-services are not related to the product and do therefore not facilitate such synergies. Visjnic, Wiengarten and Neely (2016) contradict this argument and assert that CO-services provide insights about customers' demands, which may lead to the discovery of innovations unrelated to the current product. The average length of product lifecycles (PLC-lenghts) within an industry is dependent upon the frequency of technological disruptions (Bilir, 2014). Since, these disruptions re-start the product lifecycle (Anderson & Tushman, 1986). Although it is known that PO-servitization compared to CO-servitization has a positive effect on product innovations, the effects of servitization on technological disruptions measured by PLC-length is yet unknown.

The motivation for this study is to fill these two gaps in the literature. First, it clarifies the different performance implications of product-oriented servitization and customer-oriented servitization in different phases of the industry lifecycle. Second, it examines the influence of product lifecycle lengths on the performance effects of servitization. Therefore, the research goal of this study is *to understand the relationship between servitization and firm performance within different lifecycle contexts.*

This study is novel as it is the first to look at the service-ratio of specific service types; it is the first to measure performance implications of servitization across different phases of the industry lifecycle; and it is the first to examine the influence of product lifecycle lengths within servitization literature.

The research for this study was performed on 96 manufacturing firms in eleven industries over an eight-year time period between 2011-2018. Data was gathered by integrating multiple secondary data sources. The results of this study indicate that the servitization-performance relationship is contingent on the alignment between three aspects: the type of service offering, industry lifecycle context and servitization extend. In contrast to what was expected, the performance effects of servitization are not influenced by product lifecycle length.

The second section starts with a review of existing literature on the relationship between servitization, firm performance and different lifecycle contexts, which is followed by a justification for the hypotheses. The third section presents the research methods that were applied. The fourth section provides a summary of the results and the fifth section a discussion about the study’s findings.

2. Theoretical background

This section provides an overview of existent literature on the most important concepts of this study and explains the relationships between them.

2.1 Servitization and firm performance

In the first paper on servitization by Vandermerwe and Rada (1988, p.314) the term servitization was defined as: "increasingly offering fuller market packages or "bundles" of customer-focused combinations of goods, services, support, self-service, and knowledge." Although this definition does not specifically mention to which organizations servitization may apply, most studies since have focused on manufacturing firms (Brax & Visintin, 2017). Further, this definition mentions many different product extensions falling under the umbrella of servitization. Cusumano et al (2006, p.5) clarify in their study that these extensions could be defined as: "complementary activities meant to assist in promoting adoption of the core product or to enhance the core product." In contrast, Wang et al (2018, p. 1564) define servitization as: *"a transformational process of adding services to products with a strategic transition from goods-dominant logic to service-dominant logic."* This definition implies that a certain organizational change must occur, namely from a product-oriented to a service-oriented business model. The article of Visjnic et al (2016) integrates both perspectives by stating that servitization could both complement a product-oriented business model or shift the strategic focus to a more customer-oriented (service-dominant logic) business model. Therefore, this study combines these definitions and defines servitization as: a strategy *in which manufacturers include services alongside their core product in order to change their business model and/or complement their product business.*

Initially the assumption was that servitization would always have positive performance implications for manufacturers. This was based on the believe that services provide an additional stream of income, stable revenues, increased customer loyalty and synergistic effects with the product business (Vandermerwe & Rada, 1988; Markides & Williamson, 1996; Sahwney, 2006; Cusumano et al, 2006). This evolved into a view that perceives servitization as a transition from a product-only to an advanced service business. The logic behind this rationale is that the more a firm servitizes, the more service capability it acquires. This results in the ability to offer more advanced services that are difficult for competitors to imitate (Wang et al 2018; Olivia & Kallenberg, 2003). However, another stream of literature places more emphasis on the costs related to servitization. Gebaur, Fleisch and Friedli (2005) explain that many manufacturers fail to develop the necessary organizational capabilities required for servitization. Kowalkowski et al (2017) provide evidence for this effect, by showing that many firms are deservitizing, as the investments for developing service capabilities fail to provide significant returns.

These different perspectives on servitization result in opposing views on what kind of services are most effective for manufacturers' firm performance. Although many different categorizations of services exist, the distinction between PO- and CO-services is most often applied in literature on service performance. Other names of these two categories are services supporting the product (SSP) and services supporting the client (SSC) (Mathieu, 2001b) or product-related services and unrelated services (Fang et al, 2008). PO-services are services that are performed on the product and aim to enhance its functioning (e.g. maintenance and repair), CO-services are built on competences unrelated to the product and facilitate other customers' processes (e.g. financing and logistics) (Visjnic et al, 2019; Mathieu 2001b).

Those authors who favor PO-services believe that synergy with the product creates certain performance advantages over CO-services. Fang et al (2008), who obtain evidence that only PO-servitization has positive performance implications, assert that focusing on CO-services would result in a loss of strategic focus. PO-services retain product focus, as they require capabilities such as technical product knowledge. On top of that, CO-services increase the risk of imitation by regular service firms, because minimal product knowledge is needed. Benedettini et al (2015), who found that offering CO-services would incur higher bankruptcy risks, believe that the costs for developing CO-service capabilities are higher than those of PO-services. Since, CO-services require capabilities that not belong to manufacturers' core competences (e.g. client management). Eggert et al (2015) focus on the benefits of services on product innovation. They discover that PO-services generate knowledge about the product during use, which inspires product innovation. Another complementary effect of PO-servitization is that it increases the perceived reliability of the product, as these services enhance the functioning and durability of the product (Cusumano et al, 2015).

On the opposite side, authors who favor CO-services mention that these services have greater differentiating power and are based upon more advanced service capabilities. According to Mathieu (2001b), CO-services provide a revenue stream independent of the performance of the product market. This allows a firm to exploit its existing client base with a new service offer creating economies of scope. This form of differentiation stabilizes a firm's revenues, because it becomes more independent from the cyclicality of the product business (Cusumano et al, 2006). In addition, Visjnic et al (2016) argue that CO-servitization does create more insights about customers' demands unrelated from the product. This could inspire firms to fulfill these demands through product and service innovations. Moreover, Wang et al (2018), who found that CO-services are more positively related to market performance, state that CO-services require more advanced service capabilities which make them harder for other manufacturers to imitate. These advanced service capabilities would also benefit customer relationships. Lastly, CO-services may also indirectly benefit the core product business, because these services facilitate customers' processes that ease the adoption of the product. For example, providing financial loans to clients to purchase the product (Visjnic et al, 2019).

Although arguments and empirical findings about the effectiveness of PO- and CO-services are inconsistent, they do agree on the different characteristics of these two service types. Hence, it could be concluded that PO-services require capabilities similar to the product business, while CO-services require more advanced service capabilities. PO-services retain the focus on the product, while CO-services differentiate the firm. PO-services provide knowledge of the product during use, while CO-services may identify new customer demands.

2.2 Servitization and industry lifecycles

Klepper (1997) explains that within manufacturing industries the industry lifecycle evolves in a regular fashion. In the early stages, the product technology is new to both manufacturers and consumers. Many firms are entering the market and try to find the most optimal product designs to best serve customers' needs. Therefore, this phase is characterized by product innovations (Utterback & Abernathy, 1975). After a while, dominant product designs emerge. This decreases customer uncertainty and results in high industry growth. In this phase it is important to scale business operations, because when the industry declines, competition will become price based. This results in a shake-out of producers that only the largest firms survive, as these benefit from scale economies (Utterback & Suarez, 1993). In the mature stage of the industry lifecycle process innovation is most important, because efficiency reduces costs (Utterback & Abernathy, 1975). However, price-based competition is not endless. Differentiation could be a way for manufacturers to escape from such forms of competition (Chesbrough, 2007).

Servitization in early industry lifecycle phases

Initially, Cusumano et al (2006) found that servitization was mostly applied within the mature stages of the industry lifecycle, as it is an effective differentiation tool to escape from price-based competition. But later on, these authors reviewed their earlier work and mentioned that PO-services also create value in the early stages (Cusumano Kahl & Suarez, 2013). In line with this argument, Visjnic et al (2019) discover that PO-services are most often adopted in the early lifecycle phases. According to Cusumano et al (2015), PO-services in the early phases take on the form of adapting services, which adapt the product to specific customer needs (e.g. customization). These types of PO-services occur because a dominant product design has not yet emerged, which is why the product should be adapted to specific customer demands. In contrast to other PO-services, adapting services are difficult to imitate for other manufacturers as they require service capabilities for understanding clients' wishes (Cusumano et al, 2015). The downside of adapting services is that they are difficult to scale, but this could be endured in the early stages of industry development as user volume is expected to be low.

The main added-value of offering PO-services in the early phases is that it decreases the uncertainty that many consumers have about the new product (Visjnic et al, 2019). This decreasing uncertainty has positive implications for product sales. This is in line with the argument of Teece (1986), who state that services function as complementary assets in capturing the value of new technologies. Another argument in favor of offering PO-services, is that these services keep the strategic focus on the product business (Fang et al, 2008). This is beneficial in the early stages because the product market is expected to grow. Differentiating through CO-services would make the firm miss out on the potential of growing the product business significantly. Those firms will be forced to leave the industry when a shake-out of producers occurs in the mature phase due to a lack of scale benefits.

Further, PO-services are beneficial in finding a dominant product design. Eggert et al (2015) obtain evidence that PO-services generate information about the product during use, which increases the effectiveness of incremental product innovations. Cusumano et al (2015) add, that adapting PO-services (e.g. customization) generate information about customers' demands. Both types of information help manufacturers to find a design that fits best with customers' needs. Those arguments are in line with the article of Chesbrough (2011), that states that open service business model innovation (servitization) may help to sense possibilities for product innovation.

Based on these arguments, it is expected that investments for developing a PO-service capability in the early lifecycle stages will result in a competitive advantage. However, PO-servitization is only likely to have positive performance implications up to a certain extend. A firm that relies too much upon its service activities will shift the strategic focus away from its product business (Fang et al, 2008). This would diminish the positive effect of PO-servitization as its main aim is to complement the product business. For that reason, it is expected that PO-servitization has an inverted U-shape relationship with firm performance in the early phases of the industry lifecycle. Thus, the following hypothesis is proposed:

H1: *Product-oriented servitization has a significant inverted U-shape relationship to firm performance in the early phases of the industry lifecycle*

Servitization in the mature industry lifecycle phase

The mature phase of the industry lifecycle is characterized by dominant product designs, decreasing active number of firms, high volume of users and cost-based competition (Klepper, 1997). Due to the emergence of a dominant design, it is no longer necessary to adapt the product to specific customer wishes. Therefore, PO-services take on the form of smoothing services, which are standardized services that ensure the smooth use of the product (Cusumano et al, 2015). Cusumano et al (2013) state that these services fit well with the mature phase as standardized services could be scaled to a large userbase and incur low costs. However, smoothing PO-services depend only on product related capabilities, which is why they could easily be imitated by other manufacturers (Mathieu, 2001). On top of that, Visjnic et al (2019) state that product-knowledge in the mature phase often becomes publicly available. This implies that even for regular service providers it becomes possible to imitate PO-services in this phase.

Further, PO-services are meant to increase the reliability of the product which increases product sales (Cusumano et al, 2019). However, due to the emergence of a dominant designs, products already have a relatively high level of reliability. This decreases the need for complementary PO-services. In addition, PO-services retain focus on the product business (Fang et al, 2008). Although this is beneficial when the product market grows, it is less effective when it declines, because PO-service revenues cannot grow independently from the product.

In short, PO-services in the mature phase of the industry lifecycle could easily by imitated by competitors and lose most of their complementary benefits with the product business. Thus, the following hypothesis is proposed:

H2a: *Product-oriented servitization has a significant negative relationship with firm performance in the mature industry lifecycle phase*

Visnjnic et al (2019) obtain evidence that CO-services are applied more frequently in the mature as opposed to the early phases of the industry lifecycle. This happens because CO-services facilitate customers' processes that ease the adoption of the product, which is necessary for decreasing the buying reluctance of late adopters (Cusumano et al, 2015). This increases firm performance compared to other manufacturers, because those manufacturers who offer CO-services in this phase are able to draw in the last remaining customers. It is difficult for other manufacturers to imitate such CO-services as these require tacit service capabilities (Wang et al, 2018).

However, more importantly, CO-services create a business which continues to exploit the manufacturers' client base when there is less demand for their products (Mathieu, 2001b). This generates an independent stream of income which stabilizes the revenue stream of manufacturers when product revenues stagnate (Cusumano et al, 2006). In addition, Visjnic et al (2016) observe that CO-services gain insights about customers' demands unrelated from the product. This results in a snowball effect as manufacturers identify possibilities for new service offerings.

Downside of CO-servitization is that it only requires service capabilities. This leads to imitation risks from regular service providers (Fang et al, 2008). Eggert et al (2015) and Kowalkowski et al (2017) add, that industrial firms that completely shift into services are often unsuccessful as they are unable to make such a drastic organization change. Hence, CO-servitization is expected to reduce buyer reluctance and stabilize revenue streams in the mature phase, but manufacturers are unable to transition into a service-dominant business. Thus, the following hypothesis is proposed:

H2b: *Customer-oriented servitization has a significant inverted U-shape relationship with firm performance in the mature phase of the industry lifecycle*

2.3 Servitization and product lifecycle lengths

Before explaining what PLC-lengths are and how they could influence the relationship between servitization and firm performance, it is important to explain the distinction between industry lifecycles and product lifecycles. In this study, an industry lifecycle refers to the lifecycle of a firm's core industry. This industry is identified by a four-digit SIC-code. Within an industry different services, product components and complementary products are sold to foster the functioning of the core product. The product lifecycle refers to the lifecycle of each individual product component. For example, the aircraft manufacturing industry has its own industry lifecycle in which different product lifecycles exist, such as the product lifecycle of aircraft engines.

The flow of product lifecycles in manufacturing industries evolves in a relatively similar way as the industry lifecycle (Klepper, 1997). Anderson and Tushman (1986) state that product lifecycles could be disrupted by technological discontinuities in the market. The frequency of these technological disruptions within an industry determines the PLC-length, in such way that the more frequent such disruptions occur the shorter the industries' average PLC-length (Bilir, 2014). For firms in the mature phase, it is important to anticipate upon such technological discontinuities in order to escape from the maturing product markets.

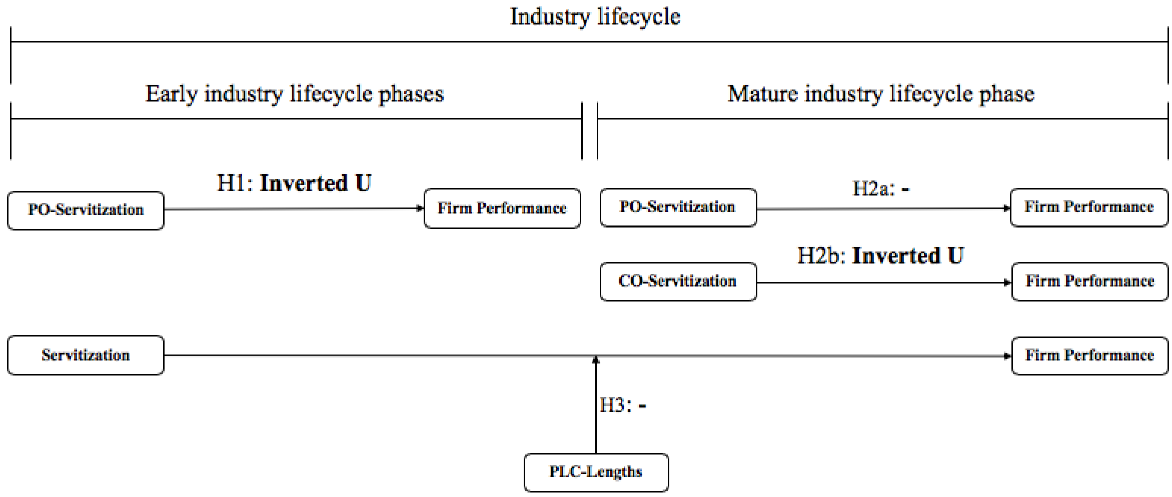
Sensing is a way that could help established firms to discover such discontinuities (Maula, Keil & Zahra, 2013). According to Chesbrough (2011), open service business models (servitization) are a way to gain inspiration for product innovations. Eggert et al (2015) argue that especially combinations of products and services provide the best chance on product innovation success. Fang et al (2008) and Visjnic et al (2019) have already shown that especially PO-servitization is most effective in R&D intense industries. Since, PO-services generate information about the product during use, which helps to optimize the product and increase the reliability of new technologies (Cusumano et al, 2015; Visjnic et al, 2019). However, R&D intensity is an indicator of all sorts of innovations and not for technological disruptions specifically. Only generating information about the product during use will not be enough to discover technological disruptions, because disruptions are not related to the current product. Fortunately, CO-services and PO-services that adapt the product to specific customer needs (e.g. customization), generate information about changing customer demands (Visjnic et al, 2016; Cusumano et al, 2015). This inspires manufacturers to create new products in order to fulfill these demands. These new products will then be optimized through incremental product innovations based on information about the new product during use generated by PO-services.

Hence, when PLC-lengths are relatively short, it is expected that the performance effects of servitization in general increase, because it senses changing market demands and complements new product technologies. Thus, the following hypothesis is proposed:

H3: *The relationship between general servitization and firm performance is negatively moderated by the average length of product lifecycles within a firm's industry, in such way that firm performance positively increases when product lifecycle lengths are short.*

Figure 1 provides a representation of this study's research model. Hypothesis H1 is focused on the performance effects of servitization in the early industry lifecycle phases, hypotheses H2a and H2b concern the performance implications of servitization in the mature lifecycle phase and hypothesis H3 considers the influence of PLC-lengths on the general servitization-performance relationship.

Figure 1: Research model



3. Research Design

This section elaborates on all methods that were applied in order to test for the proposed relationships between the study variables.

3.1 Sample and data collection

For this study secondary data from the Compustat Business Segments and Financial Fundamentals databases in an eight-year time-period of 2011-2018 were used. It is necessary to use a timeframe of several years because not all firms provide publicly available data on service revenues. This allows to only include firms in the sample that reported service activities at least once between 2011-2018. Previous literature on servitization also used these Compustat databases and applied the same selection method (Visjnic et al, 2019; Fang et al, 2008; Cusumano et al; 2006). The only difference is that these studies cover a longer time period, but unfortunately the Compustat Business Segments database does not anymore retain its data for longer than 9 years.

Data on service revenues are only available in Compustat Business Segments, which only includes manufacturing firms that are publicly listed on North American Stock Exchanges. Firms listed on a stock exchange are relatively big, because firms usually go public to seek investments for growth opportunities. Neely (2007) and Dachs (2014) show that mostly large firms engage in servitization as services are labor-intensive and require many resources. Crozet and Milet (2017) confirm this finding but warn that smaller firms also servitize with different performance results (especially below 100 employees). Therefore, the results of this study may not be generalizable to smaller firms. Neely (2011) discover that the servitization trend is similar in most emergent countries. Therefore, it is expected that the insights drawn from this study could be generalized to all large manufacturers in emergent countries. A firm is considered as a manufacturing firm when their primary SIC-code starts with two digits in the following range 20-39 (all manufacturing industries) or if they have the primary SIC-code 7372 (pre-packaged software industry). The products within the pre-packaged software industry require similar organizational capabilities as manufacturing products (Cusumano et al, 2006).

For this study, data was acquired on a sample of 101 manufacturing firms spread out over eleven industries. A limited amount of industries was beneficial to the reliability of the results, because too many different industries would create difficulties in controlling for specific industry effects. Not all of the 101 firms in the sample reported revenues in each of the eight years. Therefore, the total amount of firm-year combinations (cases) that represent the beginning of the sample size was 686. Three cases were removed as they had missing data on EBITDA. Sixteen cases were removed as they had a different total sales revenue in Compustat Financial Fundamentals compared to the Compustat Business Segments, which would have caused concerns for reliability. Further, the scale on EBITDA margin contained 46 extreme outliers. These outliers were removed, because losses ranging from 400-40% are most likely caused by other circumstances than bad management. Another six extreme outliers on the CO-servitization scale were removed. It is expected that these outliers were caused by companies that reported both service and product revenues within one business segment, which makes the CO-servitization ratio artificially high. After removing these cases a sample size of 96 firms and 614 firm-year combinations remained.

Table 1 provides an overview of the number of firms and cases (firm-year combinations) in the sample per industry. The last two columns mention the number of firms for which all data was removed and number of cases per industry that were removed in the data cleaning process. Table 2 provides an overview of the size of the remaining firms and cases (firm-year combinations) measured by number of employees. The firm total in the first column of this table is more than 96, because some firms belong to one category in one year and to another in another year.

Table 1. Counts and percentages industries

SIC	Industry name	Number of firms	Percentage of all firms	Number of cases	Percentage of all cases	Removed firms	Removed cases
2834	Pharmaceuticals	8	8.33%	36	5,86%	1	11
3312	Steel manufacturing	8	8.33%	62	10,01%	0	0
3510	Engines and turbines	6	6.25%	34	5,54%	0	3
3523	Farm machinery	5	5.21%	37	6,03%	0	1
3559	Industry machinery	10	10,.2%	66	10,75%	0	5
3571	Electronic computers	10	10.42%	51	8,31%	0	11
3661	Telephone apparatus	10	10.42%	65	10,59%	0	12
3711	Automotive	10	10.42%	73	11,89%	0	0
3721	Aircraft manufacturing	9	9.38%	66	10,75%	0	3
3812	Radars and navigation	6	6.25%	42	6,84%	1	6
3845	Medical apparatus	4	4.21%	22	3,58%	2	13
7372	Pre-packaged software	10	10.53%	60	9,77%	1	7
	Total	96	100%	614	100%	5	72

Table 2. Counts and percentages of total employees

Number of Employees	Number of firms	Percentage of all firms (96)	Number of cases	Percentage of all cases
- 1.000	24	25%	143	23,3%
1.000-2.500	14	14.58%	55	9%
2.500-10.000	28	29.16%	133	21,7%
10.000-100.000	36	37.5%	214	34,9%
100.000 +	13	13.54%	69	11,2%
Total	115	100%	614	100%

The choice for quantitative data is justified by the methodological fit framework of Edmondson and McManus (2007), as both servitization and industry/product lifecycles are well established theoretical constructs. A correlational design is most appropriate, since there is no possibility to manipulate respondents and relationships between constructs are examined. Secondary data are used because these data are available for all study variables. It also enables other researchers to replicate this study by using the exact same measures. Further, with secondary data it is relatively easy to have a large sample size which increases reliability.

3.2 Measures

The independent variables of this study are *product-oriented servitization (PO-servitization), customer-oriented servitization (CO-servitization) and general servitization (Gen-servitization)*. The ratio of revenues from PO-services as a share of a firm's total sales revenue is used as a proxy of PO-servitization, the ratio of revenues from CO-services as a proxy for CO-servitization and the combination of PO- and CO-service revenues as a proxy for general servitization. In previous studies, service ratio in general has been used as an operationalization of regular servitization (Wang et al, 2018). Based on findings that PO- and CO-servitization have different performance implications in different lifecycle phases, this study separates the two. Compustat Business Segments provides information on revenue streams of a firm's business segments. When the first or secondary SIC-code of a business segment is classified as a PO-service (e.g. maintenance) then the revenues of this segment count as PO-service revenue. If a segment was classified by SIC-codes indicating CO-services (e.g. financial service) then this segment counts as CO-service revenue. The complete lists of the PO and CO-services SIC-codes are provided in appendix I. CO-services occurred less frequently in the sample than PO-services. Therefore, when the scale of CO-servitization was applied, those firms that did not report CO-services in any of the eight years were removed from analyses with this measure.

This also limited the high Skewness value of the CO-servitization scale (see section 4.1).

The growth or decline in the active number of firms in the industry (four-digit SIC-code) determines the *industry lifecycle phase.* According to Utterback and Suarez (1993), when industry matures a shake-out of producers occurs and the number of active firms start to decrease. This implies that if the number of active firms in a particular year is lower than the previous year, the industry is maturing. While if the number of active firms is growing or stable, the industry is yet in the early phases of the industry lifecycle. The industry lifecycle is a binary variable in this study. When an industry is decreasing in active firms it is coded 0, when the active number of firms is increasing or stable it is coded 1. Other studies on servitization and the industry lifecycle also determined industry maturity based on the active number of firms (Suarez et al, 2013; Visjnic et al 2019).

The moderator variable in this study is *the average length of product lifecycles* within the four-digit SIC-code industry. This variable is measured by looking at the average time in which patents continue to be cited by subsequent patents (Bilir, 2014). These data were available in the Patensview database of the US Patent and Trademark Office. Unfortunately, patents were classified under a CPC-code which does not correspond to SIC-codes. For that matter, researchers Goldschlag, Lybbert and Zolas (2016) came up with a concordance in which each SIC-code is linked to different CPC-codes. The probability that a patent within a certain CPC-class is applied within an industry (SIC-code) is provided as well. To calculate the average forward citation lag within an industry, the average citation lag in each individual CPC-class had to be calculated. The average of citation lags in all related CPC-classes weighted by their probability of being applied in the industry gives a measure of the average forward patent citation lag. This measure is considered as an indicator of PLC-lengths (Bilir, 2014). To come up with this measure for eleven different industries, more than 2800 patents granted in 2000 and their subsequent citations had to be analyzed. Unfortunately, software cannot be patented, therefore all sixty cases in the pre-packaged software industry were left out from analyses with this measure.

The proxy for PLC-lengths is based upon the theory of Anderson and Tushman (1986). They explain that technological disruptions in the market re-start the product lifecycle. Thus, if the core technology for a product is no longer cited in patents, it means that the underlying technology has become obsolete. This implies that when patents are cited for a long time, the average product lifecycle length is relatively long (Bilir, 2014). This measure has been chosen over others as it specifically targets the frequency of disrupting technologies, instead of more incremental product innovations such as R&D intensity does.

The dependent variable of this study is *firm performance.* Other studies that have examined the servitization-performance relationship have used profitability as an operationalization of firm performance (Crozet & Milet, 2017; Suarez et al, 2013). Profitability measured by EBITDA margin is chosen over more traditional firm performance measures such as return on assets (ROA), because profitability measured by EBITDA margin is not depended on the tangible assets of a firm. For example, manufacturers of large machinery have high amounts of tangible assets, while firms in the pre-packaged software industry have low amounts. EBITDA accounts for these differences as it is the operating income of a firm without taking into account the cost of capital expenses. EBITDA are all firm's earnings before taxes, interest, depreciation and amortization (Crozet & Milet, 2017).

In line with previous studies, firm size indicated by total sales revenue and number of employees were checked as control variable (Fang et al 2008; Cusumano et al 2013). Further, the average industry EBITDA margin was as a control variable that controlled for specific industry effects. The reason for this control is that the profitability of firms is often dependent on the industry in which they operate, since the intensity of competition differs (Porter, 1980).

3.3 Data analysis methods

After collecting all data, incomplete or unreliable cases were removed. The outliers on the EBITDA Margin and CO-servitization scale were removed. Next, the study's variables were computed. PO-service revenue and CO-service revenue were individually divided by total sales revenue which gave the scales for PO-servitization and CO-servitization. The total service revenue (PO- and CO-services combined) divided by total sales revenue provided the general servitization variable. For the industry lifecycle phase a dummy variable was computed. When the active number of firms in an industry had increased or remained stable it was indicated 1, when the active number of firms had decreased it was indicated 0. EBITDA was divided by total revenue which provided the scale for EBITDA Margin. For PO and CO-servitization a quadratic variable was computed in order to test for curvilinear relationships.

Subsequently, the descriptive statistics were produced. Next, the mean, standard deviations, kurtosis and skewness for each study variable were produced. As a next step, the correlation table was created which shows the correlation between all numeric study variables. This was followed by regression analyses to understand the relationships between the study variables. Hypotheses H1, H2a and H2b were tested on both a linear and quadratic regression. The regression that explained most of the variance after controlling was used to explain the relationship. The last hypothesis proposes a moderation effect, to test this an interaction term between general servitization and PLC-length was computed.

4. Results

This section summarizes the results of the statistical analyses and mentions whether the constructed hypotheses are supported.

4.1 Descriptive statistics

Table 3 provides the mean and standard deviations of all the study variables which are subsequently followed by their Pearson correlations with other study variables. Since the number of employees and sales revenue are not significantly correlated with EBITDA margin, these variables are not controlled for in the regression analyses. As expected, the average industry EBITDA margin is significantly correlated to EBITDA margin. Therefore, this variable will be included as a control variable within the regression analyses.

Table 3. Correlation table

	M	*SD*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1.EBITDA margin	13.15	9.49	-							
2.PO-servitization	13.6	17.93	-.063	-						
3.CO-servitization	7.47	8.27	-.005	.285**	-					
4. Gen-servitization	17.43	17.29	-.068	.922**	.569**	-				
5. PLC-length	16.14	1.07	-.124**	.068	-.187**	-.006	-			
6. Employees	42.12	75.50	.01	-.11**	.183	-.039	.02	-		
7. Sales revenue	19672.72	41559.98	-.012	-.196**	.206	-.120**	-.023	.904**	-	
8. Ind. EBITDA mrgn	15.7	7.35	.278**	.097**	.120**	.149**	-.521**	-.188**	-.189**	-

Note that N=614, except for CO-servitization N=314. ** p < .01, * p < .05 (two-tailed)

Table 4 presents the mean, standard deviations, skewness and kurtosis for all variables that will be used in the regression analyses of this study. This indicates whether these variables are normally distributed. According to the general rule of thumb that skewness is >-1 and < 1 it could be concluded that only EBITDA margin is normally distributed. The mean of the EBITDA margin is 13.15 (SD=9.49), which indicates that on average firms had a profitability of 13.15%.

All three servitization variables have high skewness values of above 1. This means that these variables have a long tail on the right. This is explained by the fact that service ratios have a barrier of 0 on the left-side, which is why the left-tail could not be extended. The mean of PO-servitization is 13.6 (SD=17.93) indicating that the manufacturing firms in the sample had on average 13.1% of revenues coming from PO-services. The mean of CO-servitization is 7.47 (SD=8.27) indicating that the manufacturing firms in the sample (*N=314*) had on average

7.47% of revenues coming from CO-services. The mean of general servitization is 17.43 (SD=17.29) indicating that the manufacturing firms in the sample had on average 17.43% of revenues coming from services.

PLC-length has a high negative skewness value of above -1. This indicates that this variable has a long tail on the left. This finding could be explained, because PLC-length is based on patents granted in 2000. Therefore, it never extends 20 years, which results on a barrier on the right side of the distribution. The mean PLC-length is 16.14 years (SD=1.07) indicating that in the sample a technology lasts on average 16.14 years before becoming obsolete.

The average industry EBITDA margin is based on all firms in a particular industry, thus not restricted to the study's sample. Apparently, the average EBITDA margin of all industry-year combinations is heavily skewed to the right. This variable does not have a barrier on the left since it allows for industries to have negative EBITDA margins. Looking more specifically at the data, it seems that especially the prepackaged software industry (SIC-code 7372) has high EBITDA margins. This may be explained by the low volume of tangible assets which allows for high profitability margins. The mean of the industry EBITDA margin is 15.7% (SD=7.35). This indicates that all firms in all eleven industries have a profitability of 15.7%.

Although the high skewness values of the variables could be explained, it still limits the reliability of the regression results since regression analyses are based upon an assumption of normality.

Table 4. Distribution of study's variables

	M	*SD*	*Skewness*	*Kurtosis*
EBITDA margon	13.15	9.49	.246	.724
PO-servitization	13.6	17.93	1.401	1.267
CO-servitization	7.47	8.27	1.828	.138
Gen-servitization	17.43	17.29	1.231	.930
PLC-Length	16.14	1.07	-1.183	.152
Ind. EBITDA margin	15.7	7.35	1.099	-.009

Note that N=614, except for CO-servitization N=314.

4.2 Regression analyses

In Table 5 the linear hierarchical regression results between general servitization and firm performance are indicated. This relationship is not reflected in the hypotheses because it would just add to the broad range of inconsistent studies trying to depict this relationship. However, understanding the relationship between general servitization and firm performance in this study, indicates if PO- and CO- servitization in different lifecycle contexts differ from the general servitization-performance relationship. Further, it indicates how the interaction term in hypothesis 3 between servitization and PLC-length changes this relationship.

In the second model of table 5, the general servitization variable indicates that servitization has a significant negative relationship with firm performance when controlling for industry EBITDA margin (ß = -.112 $p < .05$). This model explains unique variance with ΔR_2=.021 (p<.05).

Table 5. Linear hierarchical regression without lifecycle context

Model	*B*	*SE B*	*ß*	*p*
Step 1				
Ind. EBITDA margin	.359	.050	.278	.000
Step 2				
Ind. EBITDA margin	.381	.050	.295	.000
Gen-servitization	.061	.021	-.112	.004
Step 3				
Ind. Ebitda margin	.369	.051	.286	.000
PO-servitization	.034	.063	.062	.590
SQRD_Gen-servitization	-.002	.001	-.183	.107

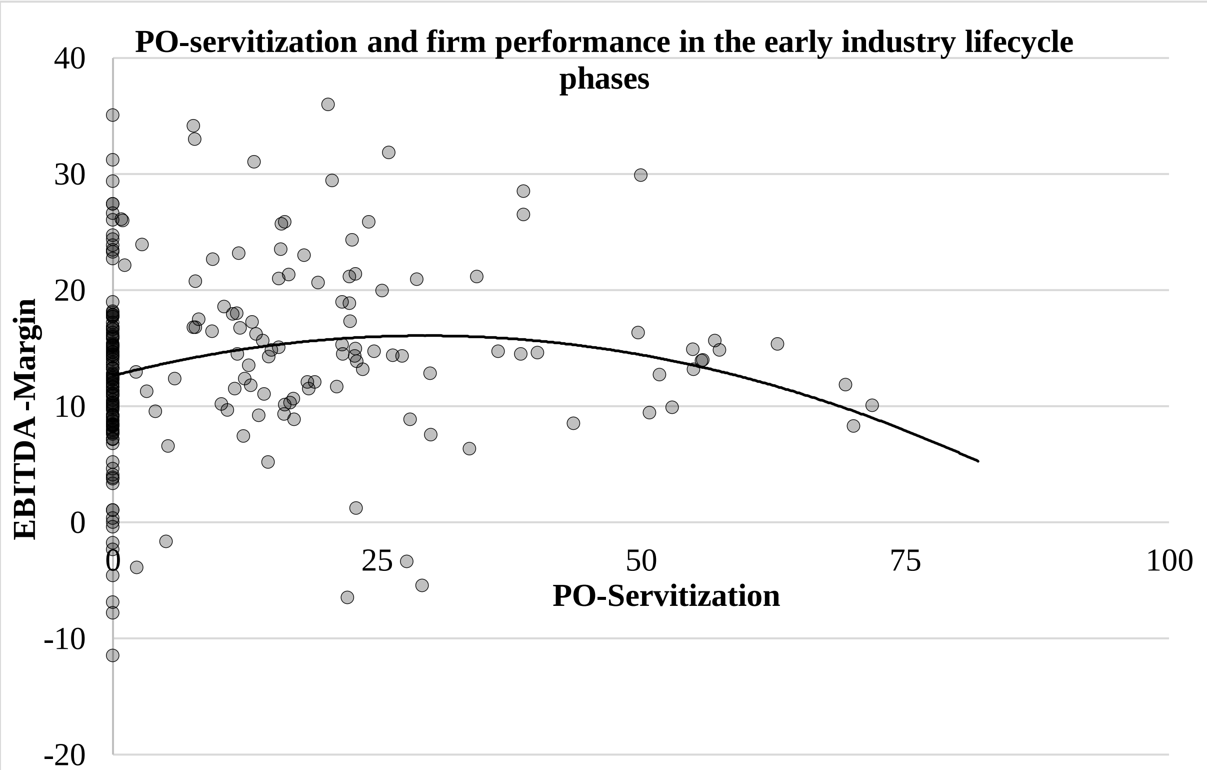
Note. R_2=.076 step 1; ΔR_2=.012 (p<.05) step 2; ΔR_2=.004 (p>.05) step 3

In table 6 the linear hierarchical regression results for hypothesis H1 are presented. Hypothesis H1 of this study is: *product-oriented servitization has a significant inverted U-shape relationship to firm performance in the early phases of the industry lifecycle*. In model 3 the squared PO-servitization variable indicates that such a relationship is existent and significant when controlling for industry EBITDA margin and linear PO-servitization (ß = -.399, $p < .05$). This model explains unique variance with ΔR_2=.021 (p<.05). Therefore, hypothesis H1 is supported. To better understand this relationship figure 2 presents the scatterplot and curvilinear regression line. This line indicates that PO-servitization is positively related to firm performance until it represents about 30% of total revenues, after which the relationship turns negative.

Table 6. Linear hierarchical regression within the early lifecycle phases

Model	*B*	*SE B*	*ß*	*p*
Step 1				
Ind. EBITDA margin	.137	.088	.105	.119
Step 2				
Ind. EBITDA margin	.130	.088	.099	.143
PO-servitization	.029	.033	.059	.380
Step 3				
Ind. Ebitda margin	.086	.090	.066	.337
PO-servitization	.212	.090	.433	.020
SQRD_PO-servitization	-.004	.002	-.399	.031
	Note. R^2=.011 step 1; ΔR^2=.003 (p>.05) step 2; ΔR^2=.021 (p<.05) step 3			

Figure 2.



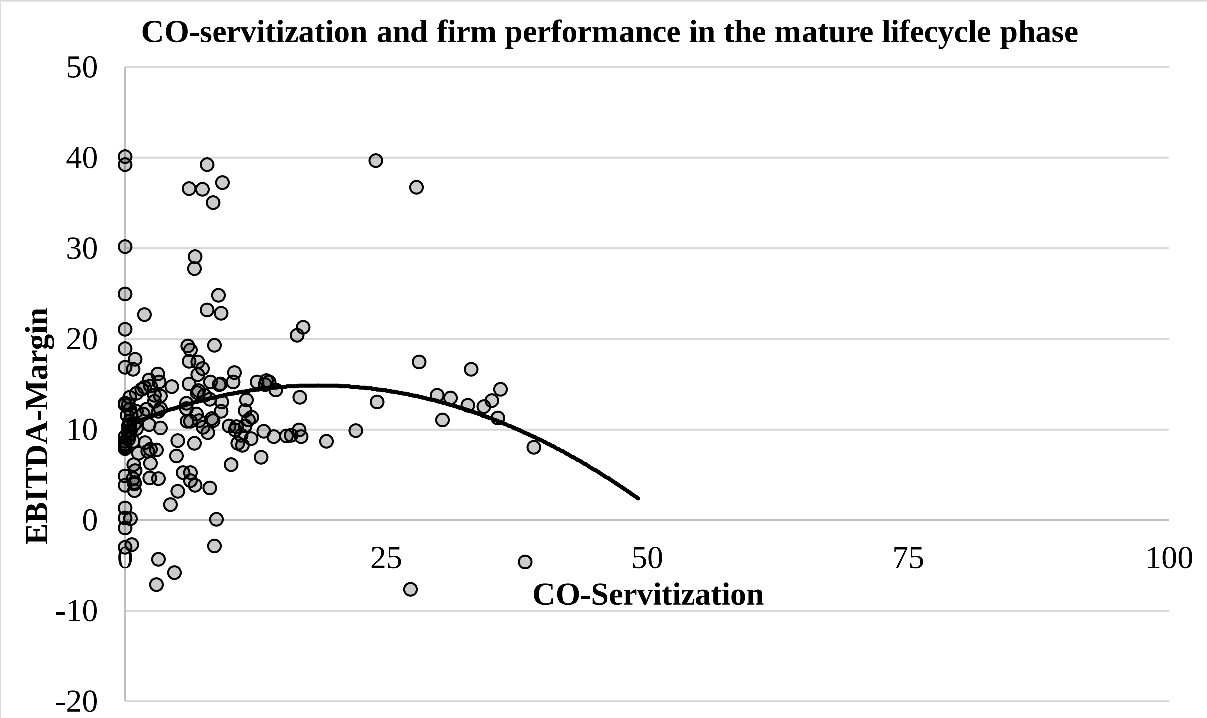
In table 7 the linear hierarchical regression results for hypothesis H2a and H2b are presented. Hypothesis H2a of this study is: *product-oriented servitization has a significant negative relationship to firm performance in the mature phase of the industry lifecycle*. In model 2 of the upper part of the table, the PO-servitization variable indicates that such a relationship is existent and significant when controlling for industry EBITDA margin ($ß = -.148$, $p < .05$). This model explains unique variance with ΔR^2=.022 ($p<.05$). Therefore, hypothesis H2a is supported. An important side note is that the standardized beta coefficient is smaller than in the general relationship between servitization and firm performance (ß = -.148 < B= -.112). This indicates that PO-servitization in the mature phase has a stronger negative relationship with firm performance than servitization in general.

Hypothesis H2b of this study is: *customer-oriented servitization has a significant inverted U-shape relationship to firm performance in the mature phase of the industry lifecycle*. In model 3 of the bottom part of the table, the squared CO-servitization variable indicates that such a relationship is existent and significant when controlling for industry EBITDA margin and linear CO-servitization (ß = -.457, p <.05). This model explains unique variance with ΔR^2=.024 (p<.05). Therefore, hypothesis H2b is supported. To better understand this relationship figure 2 presents the scatterplot and curvilinear regression line. This line indicates that CO-servitization is positively related to firm performance until it represents about 20% of total revenues, after which the relationship turns negative.

Table 7. Linear hierarchical regression within the mature lifecycle phase

Model	*B*	*SE B*	*ß*	p
Step 1				
Ind. EBITDA margin	.436	.061	.339	.000
Step 2				
Ind. EBITDA margin	.455	.061	.354	.000
PO-servitization	.081	.026	-.148	.002
Step 3				
Ind. Ebitda margin	.449	.061	.350	.000
PO-servitization	.016	.072	-.030	.822
SQRD_PO-servitization	-.001	.001	-.126	.339
	Note. R^2=.115 step 1;	ΔR^2=.022 (p<.05) step 2;	ΔR^2=.002 (p>.05) step 3	
Step 1				
Ind. EBITDA margin	.365	.090	.295	.000
Step 2				
Ind. EBITDA margin	.374	.096	.302	.000
CO-servitization	-.021	.074	-.022	.773
Step 3				
Ind. EBITDA margin	.372	.095	.300	.000
CO-servitization	.388	.203	.408	.058
SQRD_CO-servitization	-.013	.006	-.457	.032
	Note. R^2=.087 step 1;	ΔR^2=.000 (p>.05) step 2;	ΔR^2=.024 (p<.05) step 3	

Figure 3.



In table 8 the moderated regression results for hypothesis H3 are presented. Hypothesis H3 of this study is: *the relationship between general servitization and firm performance is negatively moderated by the average length of product lifecycles within a firm's industry, in such way that firm performance positively increases when product lifecycle lengths are short.* The interaction variable between servitization and PLC-length indicates that such a relationship is not significant when controlling for industry EBITDA margin (ß = -.004, p > .05). Therefore, hypothesis H3 is rejected.

Table 9 presents an overview of all the hypotheses and indicate whether they are supported by the study's findings.

Table 8. Moderated regression results without lifecycle context

	EBITDA margin		
	ß	*SE*	*p*
Ind. EBITDA margin	.117	.068	.882
Gen-servitization	-.059	.390	.882
PLC_length	-.538	.496	.279
Gen-servitization x PLC-lentgth	-.004	.024	.859
	Note. R_2=.022 (p<.05)		

Table 9. Hypothesis testing

Hypothesis	*Description*	*Supported/ Rejected*
H1	Inverted U-shape relationship between PO-servitization and firm performance in early industry lifecycle phases	Supported
H2a	Negative relationship between PO-servitization and firm performance in the mature industry lifecycle phase	Supported
H2b	Inverted U-shape relationship between CO-servitization and firm performance in the mature industry lifecycle phase	Supported
H3	Negative moderation effect by PLC-length on the relationship between general servitization and firm performance	Rejected

5. Discussion & conclusion

The research goal of this study was: *to understand the relationship between servitization and firm performance within different lifecycle contexts*. This study yields that the success of servitization is contingent upon three aspects:

- the types of *service offerings*, in combination with
- the *industry lifecycle phase* and
- the *ratio of services* compared to the product business.

When manufacturers offer services in the right industry lifecycle phase and do not overextend, servitization has positive performance implications. Furthermore, a conclusion is that, the benefits of servitization are not influenced by PLC-length. This means that the servitization-performance relationship does not increase nor decrease based upon the frequency of technological disruptions within the product market.

5.1 Theoretical contributions

This study includes contributions to different strategic management and marketing themes within servitization literature, and also adds to innovation, lifecycle and business model literature.

First, this study contributes to the servitization literature on service performance that servitization is not only effective in the mature industry lifecycle phase but also in earlier phases. However, this is only true for PO-servitization aiming to complement the product business. This is substantiated by the finding that PO-servitization has positive performance implications for manufacturers, but only if the product business remains the most substantial part of the firm in terms of revenues (30-70%). This supports the recent articles of Cusumano et al (2015) and Visjnic et al (2019) stating that PO-servitization in the early lifecycle phase helps manufacturers in finding a dominant product design and decreasing customer uncertainty. This also adds to the innovation literature by finding evidence for Teece's (1986) argument that services function as complementary assets in the early industry lifecycle to capture the value of new technologies.

Second, this study resolves an ongoing debate in servitization literature regarding service performance. On one side, it contradicts Fang et al (2008) and Benedetinni et al (2015) who argue that PO-servitization is superior to CO-servitization due to synergies with the product business. On the other side, it contradicts Mathieu (2001) and Wang et al (2018) who argue that CO-servitization is superior to PO-servitization because of the development of advanced service capabilities. The truth is, based upon findings that PO-servitization only has positive performance implications in the early industry lifecycle phases and CO-servitization only in the mature phase, that performance implications of both servitization types are contingent upon industry lifecycle context. This also adds to the lifecycle literature that focuses on firm strategies (Klepper, 1997; Utterback & Suarez, 1993).

Third, this study builds on the work of Cusumano et al (2006) and Matthieu (2001b) in servitization literature regarding service offerings. This literature establishes that CO-servitization promotes adoption of the product and functions as a differentiation mechanism in maturing industries. This study endorses this argument, because CO-servitization has positive performance implications when product markets mature. This implies that CO-services are able to decrease the buying reluctance of late adopters and stabilize revenue streams in stagnating product markets through economies of scope. Further, this study identifies that performance benefits of CO-servitization in the mature phase decline after CO-servitization reaches a certain extend of product revenues (20-80%). This is in contrast with servitization literature on service evolution and service transition that perceives servitization as a gradual transition into a service-dominant business (Olivia & Kallenberg, 2003; Wang et al, 2018), but is in line with Fang et al (2008) and Kowalkowski et al (2017), who argue that manufacturers are unable to shift into a service-dominant business due to competition of regular service firms and difficulties with succeeding in organizational change (Fang et al, 2008; Kowalkowski et al, 2017).

Fourth, this study's findings are somewhat inconsistent with the predictions on open service innovation by Chesbrough (2011) in business model literature. As this study establishes that servitization has no benefits in industries with short PLC-length, it indicates that PO- and CO-servitization do not gain enough relevant information about changing market demands to sense technological discontinuities. On the other side, due to the fact that PO-servitization is effective in the early industry lifecycle phase, that is characterized by product innovations, it could be concluded that the sensing benefits of PO-servitization do contribute to more incremental product innovations. This part supports Chesbrough (2011) and earlier studies in the service performance literature that discovered that PO-services are effective in industries with high R&D intensity (Visjnic et al, 2019; Fang et al, 2008; Eggert et al, 2015).

5.2 Practical implications

Managers of manufacturing firms should carefully consider the suitability of their service offerings within the context of their industry. They should take into account factors as complementarities with the product business, differentiation effects, imitations risks and knowledge generation.

First, in the early phases of the industry lifecycle managers may consider offering PO-services that adapt the product to specific customer wishes (e.g. customization). This reduces customer uncertainty regarding the new technology and spurs incremental product innovations. Imitation risks are low, because these types of services require both service capabilities and product knowledge. However, these managers should be careful not to overextend in these services as this would diminish the synergistic effects with the product. CO-services are useless in this phase because differentiation would hamper the potential growth in product revenues.

Second, in the mature phase of the industry lifecycle managers may consider offering CO-services in order to promote the adoption of the product. This would provide them with an advantage over other manufacturers that are competing on costs. These manufacturers are often unable to imitate these CO-services as they require advanced service capabilities. However, manufacturers should be aware that CO-services are mostly effective because it exploits the product business's client base, but they are unable to transition into a service-dominant business in which CO-services have to outperform regular service firms independently. PO-services have negative performance implications in this phase as the demand for product reliability decreases and risk of imitation increases due to publicly available product knowledge.

5.3 Limitations and future research

This research had some limitations that should be noted when interpreting the results.

First, most of this study's data came from Compustat Business Segments and Compustat Financial Fundamentals. The use of these databases leads to certain selection biases. Not all service activities are reported as independent revenues. Many firms include these in the product price or do not report their service revenues separately from product revenues. In line with previous research, this research accounts for this selection bias by only including companies that report service activities at least once between 2011-2018. However, it may still be the case that some service activities of manufacturers are not reflected in the data. Further, Compustat databases only provide data on firms listed on North American stock exchanges. In general, firms listed on these stock exchanges belong to the largest on the globe. This could have influenced the servitization-performance relationship. Since, larger firms are better able to cover the risks related to the high servitization investments but are less able to quickly react to service opportunities in the market (Dachs et al, 2014). Furthermore, firms listed on North American stock exchanges mostly operate in emergent countries. The availability of knowledge and infrastructure in these countries are on a high level, these characteristics enable servitization (Szasz et al, 2017). Therefore, this study's insights do not account for firms operating in emerging countries.

Second, the data available in Compustat Business Segments only allows to make a relatively broad distinction between two service types. Within these two types there are still performance differences between specific kinds of services. For example, maintenance and implementation are both PO-services, but maintenance requires frequent client interactions and implementation occurs only short after the product is sold. Therefore, maintenance services are expected to generate more information about the product during use and thus may have increased benefits for incremental product innovations.

Third, although regression analyses in this study controlled for certain industry differences, it could still be that servitization is more effective in one industry compared to another. For example, customers of large airplanes might have a greater demand for maintenance than customers of pharmaceutics, as airplanes are operated for a longer time. Therefore, the results could the servitization-performance relationship could be positively influenced because the study includes more cases from the aircraft industry. In addition, the industry lifecycle context was based upon the decline or growth of the active number of firms in an industry. The subsequent interpretations of this measure are based upon the assumption that all industries evolve in a regular fashion (Klepper, 1997), but there might be industry specific differences in the evolvement of the lifecycle. Furthermore, industry lifecycle was based upon a dummy variable that did not account for certain strengths in growth and maturity.

Fourth, the measure of PLC-length, based on the industry's average forward patent citation lag, is subject to certain limitations. Patents are not the only way to protect the intellectual property underlying product innovations. Therefore, firms in some industries are less likely to apply for patents as opposed to others (Pisano & Teece, 2007). This limits the reliability of the results as technology obsolescence in this measure is based on the discontinuity of patent citations. For that reason, industries in which patents are applied less frequently may unjustifiably be considered as having shorter PLC-length, because the remaining relevance of inventions is not always captured in subsequent patens. Further, due to time limitations, only patents that were granted in 2000 are captured in this measure. This may influence the results, because the frequency of technological disruptions may have increased or decreased after this time. For example, the telephone apparatus industry has had a major technological shift after the introduction of the smart phone in 2007. Such a drastic change might have made many telephone inventions in 2000 obsolete, this would shorten the PLC-length drastically while in practice the frequency of technological disruptions may be average.

Fifth, the relationship between servitization and firm performance was tested based on servitization extend in terms of revenue, but not on the servitization length in terms of time. It might be the case that the real benefits from fully transitioning into a service-dominant business starts to pay-off only after several years of servitization. This is because the development of service capabilities might require several years of optimization before delivering positive results (Fang et al, 2008). This study does not account for such overtime learning effects.

Sixth, there were a couple of difficulties during the operationalization of this study that could not be restored. The firms in the Pre-packaged software industry were not included in the sample of the last hypothesis. This is because software cannot be patented, therefore for firms in this industry the PLC-length could not be calculated. Lastly, many measures had high skewness values due to barriers on the left or right side of the distribution, this decreases the reliability of regression analyses.

Based on these limitations, I propose certain avenues for future research that would contribute to the understanding of the servitization-performance relationship.

Due to the shortcomings of Compustat databases, future researchers might consider creating a large sample survey for manufacturers that provides detailed information on the kinds of services they offer. With these data researchers could examine the performance implications of more specific service categories and be more certain that no service activities are missing in the data. A survey is also less subject to the risk of selection biases in firm size, because it is not restricted to publicly listed firms. Further, this same survey could be sent out to firms in emerging countries to discover the performance effects of servitization there.

To account for within industry differences future researchers might consider performing case studies on firms within one industry. The combination of these researches would provide insights about the different effects of servitization across industries, which may help to discover more detailed industry antecedents in the servitization-performance relationship.

Since this study was a first to apply the PLC-length measure in servitization literature, it would be useful if future researchers apply different measures for this variable. This would provide more clarity on the effectiveness of servitization in sensing technological disruptions. For example, a measure could be to analyze the cyclicality of R&D investments within an industry, because technological disruptions re-start the industry lifecycle which causes a need for product innovations (Anderson & Tushman, 1986; Utterback & Abernathy, 1975). A focus on product innovations would cause a peak in R&D investments. Therefore, when an industry is characterized with high R&D cyclicality, it indicates that technological disruptions occur relatively frequently.

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Appendix I: PO- and CO-service segments SIC-codes

PO-services	CO-services
7389*	6512
8742 *	5169
4011	6794
8711	5961
4911	5122
7699	4731
7629	6552
7359	4449
7379*	7011
7375	4210
7378	6141
7373	6153
4813	6150
4899	5083
5013	6159
7353	6411
4812	5049
4581	5088
8092	6799
	6159
	6141
	5045

*Depended on the segment name given by the firm itself

Appendix II: Description of variables in dataset

Variable name SPSS	**Description**
ID	The number of a case (firm-year combination)
conm	Company name
sic	Sic-code of firm's core product
gvkey	Code for company identification
Year	Fiscal year
Product_Srev	Product sales revenue
PO_servRev	Product-oriented service revenue
CO_servRev	Customer-oriented service revenue
EBITDA	Total EBITDA
EMPL	Number of Employees in thousands
Tot_Rev	Total revenue
Tot_Srev	Total sales revenue
Act_F_Ind	Active number of firms in industry
Diff_Act_F_IND	Growth or decline in active firms of industry compared to the previous year
PLC_Length	Product lifecycle lenght
AvgIND_EBITDAmargn	Average Industry Ebitda margin
Gen_servitization	Service ratio
PO_servitization	Product-oriented service ratio
CO_servitization	Customer-oriented service ratio
DummyCOserv	Dummy customer-oriented service ratio
Ebitda_Mrgn	Ebitda margin
IND_maturity_Mrgn	Industries average EBITDA margin
DummyMaturity	Indication of mature and early industries
CO_SQRDservitization	Squared service ratio of customer-oriented servitization
PO_SQRDservitization	Squared service ratio of product-oriented servitization
Gen_SQRDservitization	Squared service ratio of general servitization