Exploring the impact of internal and external sources of information on servitization at small and medium-sized manufacturing firms

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1 Introduction

During the 1990s the world economy was undergoing a substantial change in its nature, driven by either the globalization of business and the increasing availability and applicability of information and communication technologies. Many academics agree that the world economy is in the middle of a revolution towards the "New Economy" (Pohjola, 2002). Traditional production techniques and the management of traditional organizational resources (land, labor and capital) became obsolete. The new economy is predominantly led by the generation and management of knowledge. Nonaka (1994) became very popular with his framework on knowledge creation and impacted managerial thinking on how organizations create and deliver value. The acknowledgement of a rising new economy generated much interest from academics and subsequently led to the development of the knowledge-based view of the firm. This view is based on the growing accumulation and availability of information in the last two decades that plays an important role in the postindustrial "new economy". There are several characteristics of this new economy, as it is focused on: intangibles rather than tangibles; a shift towards providing services rather than offering goods; interconnectivity through communication media which results in networks of organizations and people; digitization and digitalization of information; the transition from real to virtual work; and rapid technological changes (Choo & Bontis, 2002).

Knowledge is seen as the main driver of innovation. Nonaka (1994, p. 15) states that knowledge is "created and organized by the very flow of information", while information is "a flow of messages". The assumption is made that information can come from a wide variety of sources, both internal and external. For example, information can come from employees and their experiences and skills. However, internal sources of information are often not enough, which motivates firms to seek external sources of new information to bring into the firm (Mol and Birkinshaw, 2009). External sources can provide useful information that is not yet available within the firm. This led to a growing interest in service provision and new service development rather than product manufacturing. It is argued that western economies depend more on service provision than manufacturing (Nijssen et al., 2006). However, according to Meyer and DeTore (2001), despite this trend research on innovation is still dominated by product innovation rather than service innovation.

The term "servitization" was introduced in literature by Vandermerwe and Rada (1988). Since the introduction of servitization, there has been a fundamental change in the way many manufacturing firms create value. Physical products are often reduced to just a part of the

offering (Oliva & Kallenberg, 2003) in which services are integrated as value-added activities (Gebauer, Friedli, & Fleisch, 2006). This means that servitization is not merely about providing services to customers, but companies have to think about the combinations of products and services that create value for customers by addressing their needs. This has an impact on the strategies of many manufacturing firms, that has traditionally been focused on products (Tan et al., 2010). This focus is, at least partly, shifting from products to customers. The "product-service continuum" is often being used in academic research (Oliva and Kallenberg, 2003; Gebauer & Friedli, 2005; Kowalkowski et al., 2015) to identify the forms of servitization. Based hereon, this study distinguishes two types of services. First, product-oriented services relate to the business logic that has traditionally prevailed in manufacturing firms, namely that economic value is created in products through industrial processes and exchanged in a transactional manner. Vargo and Lusch (2004) in Kowalkowski (2010) refer to this logic as the goods-dominant logic. In contrast, service-dominant logic refers to the provision of relational services and solutions. According to Kowalkowski (2010, pp. 229-230), within this logic "goods are seen as distribution mechanisms for service provision. Furthermore, the value of goods is based on their value-in-use and determined by the customer, which clearly goes beyond conventional value-in-exchange (i.e. market value, price)." He argues that an emphasis on value-in-use helps with the development of new business models. Examples are outcome-based contracts where suppliers and customers have to determine the potential productivity gains over time. This refers to the second type of services in this study, namely business model-oriented services.

Further, although servitization does not necessarily relate to digitalization, it has recently been linked in research (Luz Martín-Peña, Díaz-Garrido, & Sánchez-López, 2018; Kohtamäki et al., 2020). Digital servitization focuses on the interplay between digitalization and servitization as a new way to create value. This topic is fairly new in academic research and thus little is known about the interplay between the two. Questions have been raised about the profitability of digitalization investments, as digitalization seems to have a serious impact on manufacturing firms but the nature of this impact is still unclear. Manufacturing firms, especially SMEs, are faced with difficult challenges on creating or adding value through digitalization investments (Ehret & Wirtz, 2017), also described as the digitalization paradox.

1.1 Research question

The aim of this study is to gain insights in how information sources affect servitization in manufacturing SMEs and to examine the role of digital solutions in this relationship. In the manufacturing industry, market pressure is forcing firms to innovate and introduce new

products and services to distinguish themselves. Especially for SMEs it is impossible to rely on internal sources of information only. As a result, they are engaging in external cooperation projects more than ever (Eriksson, 2005 in Svetina & Prodan, 2008). Damanpour, Sanchez-Henriquez and Chiu (2018) studied the relevance of internal and external information sources on managerial innovations and concluded that information from external sources (customers, experts and users) assists leaders to identify needs, opportunities and problems. Additionally, they mention the constructive role that employees can have in innovation processes. Svetina and Prodan (2008, p. 291) conclude that "in-house learning is crucial for firms' innovation performance; however, interactive learning outside the firm also significantly contributes to innovativeness." So, more specifically, the aim of this study is to gain insights into the impact of internal and external sources of information on the amount of product-oriented services and business model-oriented services offered by manufacturing SMEs. This leaves us with the following research question:

- *To what extent do internal and external sources of information at manufacturing firms have an impact on the amount of product-oriented services and business model-oriented services that they offer?*

Further, this study examines the role of digital solutions in providing services and acquiring information, which leads to an additional question:

- *To what extent do digital solutions assist in the collection of information?*

This study is organized as follows: insights into servitization, the product-service continuum and theoretical perspectives on digital servitization are presented in the second chapter. This is followed up by theoretical perspectives on information sources at manufacturing firms and the proposition of hypotheses in the third chapter. The fourth chapter presents the methodology of mixed methods, the data sample and data collection of the quantitative and qualitative approach and the insights into the validity and reliability of this study. The results are distinguished into a quantitative and qualitative section and in the end brought together to complement their theoretical insights in chapter five. Last, chapter six summarizes the results and provides a discussion on theoretical and practical implications, limitations and an ethical reflection.

2 Servitization

Manufacturing firms started to find alternative ways to create value since the development of a new economy in which knowledge predominates. It became more and more difficult to create and sustain competitive advantages through products. Manufacturing firms started to provide services in addition to their physical products as a new strategy to gain competitive advantages. Integrated product-service offerings are unique, durable and easier to defend from competition in low cost economies, in which manufacturing firms often find themselves (Baines et al., 2009). The common view in literature is that services are intangible offerings that are performed, in contrast to physical products that are being produced. In the late 1980s, Vandermerwe and Rada (1988) introduced the term "servitization". They define servitization as "the increased offering of fuller market packages or 'bundles' of customer-focussed combinations of goods, services, support, self-service and knowledge." Vandermerwe and Rada (1988, p. 314) Hereafter, many other academics studied the concept of adding service components to physical products, sometimes through different terminology such as product-service systems (PSS). For example, Baines et al. (2007) describe a PSS as a combination of products and services that deliver value in use. According to Baines et al. (2009, p. 555) servitization is "the innovation of an organisations capabilities and processes to better create mutual value through a shift from selling products to selling PSS."

Before servitization became a popular term in academic literature, managers of manufacturing firms tended to perceive the provision of services as a necessity and definitely not as a core offering. Value creation in manufacturing firms came from the production of physical products, in which services were only seen as add-ons (Gebauer & Friedli, 2005). This is also referred to as the goods-dominant logic by Vargo and Lusch (2004), in which the purpose of economic activity is to produce and deliver goods that can be sold. The steep increase in availability of information and knowledge changed this perception. Offering services has become an explicit strategy in which most value is created through services, not products anymore. Products are becoming the add-ons for services. In the last decades, several leading manufacturing firms (e.g. General Electric, IBM, Toyota Industries and Xerox) have made a business model transition from traditional product sales to offering services and solutions as a partner (Kowalkowski, 2010). This transition is also called service infusion (Gebauer & Friedli, 2005; Mathieu, 2001; Oliva & Kallenberg, 2003).

Although there are many successful transitions from purely manufacturing firms to firms that offers solutions, a lot of firms fail to grasp the benefits of adding services to their

value proposition, referred to as servitization failure. To explain this failure, Valtakoski (2017) emphasizes the dyadic nature of servitization in which both the manufacturers and their customers play an important role. Manufacturers may fail to create sufficient value for the customer due to a lack of customer orientation or failing to understand or transfer customer knowledge.

2.1 Product-service continuum

Oliva and Kallenberg (2003) applied the product-service continuum (introduced by Chase (1981)) to identify to what extent firms deliver value through products and services. Oliva and Kallenberg (2003) suggested two elements to explain the transition along the continuum. The first element relates to the focus of customer interaction ranging from transaction-based to relationship-based. Provision of advanced services is made possible through relationship-based interaction rather than transaction-based. However, relationship-based interaction often creates the need for different contract forms that, at first sight, are generally not so appealing for customers. Time and effort is needed to establish an ongoing relationship with customers in order to provide advanced services (Oliva & Kallenberg, 2003). The second element refers to the services itself. Service offerings can range from product-oriented services to "user's processes-oriented services" (i.e. pursuing efficiency and effectiveness of end-user's processes related to the product (Baines et al, 2009)).

Firms are positioned at the one extreme (left) of the continuum when their value offering derives mostly from physical products. Those firms provide services merely as add-ons (e.g. documentation, transport, maintenance, repairs, updates). A characteristic of those firms is the focus on transaction-based interaction with customers, where services are product-oriented. Frank et al. (2019, p. 342) uses a categorization of services by Cusumano et al. (2015) and refer to these services as smoothing services that "facilitate the product sale or usage without significantly altering the product functionality". These services are most accessible for manufacturing firms. In this study both these services are referred to as *product-oriented services*. The development of new product-oriented services and the adoption can be considered incremental change for manufacturing firms. According to Gallouj and Weinstein (1997), incremental service innovation is seen as new services with few changes to existing characteristics. For example, employees would not have to drastically change their knowledge and competencies. Also, operational routines would not have to be redeveloped in order to provide the product-oriented service. Norman and Verganti (2014, p. 82) describe incremental innovation as "improvements within a given frame of solutions (i.e. 'doing better what we

already do')." Manufacturing firms are often specialized in manufacturing their own products. Product-oriented service are closely related to their specialization and do not need radical changes in their business model or knowledge. As mentioned, the services are merely add-ons to products (goods-dominant logic).

At the other extreme (right) of the continuum are firms that deliver value mostly through the provision of services, where products are the add-ons. The communication with customers is less focused on transactions, while there is an increasing focus on creating and retaining strong relationships with customers. The relationship changes from being supplier and customer to being partners. Services change accordingly from product-oriented to an orientation towards customers' processes. A general characteristic of these services is that the services are offered through the entire product life cycle instead of services related to the installation of a product. These product-service combinations are often more profitable (Frambach, Wels-Lips, & Gündlach, 1997), less sensitive to price-based competition (Malleret, 2006) and more difficult to imitate (Oliva & Kallenberg, 2003). Kowalkowski (2010) uses theory from Vargo and Lusch (2004) to refer to this side of the continuum as service-dominant logic. In this logic, Kowalkowski (2010) describes a shift in focus from value exchange towards value-in-use. This means that manufacturing firms capture value in the utilization of products instead of production. "The function of goods is to deliver service." (Kowalkowski, 2010, p. 230) This requires manufacturing firms to define the value of utilization of their products and change their way of offering these products. This often takes place in cooperation with customers, because "value is defined by and cocreated with the customer rather than embedded in output" (Vargo & Lusch, 2004, p. 6). Manufacturing firms should learn customers' needs and be adaptive to it. The service-dominant logic requires manufacturing firms to develop new business models. For manufacturing firms this can be described as a radical change, as it requires major changes to existing characteristics or even new characteristics (knowledge, competences and routines) of the firm (Gallouj & Weinstein, 1997). These services are the least accessible and Frank et al. (2019) refer to them as substituting services. Customers pay for the usage of products and this substitutes the transactional business model of manufacturing firms. This study refers to these business model-service combinations as *business model-oriented services*.

2.2 Digitalization and digital solutions

The terms "Industry 4.0" and "digitalization" have become well-accepted terms in scientific literature (e.g. Hermann, Pentek and Otto, 2015; Oztemel and Gursev, 2020). Kohtamäki et al. (2020, p. 2) refer to the act of digitalization as "digitalization of downstream activities at the

front end of the manufacturing company's value chain, where the company is collecting, warehousing, analyzing, and using market data for improved value co-creation and appropriation." The fourth industrial revolution, as Park and Huh (2018) describe Industry 4.0, is driven by digital technologies such as Cyber-Physical Systems and the Internet of Things and Services in industrial manufacturing (Stentoft et al., 2019). Academic researchers are exploring the impact of Industry 4.0 and digitalization on all sorts of research fields, such as servitization (Luz Martín-Peña, Díaz-Garrido, & Sánchez-López, 2018; Lenka, Parida, & Wincent, 2016), business model innovation (Müller, Buliga, & Voigt, 2018; Ibarra, Ganzarain, & Igartua, 2018) and supply chain management (Seyedghorban et al., 2019; Hahn, 2020).

Industry 4.0 is a term created in 2011 in Germany to strengthen the competitiveness of the German manufacturing industry (Hermann, Pentek, & Otto, 2015) and has since gained much interest from both the academic literature and the manufacturing industry. This interest is driven by the idea that technologies related to Industry 4.0 can play an important role for manufacturing firms in creating value for their customers. Based on a report from McKinsey (2015), Industry 4.0 is driven by four technological disruptions: big data, advanced analytics, human-machine interfaces and digital-to-physical transfer. McKinsey (2015) state that only 48% of manufacturing leaders think they are ready for the fourth industrial revolution. Issa et al. (2018) mention that less than 20% of manufacturing firms are successfully creating value from digitalization technologies. This is even worse for small and medium-sized enterprises (SMEs), as those seem to struggle with adopting and implementing digitalization technologies (Stentoft et al., 2019).

Although there are many practical challenges for manufacturing firms, there is a consensus in literature about the possibility to create value from digitalization technologies (Zangiacomi et al., 2020; Müller, Buliga, & Voigt, 2018; Luz Martín-Peña, Díaz-Garrido, & Sánchez-López, 2018). A method of value creation that is at the core of innovative technologies is servitization (Luz Martín-Peña, Díaz-Garrido, & Sánchez-López, 2018). Kohtamäki et al. (2020) even emphasize that servitization is essential to realize positive financial performance from high investments in digitalization.

Digitalization and servitization have their origin from different research areas. Digitalization originated from engineering and computer science and focused on manufacturing process value, while servitization had its origin in management studies and focused on customer value (Coreynen et al., 2017; Tongur and Engwall, 2014 in Frank et al., 2019). However, connecting the two in scientific research resulted in the agreement that digitalization could assist service provision at manufacturing firms (Ardolino et al., 2017). For instance, Frank et

al. (2019, p. 345) developed a conceptual framework for the connection of digitalization and servitization. They use three categories to determine the level of digitalization at manufacturing firms. First, manual services are services that make use of digital technologies only as support. They are provided manually. Second, digital solutions are provided automatically using moderate levels of digital technologies, such as cloud computing and embedded software. Finally, Industry 4.0 related-services utilize high-tech tools to provide value for the customer, but also for the processes of the manufacturing firm itself. Next, the three categories of services – smooth, adapting and substituting – are used to develop 9 forms of digital solutions. On the bottom left are manual smoothing services with a low level of both digitalization and servitization. Gradually moving to the top right, it ends with the highest level of digital solutions – factory-integrated substituting services. Although it is considered the highest level, manufacturing firms should not always aim for this level. Frank et al. (2019) recommend to align the level of digital solutions with strategic options and the business model. For example, Visnjic, Ringov and Arts (2019) concluded that manufacturing firms often choose for customer-oriented services in environments with high value generation uncertainty (e.g. late stage of the product life cycle), while going for a strategy with product-oriented service provision in environments with high technological uncertainty (e.g. early stage of the product life cycle). Manufacturing firms "do not necessarily follow the product-service continuum. They alternate and offer types of services simultaneously as a response to the challenges and opportunities they face in their industry lifecycle." (Visnjic, Ringov & Arts, 2019, p. 382)

3 A knowledge-based view of servitization

A theory of the firm is needed to understand firms, their existence and their differences. As firms are very complex organizations with many different elements, both internal and external, a variety of theories have been proposed. It is safe to say that the most popular theory of the firm is the resource-based view of the firm (RBV), proposed by Barney (1991) and has since grown to a literature stream on its own. The objective of the RBV is to explain how firms create sustainable competitive advantage through their own resources. Barney (1991, p. 101) describes firm resources as "all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness." He categorizes the resources into physical capital resources, human capital resources and organizational capital resources. However, during the 1990s a new economic environment developed, predominantly led by the generation and management of information and knowledge, instead of its predecessors – land, labor and capital (Bubou & Amadi-Echendu, 2018). In this "new economy" the focus shifted towards the importance of knowledge creation, knowledge sharing and knowledge utilization, mainly driven by innovative technological disruptions such as digitization and digitalization. This theory of the firm is called the knowledge-based view of the firm and recognizes information and knowledge as a productive resource.

Nonaka (1994) is one of the researchers that acknowledges the importance of knowledge in the new economy that is still developing, a "knowledge society". His theory became one of the most cited theories in the knowledge management literature and impacted managerial thinking on innovations in organizations – product innovation, technical innovation, process innovation or organizational innovation. It is important to recognize the difference between information and knowledge, as knowledge relates to human actions. Nonaka (1994, p. 15) describes the difference between information and knowledge as follows: "information is a flow of messages, while knowledge is created and organized by the very flow of information, anchored on the commitment and beliefs of its holder." He then argues that knowledge is created through the conversion between tacit knowledge (e.g. skills, know-how) and explicit knowledge (e.g. information). Thus, firms have to manage their flow of information in a right way in order to refresh and renew their stock of knowledge. Digitalization may support or even enhance the collection and flow of information. Vuori, Helander and Okkonen (2018) mention three domains: (1) information management and refinement performed by computer software, (2) information acquisition and sharing in cooperation through a networked work environment,

and (3) communication. On the one hand, digitalization supports the flow of information and knowledge and provides easier interaction with different kinds of information sources. On the other hand, digitalization may also cause negative effects, for example through information overload, time management challenges and technological shortcomings.

3.1 Information and its sources

In a knowledge-based economy there is an increasing availability of information. From a manufacturer's perspective, this seems both advantageous and disadvantageous. Information is seen as the main ingredient for innovation, so more information would result in more innovation. However, deciding what information should be used and what should be ignored becomes more complicated the more information is available (Varis & Littunen, 2010). Firms should carefully decide what information is valuable for them and examine where that information comes from. According to Svetina and Prodan (2008), sources of information can be divided into internal and external sources.

3.1.1 Internal sources and servitization

For a long time manufacturing firms mostly relied on their internal sources for new information to innovate. Generally, manufacturing firms have several internal sources of information available. For example, Svetina and Prodan (2008) emphasize the importance of in-house research and development (R&D) for new information. Thorpe et al. (2005) researched SMEs and found that internal teams, as well as individual employees, play a crucial role as information sources for innovation. To optimize this, firms often organize education and training programs (Svetina & Prodan, 2008). Additionally, production processes are an important source of information through continuous improvements. The value of internal sources of information is also determined by their absorptive capacity. Cohen and Levinthal (1990) in Svetina and Prodan (2008, p. 282) define absorptive capacity as "the ability to recognize the value of new, external information, assimilate it, and apply it to commercial ends". Valuable internal sources should be able to convert external information into new innovations. Svetina and Prodan (2008) argue that the amount of internal sources of information has a positive effect on the amount of innovations at a firm. In line with this argument, and the statement that the development and provision of product-oriented services can be seen as an incremental innovative transition at manufacturing firms, the following hypothesis is formulated:

H1 *The amount of internal sources of information has a positive impact on the amount of product-oriented services offered at small and medium-sized manufacturing firms.*

It is expected that this effect will not be found at business model-oriented services, because the development and provision of these services is considered a radical change that transcends the nature of manufacturing firms, namely the production of goods. For SMEs it is very difficult to innovate in isolation, and therefore they mostly rely on external sources of information (Pavitt, 1998 in Svetina & Prodan, 2008). However, this is not solely the case for business model-oriented services, but also for the development and provision of product-oriented services. Manufacturing firms have to develop new products and services more frequently and quickly than ever due to competitive pressures. Especially for SMEs, this is impossible to execute with the mere use of internal sources of information. They have to increasingly cooperate in interfirm projects (Eriksson, 2005 in Svetina & Prodan, 2008).

3.1.2 External sources and servitization

Svetina and Prodan (2008) confirm that internal sources are very important for firms in order to innovate. However, the information flow from outside the firm contributes to innovativeness to a large extent too. To a great degree research on innovation is focused on the role of external sources of information (Damanpour, Sanchez-Henriquez & Chiu, 2018), as new information mostly exists outside organizational boundaries and this is often required to innovate (Mol & Birkinshaw, 2009). External sources can provide information where internal sources cannot.

An important external source that is now being recognized in scientific research are the customers (Johansson, Raddats & Witell, 2019). Generally, manufacturing firms interact with customers for a relatively long time, which allows them to generate a lot of information about their customers. This process is referred to as customer knowledge development, where firms gather information about customers' new service preferences (Joshi & Sharma, 2004 in Johansson, Raddats & Witell, 2019). Service provision (e.g. co-engineering and maintenance) can be used as a means to build relationships with customers and gather information from customers due to the prolonged nature of service provision in comparison to product provision. Other useful external sources are suppliers, other firms or even competitors. They can provide useful insights into market requirements, trends, needs and organizational processes. Svetina and Prodan (2008) refer to a study of Keeble et al (1998) to indicate that 76% of firms (in Cambridge region) have close interaction with other firms. However, information not only comes from firms but also be sourced from institutions (e.g. universities, research institutes and

other knowledge institutions). They are able to provide manufacturing firms with scientific research and information in order for the firms to innovate (Svetina & Prodan, 2008).

Damanpour, Sanchez-Henriquez and Chiu (2018) confirmed the finding of Daft (2001) that external sources of information assist managers to identify opportunities or problems in order to fill the needs and wants in the market. As also mentioned above, for small and medium-sized manufacturing firms, it is often not enough to solely rely on internal sources of information. New information that is needed to innovate can be found through external sources, such as customers, suppliers, research institutions and more. Although adoption of product-oriented service is seen as an incremental change for manufacturing firms, it is often not the main activity of these firms to provide services. Product-oriented services closely relate to certain products, but it is expected that external information is still needed to provide the services in a good manner. Moreover, it is expected that multiple external sources may expand the amount of product-oriented services that can be offered. Therefore, this study hypothesizes the following:

H2 *The amount of external sources of information has a positive impact on the amount of product-oriented services offered at small and medium-sized manufacturing firms.*

In addition, it is also expected that multiple external sources may expand the amount of business model-oriented services that can be offered. Adopting these services is seen as a radical change for manufacturing firms because their business model is mainly transaction-based. Manufacturers need information from external sources to gain a deeper understanding of their customers. This allows them to develop appropriate offerings and a corresponding revenue model (Johansson, Raddats & Witell, 2019). This results in the following hypothesis:

H3 *The amount of external sources of information has a positive impact on the amount of business model-oriented services offered at small and medium-sized manufacturing firms.*

3.1.3 Digital solutions as a means

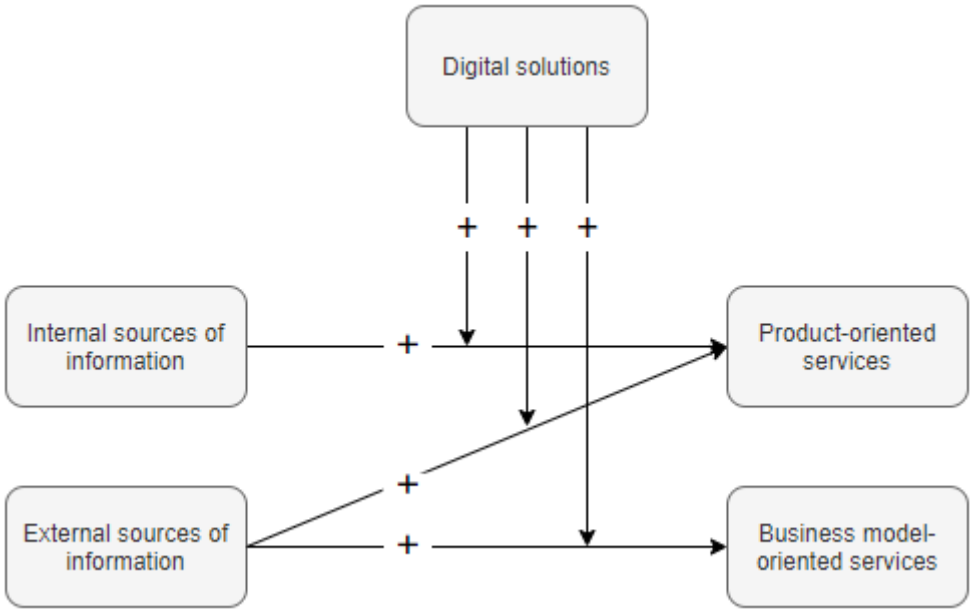
The original purpose of digitalization was to increase the value of internal processes. However, since servitization is brought into the research area of digitalization, new opportunities arose. Frank et al. (2019, p. 343) describe digitalization as "a new industrial maturity stage of product firms, based on the connectivity provided by the industrial Internet of things, where the companies' products and process are interconnected and integrated to achieve higher value for both customers and the companies' internal processes". Digital technologies can increase the

value of services for customers and at the same time serve as a means to gather information from customers. Such digital technologies can be servitized in order to gain a better understanding of customers' processes and therefore their needs and demands (i.e. what value means for them). Digital technologies such as Internet of Things and the analysis of big data allow manufacturing firms to obtain a large amount of information regarding customers' behaviour and product usage (Frank et al., 2019). In other words, it is expected that digital solutions enhance the impact of information sources on both the amount of product-oriented services and business model-oriented services. More specific:

H4 *Digital solutions have a positive interaction effect on the impact of (a) internal sources and (b) external sources on the amount of product-oriented services offered at small and medium-sized manufacturing firms.*

H5 *Digital solutions have a positive interaction effect on the impact of external sources on the amount of business model-oriented services offered at small and medium-sized manufacturing firms.*

Figure 1: Conceptual model



4 Methods

This chapter provides the methodology to research the impact of information sourcing on servitization and the role of digitalization in this relationship. To examine the proposed model and to gain a deeper understanding of each construct and its interplay in practice, this study takes a mixed methods approach, containing both quantitative and qualitative elements.

4.1 Research strategy

According to Johnson, Onwuegbuzie and Turner (2007, p. 123), "mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g. use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration." The basic principle of the combination of qualitative and quantitative methods is that it is a very appropriate approach to gain insights into a social phenomenon. Both methods could compensate each other's shortcomings and act complementary (Bleijenbergh, 2015). There are six primary characteristics of mixed method research that should be considered in the research process: purpose of mixing, theoretical drive, timing, point of integration, typological use, and degree of complexity (Schoonenboom & Johnson, 2017). As for the purpose of mixing, this study seeks both corroboration of results from different methods as well as clarification of the results from the quantitative method with results from the qualitative method. The aim here is both *triangulation* and *complementarity*, based on a classification of five purposes from Greene (2007) in Schoonenboom and Johnson (2017). The theoretical drive of this study is to use quantitative testing of hypotheses as well as qualitative exploration in practical circumstances. Creswell and Plano Clark (2011) refer to this type of research as *convergent parallel design*, where quantitative and qualitative components are carried out independently and brought together for an overall interpretation. In general, this type is less complex, because the components are independent, in contrast to integrated mixed method designs, which are seen as more complex. Last, as is most common, the integration of methods takes place in the result section. As Schoonenboom and Johnson (2017) mention, a quantitatively measured *effect* can be explained by an underlying *process* that is measured qualitatively.

4.2 Quantitative sample and data collection

To research the topic discussed in this study, the first approach of data collection is in a quantitative manner. An EMS database based on a Dutch survey is used to analyze data from Dutch manufacturing SMEs. This survey is being used in order to gain insights in the practices of manufacturing firms to modernize production and business processes. Data is collected regarding the use of new technologies, organizational concepts and indicators such as productivity, flexibility and quality. Firms with at least 10 employees are included in the database. The results are based on answers from business directors and leaders from 203 manufacturing firms and data analysis is done by performing multiple regression analyses in SPSS. This approach is used to determine if there is a relationship between information sourcing and servitization. More specifically, it is used to determine to what extent internal and external information sourcing in manufacturing firms affect the different forms of services, namely product-oriented services and services related to business models other than regular sales. In addition, it is used to measure how digital solutions in the service portfolio interact with information sourcing. Therefore, a quantitative method answers the question if manufacturing firms differ in their services offered, depending on the sources of their information, and the role of digitalization herein. However, this method does not provide detailed insights into this relationship, i.e. why the relationship exists (or not) and how it is affected. The quantitative operationalization of the theoretical constructs is summarized in table 1 and thereafter elaborated individually.

4.2.1 Operationalization of quantitative variables

The operationalization of each variables is elaborated in this section. In order to measure the theoretical constructs, they have to be defined into measurable factors. Additionally, the reliability of these variables should be on acceptable levels to ensure that they measure what they should be measuring in this study. Cronbach's alpha (α) is used to capture the reliability.

4.2.1.1 Dependent variable

The measurement of servitization is based on the division of this variable into two constructs. Both constructs define a different type of service provision. The first dependent construct is based on services that are directly related to the products of manufacturing firms. The eight items used within this construct are: (1) installation and start-up services, (2) maintenance and repair services, (3) training, (4) remote support services for clients, (5) design, consulting and

project planning, (6) software development services, (7) revamping or modernization services, and (8) take-back services. Each item was measured using a yes/no option on the question if a firm offers particular services. A reliability test was performed and resulted in a Cronbach's alpha of 0.785. There was no option to delete certain items in order to significantly increase the Cronbach's alpha.

The second dependent construct is related to commercial services that are offered to create additional or different revenue streams. Those services can be seen as different types of business models than the mere sale of products. Items that were included in this construct are: (1) renting of products, machinery or equipment, (2) full-service contracts to maintain your products, (3) operation of own products are at customer site / for the customer, (4) management of maintenance activities for the customer to guarantee availability or costs, (5) contracting offers, and (6) other service concepts with performance-based pricing. The items were separately measured using a yes/no option on the question if a firm offers a particular service. Based on Nunnally (1967) in Peterson (1994), for rather preliminary research topics a minimal Cronbach's alpha of 0.6 is acceptable. This construct had a Cronbach's alpha of 0.636 which relates to the preliminary element of this construct due to a heterogeneity of services. In this study there is no standard cluster of services yet and deletion of particular items will not result in a more reliable construct. Here, Cronbach's alpha is used as a formative index.

4.2.1.2 Independent variable

Information sourcing is measured based on obtaining four types of information, being information on new products, new process technologies, new services and new organizational concepts. As information can either be obtained from internal sources and/or external sources, a distinction is made by splitting information sourcing into internal information sourcing and external information sourcing.

The independent construct of internal sourcing ($\alpha = 0.683$) is measured by asking firms which internal sources (R&D/engineering, production, customer service, management) are relevant for each type of new information. This led to a construct consisting of 16 items (e.g. "information for new products from the R&D department"). The independent construct of external sourcing ($\alpha = 0.739$) is measured by asking firms which external sources (customer/end user, supplier, research institutions/universities, conferences/trade fairs) are relevant for the same types of new information. This also led to a construct of 16 items (e.g. "information for new services from customers").

4.2.1.3 Moderating variable

Six items were included to measure digitalization in service offerings of manufacturing firms ($\alpha = 0.699$). Measurement was done by asking manufacturing firms which of the following digital solutions are included in their current service offering: (1) web-based offers for product utilization, (2) web-based services for customized product configuration/design, (3) digital (remote) monitoring of operating status, (4) mobile devices for diagnosis, repair or consultancy, (5) data-based services based on big data analysis, and (6) other digital based services. As seen, this variable only included items with digital methods/technologies that are related to the services that are offered. For example, digitalization solely related to production were not included as this is not relevant for the purpose of this study.

4.2.1.4 Control variables

The model is controlled for the effect of alternate variables to analyze how they influence the proposed hypotheses. First, the model is controlled for size, in terms of number of employees. On average, the manufacturing firms in this study have 81 employees. However, a relatively large difference is found in the mean and median (42) of Size, due to one outlier of 4500. In order to use size as a control variable, the log function is applied to create a normally distributed construct. This led to a mean of 3.77 and a median of 3.74.

Further, the model is also controlled for industry sector. This control variable is divided into seven categories, being (1) metal and metal products, (2) food, beverages and tobacco, (3) textiles, leather, paper and board, (4) construction and furniture, (5) chemicals (energy and non-energy), (6) machinery and equipment transport and (7) electrical and optical equipment. Since industry sector is a nominal variable, which cannot be used in regression analysis, it is converted into multiple dichotomous variables with Metal as the reference group.

Table 1: Operationalization of theoretical constructs

Constructs	Dimensions	Questions	Items
Servitization	Product-oriented services	Which of the following product-oriented services do you offer your customers?	• Installation, start-up • Maintenance and repair • Training • Remote support for clients • Design, consulting, project planning • Software development • Revamping or modernization • Take-back services
	Business model-oriented services	Which of the following services does your firm offer your customers?	• Renting products, machinery or equipment • Full-service contracts with a defined scope to maintain your products • Operation of your own products at customer site / for the customer • Taking over the management of maintenance activities for the customer in order to guarantee availability or costs • Contracting offers • Other service concepts with performance-based pricing depending on use, availability or customer output quantity
Information sourcing	Internal sourcing of information	Which of the following sources of information are most relevant for important innovation ideas in your firm in these areas: • New products • New processes (technologies) • New services • New organisational concepts	• R&D, engineering • Production department • Customer service • Management
	External sourcing of information	Which of the following sources of information are most relevant for important innovation ideas in your firm in these areas: • New products • New processes (technologies) • New services • New organisational concepts	• Customer or user • Supplier • Research institutions, universities • Conferences, trade fairs
Digitalization	Digital solutions	Which of the following digital solutions do you offer as part of your service portfolio?	• Web-based offers for product utilization • Web-based services for customized product configuration or product design • Digital (remote) monitoring of operating status • Mobile devices for diagnosis, repair or consultancy • Data-based services based on big data analysis • Other digital based services

4.3 Qualitative sample and data collection

Besides using a survey to collect and analyze quantitative data, this study also includes the collection and analysis of qualitative data. Qualitative research consists of collecting and interpreting linguistic material. The richness of such material gives the researcher the opportunity to make statements about a specific social phenomenon in reality, based on a relatively small amount of observation units (Bleijenbergh, 2015).

A semi-structured interview is created, consisting of 9 open questions regarding the theoretical topics of this research. Analysis of the theoretical topics is used as a guide for the development of the interview questions. This method of interviewing gives the researcher the possibility to predetermine themes and order to some degree, but still ensures flexibility for the respondent to deviate from the question and for the researcher to anticipate and go in depth by formulating follow-up questions on the spot (McIntosh & Morse, 2015). In addition, semi-structuring the interview ensures that respondents are presented mainly the same questions, which increases the reliability of data collection (Bleijenbergh, 2015). Every interview started with an informative introduction of this research, followed by some introductory questions about the respondent and the manufacturing firm he/she represents. This includes his/her function, his/her activities and experience, the amount of employees, the age of the firm, the sector they are active in, the main type of products and customers, and the main activities of the firm. The remaining of the interview is divided into three theoretical constructs, respectively servitization, digitalization and information management. Each construct is introduced to the respondent by providing a specific description that fits this research. The questions are formulated completely open to give the respondent as much room to talk as possible without suggesting a certain answer or direction. Follow-up questions are used to go in-depth on interesting or remarkable topics or to ask for specific examples.

Six representatives for manufacturing firms located in the Netherlands are interviewed, either physically or online using a video call application. The sample includes one large firm (± 1.750 employees at the Dutch facility), four SMEs ranging from approximately 100 to 300 employees and one startup with 8 employees. Two firms (D and F) are active in the semiconductor/chip industry (electronics sector), two are active in the metal industry (C and E), one is active in machinery (A) and one in the energy sector (solar) (B). The respondents are selected based on their knowledge on the service provision and information management at the firm. All respondents have a function related to sales and/or business development. On average, a single interview took approximately 50 to 60 minutes. The audio of each interview is recorded and then immediately followed up by transcribing it. The interview data is used confidentially

by fully anonymizing the transcripts and deleting audio recordings afterwards. Transcription is followed up by coding the verbal data from interviews using ATLAS.ti. Flick, Kardorff and Steinke (2004) describe coding as deciphering or interpretation of data by naming certain concepts. Boeije (2005) in Bleijenbergh (2015) defines qualitative analysis as "the unraveling of data about a certain subject in categories, naming of those categories with concepts, and applying and testing of relationships between concepts in the light of the defined problem." A known method of analysis consists of three phases of coding – open, axial and selective coding. Although named phases, the process of coding is not sequential, but an iterative activity in which you go back and forth between phases. The analysis started with open coding, where the data is fractured by linking codes to words, sentences or paragraphs in the transcript. Although any directional bias (e.g. from the formulated hypotheses) should be prevented, background knowledge about the area of investigation is used to filter relevant data. The process of open coding resulted in a code list with 74 different codes from six transcripts. Those codes were then categorized into code groups that cover the underlying themes within the open codes. This led to 9 axial codes that are highly related to the theoretical constructs within the conceptual model of this study. An exception is the coding group that includes the firm descriptives. Last, during the process of selective coding certain patterns or reoccurring phenomena were found in the data by analyzing the codes. Such patterns and phenomena are used to determine theoretical relationships and explanations to form a potential theory.

In the results section, the analysis is divided twofold. First, analysis of the interviews gave an indication of *what* the interviewed firms do regarding the variables. In this study, this is referred to as the application of variables (e.g. the application of product-oriented services). Second, the interviews also show *how* and *why* these firms operate in a certain manner regarding the variables (e.g. how and why are product-oriented services offered). This is referred to as the substance in practice of variables. It describes the practical meaning of individual variables.

4.4 Validity and reliability

As this study takes a mixed method approach of both a quantitative and qualitative method, it is tried to seek compensation for the weaknesses of one method with the strengths of the other (Ihantola & Kihn, 2011). In other words, by using multiple methods it is tried to maximize the *internal validity*, *external validity* and *reliability* of this study.

In the quantitative section, internal validity tells to what extent variations in services offered relate to variations in the sources of information – not from other cofounding factors (Abernethy et al., 1999 in Ihantola & Kihn, 2011). By doing extensive literature research before

data collection and analysis, it is tried to optimize the logic between research and existing theory. Additionally, the model is controlled for the effects of size of the firm and the industry sector. Then, in the qualitative section, internal validity refers to the credibility of evidence from the interviews and the conclusions drawn (Ryan et al., 2002 in Ihantola & Kihn, 2011). An important threat that is looked out for is bias. This could lead to mismatches between theory and study design due to, for example, biased knowledge on theory and methodology (Ihantola & Kihn, 2011).

Next, external validity refers to generalizability (in quantitative research) and transferability (in qualitative research). According to Ihantola & Kihn (2011, p. 44), in quantitative research "external validity is seriously threatened if biases or other limitations exist in the accessible population." Also, the results should be generalizable to other time periods and across settings. Because the aim of this study is to examine servitization at Dutch manufacturing firms, external validity is ensured by using a relatively large sample size (203) of random Dutch manufacturing firms. It should be noted that the results may not be generalized across settings, due to a national nature of the sample. Further, to ensure transferability, empirical results should be compared to previous (other) theoretical findings. A lack of comparison can result in myopic conclusions (Vaivio, 2008 in Ihantola & Kihn, 2011).

Last, to have a reliable quantitative study the set of variables should be consistent in what it intends to measure. The EMS questionnaire is used for multiple years (with slight updates) to measure certain business processes, such as servitization and digitalization. It can be considered a reliable method of data collection with clear instructions, clear questions and sufficient alternatives. Reliability tests were performed using Cronbach's alpha and resulted in acceptable levels for every variable. It is important to note that some variables are still in a preliminary stage of scientific research, which could affect reliability. Further, there are reliability threats in every stage of qualitative research (Lillis, 2006 in Ihantola & Kihn, 2011). To minimize those threats a semi-structured interview is created to systematically address every theoretical topic. Moreover, additional questions are posed to respondents when needed and every interview is recorded to follow up with accurate transcripts. The biggest threat lies in the procedure of data analysis and interpretation, due to errors that may occur in data classification, attaching data to theory, linking constructs and not taking distance from preconceptions (Ihantola & Kihn, 2011). It is tried to minimize using a systematic approach for coding the transcripts and documenting and reporting how data is collected and interpreted. However, this study lacks intercoder reliability of qualitative data.

5 Results

The results consist of both quantitative and qualitative data analysis, presented in the respective order. The conceptual model from chapter 3 is used to empirically analyse multiple constructs and hypotheses. Quantitative results are presented by diving into the general descriptives followed by linear regression analyses to test the proposed hypotheses. Thereafter, qualitative results are presented by using the open and axial codes from interview transcripts to describe six manufacturing firms and their practices related to servitization and information management.

5.1 Quantitative results

The aim of the quantitative approach is to examine certain relationships between variables and its directions and strengths. Generalization is pursued to be able to propose a theory based on the relationships at hand.

5.1.1 Quantitative descriptives

Table 2 demonstrates the mean, standard deviation and valid observations of every variable used. As described above, a log variable of size is used, because the original variable of size does not provide a realistic average amount of employees in the firms in this research (81). The median provides a more realistic size, being 42 employees, due to one outlier of 4500. However, in the regression model the mean of the log variable (3.77) is used. Thereby, the distribution of the industry sectors in which the manufacturing firms are active is as follows: 19.9% in metal, 8.5% in food, 14.4% in textiles, 2.5% in construction, 12.9% in chemicals, 18.4% in machinery and 23.4% in electronic.

The results indicate that, on average, the manufacturing firms have two to three product-oriented services in their current service portfolio (mean = 2.55, std. deviation = 2.33). Moreover, 20% of the firms do not offer any product-oriented services and there are 7 firms (3.4%) that offer all 8 product-oriented services. Business model-oriented services, on the other hand, are offered far less (mean = 0.37, std. deviation = 0.85). The far majority (76.4%) of the manufacturing firms offer no business model-oriented service. Only 15.3% offer one business model-oriented service and 8.4% offering more than one. There are two firms that offer all 5 business model-oriented services and more (‘other service concepts with performance-based pricing’). Furthermore, the results show that almost 37% of the manufacturing firms utilize at least one digital solution in their service provision. In other words, this means that on average

not even one digital solution is utilized per manufacturing firm (mean = 0.78, std. deviation = 1.28). It is important to mention that this variable takes into account the manufacturing firms that do not offer services and therefore also do not utilize digital solutions in their service provision. Thus, for firms that actually offer any kind of service, this number would be higher. Last, the descriptive results show that, on average, manufacturing firms use approximately four internal sources (mean = 3.92) for the types of information included (new products, new process technologies, new services and new organizational concepts), with one firm using 13 internal sources for all their information. This is only slightly lower for external sources. There is an average of almost four external sources used (mean = 3.73) for the same types of information. One firm uses 14 external sources for all their information.

Table 2: Descriptive statistics

	Mean	Std. Deviation	N
Product-oriented services	2.5473	2.32573	201
Business model-oriented services	.3731	.85151	201
Size (log)	3.7713	.86288	201
Food	.0846	.27895	201
Textile	.1443	.35225	201
Construction	.0249	.15613	201
Chemical	.1294	.33643	201
Machinery	.1841	.38852	201
Electronic	.2338	.42432	201
Internal sourcing	3.9154	2.66229	201
External sourcing	3.7662	2.81426	201
Digital solutions in service portfolio	.7761	1.28243	201
Internal sourcing × Digital solutions	.4291	3.13284	201
External sourcing × Digital solutions	.4156	3.16671	201

5.1.2 Hypotheses

Before testing the hypotheses, the correlation matrix is used to gain insights into correlations between all variables. Appendix A shows this analysis in greater detail. Subsequently, in the following section the research model was tested performing two regression analyses with different dependent variables: product-oriented services and business models offered, respectively. The results were analysed by using three models. First, model 1 contains the control variables for size and industry sector. Then, in model 2 the independent variables ‘internal sourcing’, ‘external sourcing’ and ‘digital solutions’ are added as predictors and model

3 takes into account two interaction variables to check for potential synergy effects between information sourcing and digital solutions.

Table 3: Quantitative results

	Beta coefficients	
	Product-oriented services	Business model-oriented services
Model 2		
Internal sources	.161*	.055
External sources	-.072	.024
Digital solutions	.352**	.313**
Model 3		
Internal sources	.150*	.039
External sources	-.068	.033
Digital solutions	.372**	.345**
Internal sourcing × Digital solutions	-.164*	-.223*
External sourcing × Digital solutions	.080	.186*
Control variables		
Size	-.097	-.026
Food	-.113	-.049
Textile	-.052	.064
Construction	-.007	-.006
Chemical	.019	.003
Machinery	.460**	.169*
Electronic	.114	.048
Model summary		
Adjusted R Square	.462**	.145**
F	15.309	3.826

**. Correlation is significant at the 0.001 level.
*. Correlation is significant at the 0.05 level.

5.1.2.1 Product-oriented services

The first multiple regression analysis was performed to predict the amount of product-oriented services that are offered in a manufacturing firm based on their internal and external sourcing of information and the digital solutions in their service portfolio. Before looking at individual variables, ANOVA is used to confirm the significance of the complete model. Moreover, R^2 represents the variance of the dependent variable that is explained by all variables included. The adjusted R^2 is used, because it takes into account the multiplicity of variables in the model.

As seen in table 3, the analysis resulted in a significant regression model ($F(12, 188) = 15.309$, $p < 0.001$) with an adjusted R^2 of 0.462. This means that the overall model is significant and the amount of product-oriented services offered is explained for 46.2% based on all the variables included.

In chapter 3, a conceptual model is proposed, where specific variables are expected to have a significant impact on product-oriented services. It is expected that manufacturing firms offer more product-oriented services, the more they use internal sources for new information. In other words, H1 proposes that the amount of internal sources of information used by manufacturing firms has a significantly positive impact on the amount of product-oriented services that are offered by said firms. Also, it is expected that manufacturing firms offer more product-oriented services, the greater their utilization amount of external sources for new information is. Hence, H2 proposes that external sources of information have a significantly positive impact on the amount of product-oriented services that are offered. Table 3 summarizes the results with regard to H1 and H2. According to the proposition, internal sourcing of information indeed has a significantly positive impact on the amount of product-oriented services offered ($\beta = 0.150$; $p < 0.05$). Thus, the results from model 3^a support H1. However, external sourcing of information does not have the significantly positive impact on product-oriented services that is proposed in this study ($\beta = –0.068$; $p = 0.354$) and therefore H2 must be rejected.

Last, digital solutions in the service portfolio are included in this model to test if digital solutions have a positive synergy effect with information sourcing (internal and/or external) on product-oriented services. In H4a and H4b it is proposed that those positive synergy effects exist. As expected, the stand-alone variable ‘digital solutions in service portfolio’ has a positive and significant impact on the amount of product-oriented services offered ($\beta = 0.372$, $p < 0.001$). However, although the interaction variable of digital solutions and internal sourcing has a significant impact, it is negative ($\beta = –0.164$, $p < 0.05$). In other words, digital solutions do not strengthen the impact of internal sourcing on the amount of product-oriented services. On the contrary, it seems to weaken the impact, resulting in a rejection of H4a. Furthermore, the interaction variable of digital solutions and external sourcing does not have a significant impact ($\beta = 0.080$, $p = 0.276$). Therefore, H4b must be rejected too – digital solutions in the service portfolio do not strengthen the impact of external sourcing of information on the amount of product-oriented services offered. Additionally, model 2^a (interaction variables excluded) does not significantly differ from model 3^a ($p = 0.063$). It leads to an adjusted R^2 change of only

0.010, which means that including the interaction variables does not provide a significantly better model to predict the amount of product-oriented services offered.

Finally, the model is controlled for size and industry sector to analyze how they influence the proposed hypotheses. As also observed in the correlation matrix, manufacturing firms in the machinery sector are far more likely to offer services than manufacturing firms in other sectors. The coefficient table shows that the machinery sector has a high relevance (β = 0.460; $p < 0.001$). The size of manufacturing firms, in terms of number of employees, does not have a significant impact on the amount of product-oriented services offered.

5.1.2.2 Business models offered

A similar method is used to predict the amount of business models offered by manufacturing firms. Namely, a multiple regression analysis is performed with the same independent variables, being internal sourcing and external sourcing of information and the digital solutions in the service portfolio. ANOVA shows that the model as a whole (3^b) is significant ($F(12, 188) = 3.826$; $p < 0.001$), which means that all variables together can predict the amount of business model-oriented services that a manufacturing firm offers to a significant extent. The amount of business models offered is explained for 14.5% based on the current variables included, as the model summary shows an adjusted R^2 of 0.145. Although significant, this is relatively low compared to the adjusted R^2 of model 3^a. These results are also visualized in table 3.

Following up on the conceptual model proposed in chapter 3, specific effects of individual variables on the amount of business model-oriented services offered are expected here, too. In H3 it is proposed that external sourcing of information has significantly positive impact on the amount of business model-oriented services that manufacturing firms offer. This means that it is expected that manufacturing firms will offer more business model-oriented services when they utilize more external sources for new information. Table 3 shows the coefficients of each variable with business models offered. It seems that external sources do not have a significant impact on the amount of business models offered (β = 0.033, p = 0.719). Therefore, H3 must be rejected. Additionally, the coefficients show that internal sources do not have a significant impact either (β = 0.039, p = 0.669). As there was no proposition on internal sourcing, no hypothesis can be confirmed or rejected. However, it confirms the implicit expectation that no significant relationship exists here.

Similarly in model 3^a, the stand-alone variable of digital solutions also has a positive and significant impact in this model (β = 0.345, $p < 0.001$). This was expected, because both digital solutions and the business models offered are directly related to services. The last

proposition, however, is based on the expectation that digital solutions enhance the impact of external sourcing of information. Consequently, H5 proposes that digital solutions have a significantly positive synergy effect with external sourcing of information on the amount of business models offered by manufacturing firms. To test whether this synergy effect exists, an interaction variable of digital solutions and external sourcing is included in the model. The coefficient of the interaction variable shows that there is a significantly positive synergy effect between digital solutions and the utilization of external sources ($\beta = 0.186$, $p < 0.05$). This result means that H5 is supported – this positive interaction effect exists. The predicted amount of business models offered can be explained by this variable for 18.6%. Remarkably, another significant result is found that was not hypothesized in this study. As for the interaction variable between digital solutions and the utilization of internal sources, a significantly negative interaction effect is found on the amount of business models offered ($\beta = -0.223$, $p < 0.05$). This means that manufacturing firms tend to offer a lower amount of business model-oriented services when they use digital solutions in their service offering along with a higher amount of internal sources. In brief, digital solutions strengthen the impact of external sources on the business models that are offered, but diminish the impact of internal sources (to a negative extent).

In a similar manner, the model is also controlled for size and industry sector to measure their impact on the model. The coefficients show that neither size nor the industry sector has a significant impact on the amount of business model-oriented services offered. Although not significant, it is worth mentioning that the machinery sector has a moderate relevance in this model ($\beta = 0.169$; $p = 0.050$).

5.2 Qualitative results

Qualitative data analysis is included in this research to complement the analysis of quantitative data. The insights are in-depth to complement the quantitative results by searching for explanations to why and how certain social phenomena exist or not. The hypotheses reflect the expectations of servitization in manufacturing firms and the impact of their information sources hereon.

5.2.1 Qualitative descriptives

First there is the need to elaborate on the descriptives of the manufacturing firms that are interviewed. A semi-structured interview is performed at six manufacturing firms that differ

from each other on multiple aspects. The size of the firms (measured in the amount of people employed at the interviewed facility) ranges from 8 to 1.750 employees. As stated in the quantitative section, size does not have a significant impact on the amount of services that are offered. Similarly, in the interviews, size is never mentioned as a factor for offering more or less services.

Although all interviewed firms claim to offer services, the amount of services that are offered differs greatly between each firm. It is safe to state that the sector in which the firm operates at least partly determines the amount of both product-oriented services and business model-oriented services that are offered. Firm A is active in the machinery sector and offers far more services than the other firms. Similarly, this result is found by including the control variables for each sector in the quantitative section. It even is the only interviewed firm that offers multiple other business model-oriented services than solely the sale of products. A reason for this could be the fact that firm A is highly woven into many of the production processes and business processes of its customers, because its products (machines) are highly related to customers' processes. According to respondent A, especially their small customers are almost completely depending on the full solution of products and services that firm A provides.

> *"De kleinere bedrijven zijn afhankelijk van ons, want we zitten zo verweven in hun bedrijf qua software maar ook qua afdelingen."* [1]

The other firms are active in the (high tech) electronics sector and the metal sector. An important difference with firm A is the type of products that are offered. The firms in the electronics sector mainly offer electronic consumables and components (e.g. chips) and the firms in the metal sector solely produce metal components. High-tech electronic products range from relatively low volume to high volume production, depending on its complexity. Metal components are mainly high-volume production. Every firm provides at least some level of customization and/or product development before production and are very often involved in this process. They mostly act as contract manufacturers within the supply chain, somewhere between the top and bottom of it. For example, respondent D describes their production as follows:

> *"Als je grosso modo kijkt dan zie je dus dat... heel veel van onze producten zijn customized naar elke klant. Dat wil niet zeggen dat een bepaald product soms door meerdere klanten gebruikt kan worden, maar het start vaak in de customization naar één klant toe of een eerste start met een OEM die dan een bepaald custom profiel wil bedienen, noem ik het maar eventjes. Dat geldt eigenlijk voor een groot deel van onze*

[1] All quotes from transcripts are referenced by numbers and can be found in the full transcript document.

grafietdelen. Voor de kwartsdelen is het wat minder customized. Dus een stukje service naar de klant zit ook de customization" [2]

and respondent F:

"Dat is voor 95% custom made op basis van contract manufacturing. Wij beschouwen dat wel als productie... als volumeproductie." [3]

Their main type of customers are first-tier manufacturing firms, original equipment manufacturers (OEMs) and system integrators.

5.2.2 Qualitative variables

In this upcoming sections the qualitative results of each variable are elaborated individually. First, there is a short reflection of how theory defines the variables, as described in chapter 2 and 3. This is followed by defining the application of the variables for each interviewed firm. The phenomenon of *what* these firms do is put in tables. Thereafter, axial coding is used to determine *how* and *why* firms operate in a certain manner regarding the variables. In other words, axial coding is used to determine the substance in practice of the variables. Last, the three aspects are brought together to conclude the qualitative results through similarities and differences.

5.2.2.1 Product-oriented services

As defined in chapter 2, product-oriented services are closely related to manufactured products. These services are merely add-ons and do not need radical changes in firms' business model or knowledge. As a comparison, table 4 shows the application of the theoretical construct 'product-oriented services' for each firm individually. It becomes clear that most respondents refer to product-oriented services as services during the early stages of doing business or cooperation. Firms C and E specifically mention "early stage" and "early involvement" as important factors. Thereby, the quotes of firms D and F are highly related to services during the product engineering phase. For firm A services are an important part of the company strategy as they want to provide a full solution to unburden their customers. Lastly, firm B sees product-oriented services as a necessity that is included in their projects. This shows that only few product-oriented services are offered during late stages of doing business (e.g. after the sale of products).

Table 4: Application of product-oriented services

Firm	Product-oriented services
A	Onze kernactiviteit is het leveren van een productieoplossing en die bestaat dus uit hardware, uit software, uit proceskennis en ook uit kennisoverdracht. Dus dat is eigenlijk onze kerntaak en daar ontzorgen wij eigenlijk onze klanten mee.
B	[Diensten] zitten vaak in het project. Al die services die we besproken hebben, zijn allemaal, soort van, uit noodzaak, of uit onvoorzienigheid. Nu bij [project a] analyseren we voor hun en dan komt daar dus uit of ze ermee door willen gaan, of ze meer producten af willen nemen.
C	Vooral ondersteuning in ontwikkeling en daarom vinden klanten ons. Om onze kennis, onze kwaliteit. vaak is het zo dat als je vooraan in die ontwikkelingen meedoet, dan heb je veel meer kans om later een productieopdracht te krijgen.
D	Wij onderscheiden ons in het feit dat wij hele goede kennis van de applicatie hebben, en dat hebben we op basis van de analyses die wij kunnen doen en zodat wij dus betere feedback kunnen geven over mogelijke verbeteringen […] op de producten en op de materialen zodat de klant daar verder mee kan in zijn onderzoek, of verbetering van zijn processen. Dus dat is een service dat zij daar niet naar om hoeven te kijken.
E	[Wij zijn] meer aangekoppeld als productiepartner en door middel van early involvement, zeg maar, de aansluiting vinden en hun van kennis voorzien over produceren. Hoe het zo goedkoop mogelijk kan maken.
F	Wij hebben twee verschillende vormen van dienstverlening. Het kan dus een consultancy rol zijn in de vorm van een ingenieursbureau. [Daarnaast] voor producten kunnen wij eventueel middels consultancy of support on-side wat dienstverlenende activiteiten doen om te zorgen dat onze klanten met die producten kunnen gaan werken.

Insights and potential explanations (substance in practice) are discussed using the axial codes. As seen in the interview transcripts, the main type of service offerings are product-related and focussed on the presale phase. The firms are characterized by their specialized knowledge of their products and utilize their knowledge to customize products in the engineering phase in collaboration with their customers. Those services are referred to as co-engineering services. Within the axial code 'product-oriented services' (total of 128 open codes) the open code 'co-engineering as a service' is used over 15% of the time. For example, on the question which product-oriented services are offered, respondent D answered:

> *"De andere service die we leveren is de customization, dus wij doen engineeringwerk voor de klanten."* [4]

and similarly, respondent E answers:

> *"een stukje co-engineering, hè, waar we aan de voorkant onze kennis delen om een product mee te ontwikkelen, dat het ook maakbaar is."* [5]

The co-engineering service often goes together with knowledge provision in order to increase the chance for a production order or to unburden the customer. Knowledge of products and production processes is even used to create another revenue stream, namely by consulting other businesses. Firm B is still in an early stage of existence and thus still exploring consultancy

about the use of solar panels. Firm F already actively uses consultancy to generate more revenue. Their employees can change their role from engineer to engineering consultant easily. This way they advise new and existing customers during the product development phase, for example by researching the technical feasibility of new products or by giving advice for new production processes.

> *"Wij werken vaak in de modus van een ingenieursbureau. Als wij echt in een vroege fase van productontwikkeling worden betrokken bij het project van de klant, dan wordt er dus in eerste instantie nog niets gemaakt, maar dan wordt er alleen gekeken naar concepten, risico's, haalbaarheid en dergelijke."* [6]

The open codes 'consultancy as a service', 'knowledge provision as a service' and 'feasibility as a service' are used almost 35% of the time. In addition, 'prototyping as a service' is used 7% of the time.

In contrast, product-oriented services are offered less during the aftersales phase. Services such as monitoring, maintenance and repair are offered only sporadically, mainly because those services are not really applicable to consumable products or components. The open codes for services in the aftersales phase count for approximately 21% in total within the axial code 'product-oriented services', which even includes codes regarding the lack of such services. Respondent E, for example, refers to repair as follows:

> *"Onze klanten doen dus ook de repair van de producten die zij wegzetten, en wij zorgen dan weer voor de onderdelen"* [7]

As another example, respondent F refers to maintenance services as unnecessary or even impossible:

> *"Onderhoud op een verbruiksartikel is eigenlijk niet nodig of niet mogelijk."* [8]

However, an outlier here is firm A. This firm produces machinery that determines its customers' processes. Product-oriented services, such as assessments, consultancy, training, data analysis and management, (remote) repair and maintenance are perfectly applicable and even essential for their customers. Those services are often included in specific contracts to unburden the customer as much as possible. The main goal for firm A is to be able to offer a complete solution, consisting of products and services related to this product:

> *"Onze kernactiviteit is het leveren van een productieoplossing en die bestaat dus uit hardware, uit software, uit proceskennis en ook uit kennisoverdracht. Dus dat is eigenlijk onze kerntaak en daar ontzorgen wij eigenlijk onze klanten mee."* [9]

To conclude, the theoretical definition of product-oriented services is being compared to how these services are applied in practice as well as its substance in practice. In short, it becomes clear that the interviewed firms offer more product-oriented services in the presale stage. This empirical observation could be related to the fact that most of these firms produce components and/or consumables. In contrast, firm A produces machines and offers far more product-oriented services. Although these differences between firms exist, their application of product-oriented services highly related to its theoretical definition used in chapter 2, namely that the services are add-ons to products. In practice, the nature of these services can be described as demand-pull, because customers determine what they need. This suggests that internal sources of information do not have a significant impact on the amount of product-oriented services offered (H1), while external sources of information do have a significant impact (H2) as customers provide them with useful information (e.g. customer needs as well as technical information).

5.2.2.2 Business model-oriented services

In chapter 2, business model-oriented services are described as substitution for transactional business models of manufacturing firms. Customers pay for the usage of products instead of products itself. This definition can be compared to respondents' application of business model-oriented services, showed in table 5. Firm A is the only firm that offers business model-oriented services, both for their hardware and software. Those services include leasing, renting and pay-per-use and are used to generate revenue in a different manner than using 'traditional' sales as business model. However, the other firms still stick to sales as their only business model. Their reasoning mostly relates to the difficulties in offering business model-oriented services with components and consumables as products. Firm F tried to offer an alternative concept of pay-per-use, but that did not work out for themselves and their customers. It is important to mention that respondent E recognizes business model-oriented services as services that are offered by their direct customers (machine manufacturing).

Table 5: Application of business model-oriented services

Firm	Business model-oriented services
A	Voorheen werd er alleen een machine geleverd en nu wordt er een oplossing geleverd. Ik heb je verteld dat de hardware in principe gelijke waardeoverdracht. Of met lease. Software deels lease, maar ook software rental contracten. Maar we zijn nu aan het kijken [naar pay-per-use].
B	Omdat veel van de projecten, die pilots, voor het eerst zijn en dan moet er ook veel R&D, een stukje R&D worden gedaan voor het paneel geproduceerd kan worden. Voor een pilot doen we dus vaak de kostprijs in de hoop dat ze daarna ja zeggen op heel veel. En dan kunnen we meer vragen.
C	Wij zijn vierdelijns leverancier. Wij maken bijvoorbeeld een onderdeel voor een versnellingsbak.
D	Het is een zeer transactionaal verdienmodel.
E	Wij produceren de onderdelen. En die worden gewoon afgerekend naar rato wat ze moeten kosten. [Andere] modellen zijn meer van toepassing op onze klanten die hun machines weg kunnen zetten tegen leasing of pay-per-use of dat soort zaken.
F	Het is echt verkoop, omdat onze producten echt over het algemeen verbruiksartikelen zijn en niet kunnen worden geleend. Wij leveren geen instrumenten, om het zo maar te zeggen. Het zijn echt verbruiksartikelen, dus het gaat altijd om offertes en facturen voor een vast aantal producten die wij leveren.

Axial coding is used to examine the substance of practice of the manufacturing firms at hand in greater detail. Quantitative analysis showed that very few manufacturing firms offer business model-oriented services (mean = 0.373). Most of those manufacturing firms still have a traditional business model based on the sale of manufactured products. This is also the case for the manufacturing firms that were interviewed. The largest proportion of their value offer comes from contract manufacturing. Similar to the quantitative analysis, coding analysis also suggests that sales is still the most common business model. Almost 50% of the axial code 'business model-oriented services' (total of 50 codes) is related to sales or contract manufacturing. Firm A excluded, this increases to approximately 75%. The interviews suggest that the reason why providing business model-oriented services is so difficult, if not impossible for many manufacturing firms, is also here the type of products that are manufactured. Business model-oriented services, such as leasing, renting or pay-per-use, are difficult to operate and coordinate as well as undesirable for customers when applied to components and (electronic) consumable products. When asked what business model-oriented services are offered, respondent F answered:

> *"Het is echt verkoop, omdat onze producten echt over het algemeen verbruiksartikelen zijn en niet kunnen worden geleend. Wij leveren geen instrumenten, om het zo maar te zeggen. Het zijn echt verbruiksartikelen, dus het gaat altijd om offertes en facturen voor een vast aantal producten die wij leveren."* [11]

Also, firm D has tried to implement an alternative form of pay-per-use, but quickly let go of that as it did not work out for both the firm and its customers:

"Het systeem van pay-per-use of... zeg maar... dat ze betalen aan de hand van het aantal runs... we hebben daar ook... ook contracten mee gesloten. We hebben in het verleden... met een tweetal klanten hebben we gezegd: oké je betaalt deze prijs voor zoveel runs en als het meer is betaal je per run meer, zeg maar. En als de druk minder... als de levensduur korter zou zijn, hè... dus we hebben gezegd dat de levensduur zoveel runs moet zijn... dan betaal je minder en krijg je dus een discount op de prijs uiteindelijk. Dat verrekenen we dan, natuurlijk niet per product maar over een bepaalde periode. […] Dat hebben we losgelaten, omdat dat niet helemaal werkte voor beide kanten niet." [12]

Finally, respondent E indicated that business model-oriented services are difficult to apply to their business. Firm E sees itself as a production partner that manufactures metal components for larger OEMs and system integrators. Business model-oriented services are more applicable to those type of (manufacturing) firms, according to respondent E:

"Allebei die modellen zijn best wel lastig op onze handel te plakken, zeg maar. Wij hebben twee lines of business. Enerzijds zitten wij in... onze klant die ontwerpt en die verkoopt machines in een bepaalde industrie, dus deeghandlingmachines, een achtbaan, een vrachtauto. Daar maken wij dus onderdelen van, wij produceren en leveren de onderdelen toe die daarin zitten. Dus die modellen zijn meer van toepassing op onze klanten die hun machines weg kunnen zetten tegen leasing of pay-per-use of dat soort zaken. […] Waarbij wij, zeg maar, meer aangekoppeld zijn als productiepartner" [13]

The application of business model-oriented services mostly refers back to a traditional business model of sales (e.g. through contract manufacturing). On the contrary, in the analysis of interview A, only 13,6% of the axial code 'business model-oriented services' is coded as 'sales as a business model'. The majority of codes regarding business model-oriented services at firm A is related to providing a full solution. Firm A is an OEM that produces machines for manufacturing firms in high-tech electronic industries. However, the business strategy of firm A is not to offer hardware only. Its core strategy is to unburden its customers as much as possible and they do that by offering full solutions. A full solution consists of multiple elements, being hardware, software and services, incorporated in one or more contracts. For example, next to sales, firm A offers machines through leasing contracts:

"Er wordt ook lease steeds meer gebruikt. Lease is wel moeilijk, maar dat heeft te maken met de restwaarde. Heel veel financiële instituten hebben moeilijkheden om te begrijpen wat onze machines waard zijn na zoveel jaar. Dus we hebben er wel een paar die daar gebruik van maken." [14]

Then, for its software, firm A offers both leasing and rental contracts in order to try to completely unburden the customer regarding software updates and upgrades:

> *"voor software hebben we een rental en dat heeft ook te maken met dat de klanten ontzorgd worden qua updates."* [15]

Those contracts also include product-oriented services to ensure customers that they do not have to worry about the machine(s) or even their processes. A business model-oriented service that firm A is still developing is the concept of pay-per-use. Respondent A elaborated this by giving an example of a cooperation between Rolls Royce and KLM:

> *"Maar we zijn nu aan het kijken... ik weet niet of je het programma kent van Rolls Royce; Aviation? […] Die hebben een programma... KLM koopt bijvoorbeeld 20 nieuwe vliegtuigen bij Boeing, en die kopen alleen het vliegtuig, maar de motoren zijn van Rolls Royce, en KLM heeft een contract, pay-per-use, en dat betekent dat KLM het vliegtuig afbetaalt, maar de motoren blijven in eigendom van Rolls Royce en zij [KLM] betalen gewoon per flight mile, en daar zit alles in. Daar zit afschrijving in, daar zit onderhoud in, garantie, vervanging, etc. […] Daar zijn wij inderdaad ook mee bezig, maar wij hebben heel veel variabelen. En de reden waarom we dit doen zijn de kleinere klanten die steeds meer moeite hebben om te herinvesteren."* [16]

This shows that the strategy of putting the customer first is working out well for the customers, whom will have less difficulties reinvesting in new machines. Moreover, offering those business model-oriented services likely works out well for firm A either, as it creates long term continuity, because small customers will be able to continue to invest.

Concluding, the application of business model-oriented services is being compared to its meaning in practice and its theoretical definition. All respondents have a similar understanding of business model-oriented services to the theoretical definition. In chapter 2, these services are defined as services where manufacturing firms require to define the value of utilization of their products and change their way of offering these products. "The function of goods is to deliver service." (Kowalkowski, 2010, p. 230) However, in practice these services are not offered very often. On the contrary, currently only firm A offers business model-oriented services, whereas the other five manufacturing firms do not. According to them, it is either impossible or highly unwanted to deviate from a transactional business model. For example, firm E indicates that business model-oriented services cannot be offered by themselves, but are offered by their direct customers. The other five firms deliberately keep the transactional business model as their only way of offering products. This is seen as a traditional model and

is still widely used by manufacturing firms, especially when consumables or components are produced. This already suggests that H3 must be rejected based on qualitative results.

5.2.2.3 Internal sources of information

Based on theory of internal sources of information in chapter 3, most manufacturing firms used to rely heavily on internal sources for new information, such as their R&D department and their own production processes. In innovation fields of research, this is referred to as technology push. Firms A, B and F generate fundamentally new information mainly from their own R&D departments. However, the interviews indicate that the other firms mostly perform R&D through contract manufacturing, which demonstrates the needs and demands of customers (i.e. market pull). For firms C, D and E the R&D department is not as important for new information. Incremental changes, although hardly related to service adoption, are continuously sought-after by having a continuous flow of information from internal production processes. This is the case at every interviewed firm. However, as mentioned, its purpose is mainly to optimize internal processes. This is only indirectly noticeable for customers, for example through cheaper or better products, and does not directly influence the value proposition (e.g. through new services). The application of internal sources of information is summarized in table 6.

Table 6: Application of internal sources of information

Firm	Internal sources of information
A	Wij hebben wel acht R&Ds en er moet dat gekeken worden waar de prioriteit moet liggen. Data, zoals accuracy, wordt continu gemeten en vergeleken met andere machines die ze hiervoor gebouwd hebben. Dit is een continu proces wat gaande is, en daarin zie je ook dat data steeds meer leading wordt voor ons productieproces.
B	Omdat veel van de projecten, die pilots, voor het eerst zijn en dan moet er ook veel R&D, een stukje R&D worden gedaan voor het paneel geproduceerd kan worden. Constante feedback, en dat is ook wel het idee, dat je die verschillende projecten hebt die allemaal net iets anders zijn en daardoor leer je steeds wat bij.
C	[Informatie is] vooral meetgegevens en procesparameters, die data-analyses. En al doende leert men.
D	Natuurlijk informatie van ons intern, dan kijk je bij onze productieprocessen waar nu afwijkingen zitten. Hoe kunnen we de producten zelf verbeteren of het productieproces verbeteren?
E	Wij kunnen onze machines uitlezen, wij kunnen ons productieproces uitlezen. Je kunt daar besluitvorming over investeringen doen. Je kunt kijken of je machines nog rendabeler kunt maken.
F	Je zou kunnen zeggen dat onze research afdeling... daar wordt de meest fundamentele informatie weggehaald en gaan daarmee als voedingsbodem kijken naar nieuwe technologieën. Je kunt zeggen dat wij ook intern onze productieafdeling betrekken bij het verstrekken van informatie over de maakbaarheid van producten.

In addition, axial codes are used to gain a deeper understanding of the internal sources of information at the interviewed firms, including specific examples from practical situations. First, a remarkable result is found at the distribution of codes within the axial code 'internal sources of information'. Only two specific sources are found in the interviews, being the R&D department (⅓ of the codes) and internal production processes (⅔ of the codes). It seems that for most interviewed firms, production is the most, if not the only important internal source of information. The main reason why this source is so important, is due to their type of products. Most firms sell components or consumables, which have a relatively low profit margin. Information from internal production processes can be used to make production more efficient in order to surpass competitors. For example, this is what firm E tries to do:

> *"Veel informatie komt uit ons productieproces. Je kunt kijken of je, zeg maar, machines nog rendabeler kunt maken."* [17]

Another example is firm B. They need constant feedback from production in order to keep learning and ultimately receive production orders instead of R&D projects. Further, firm A is the only firm that provides a relatively large amount of services, both product-oriented and business model-oriented. They offer high cost and low volume machinery with a relatively high profit margin. However, respondent A also acknowledges the importance of information from production processes. They continuously measure their processes and performance to keep improving. He states the following:

> *"Dit is een continu proces wat gaande is, en daarin zie je ook dat data steeds meer leading wordt voor ons productieproces. Voor ons maar ook voor onze klant."* [18]

This shows that they use their information not only for internal process optimization, but also to increase the value proposition towards customers.

The interviews indicate that the R&D department is only moderately used as an internal source for new information. Firm A and F use R&D to innovate and consequently increase their value proposition through new products or services (i.e. technology push). For example, on the question if firm A offers upgrades for new functionalities, respondent A answered:

> *"Uiteraard doen we dat ook. Dat heeft deels te maken met de wensenlijst. Of het kan ook ontstaan dat wij iets nieuws ontwikkeld hebben."* [19]

Other firms, such as C and E do not even have an independent R&D department. Their innovation takes place in the engineering phase of new products, often in cooperation with customers to optimally meet the demands. The manufacturing firms are noticing a shift from being suppliers to becoming partners.

Finally, the theoretical definition of internal sources is compared to how it is empirically validated. According to theory (e.g. Svetina and Prodan (2008)), in-house research and development and the production department are important internal sources for new information. In practice, the internal sources for new information are only limited to the internal production department and R&D departments. However, the internal sources are definitely not as important as theory stated. When taking into account table 6 (internal sources), it becomes clear that the vast majority of the respondents indicate that internal sources, especially production, are used to internally improve products and production processes, whereas new information for new product or service development is mainly gathered from other sources. This would suggest a rejection of H1.

5.2.2.4 External sources of information

As stated in theory, new information mostly exists outside organizational boundaries and can provide information where internal sources cannot (Mol & Birkinshaw, 2009). Moreover, in literature customers are starting to be recognized as a valuable, if not the most valuable source for new information. For the interviewed firms, customers are by far the most important and most used source for new information. Information from customers is mainly related to their needs and wants in order to at least partially customize the value proposition for every customer. This value proposition often contains both physical products and services. However, information from customers is mainly focused on the engineering of products (e.g. technical specifications, design, etc.), not services. This is mentioned by firms C, D, E and F. For example, respondent D mentioned that they want to combine their internal information with information from customers in order to define better product together. On the contrary, firm B communicates with customers mainly for business information. Technical information is either gained from internal sources, suppliers or other business partners. Further, only firm A uses a significant amount of information from customers to develop and adopt services. They are woven into the processes of many of their customers and need that information to be able to offer that full solution. As seen in table 7, they get that information from assessments. This provides them with insights into customers' processes and performances in order to improve them.

Although other sources (such as suppliers, competitors, trading fairs and universities) are mentioned, they seem less important for specific information. Those sources are often used to get a general idea of market trends, upcoming technologies, new materials, etc.

Table 7: Application of external sources of information

Firm	External sources of information
A	Op voorhand doen we die assessment. Dat is om te kijken hoe de processen door het bedrijf heenlopen en die processen hebben te maken met de utilization van jouw equipment. Bij de industriële klanten […] kunnen we kijken wat de performance van onze machines zijn. Voorheen waren we alleen maar suppliers en nu ben je meer partner.
B	Omdat we toch veel kennis hebben, en zij nul kennis op het gebied van zonnepanelen, is het helemaal niet voordelig om op technisch gebied met klanten te sparren. [Dit gaat om] klantwensen. Je hebt allerlei cellenfabrikanten en daar heeft [collega 2] overal contact mee [voor technische informatie].
C	Vaak is het zo dat als je vooraan in die ontwikkelingen meedoet, dan heb je veel meer kans om later een productieopdracht te krijgen. [Dit komt] meestal vanuit de klant.
D	End users zijn een hele belangrijke informatiebron. Zij laten ons heel goed zien van: oké hoe werkt het in een applicatie, in een proces. Maar uiteindelijk ook de OEM natuurlijk die zeggen welke nieuwe designs ze willen. Dan ben je veel beter verbonden met je klant in hun processen. Plus […] de marktinformatie van wat er gebeurt in de markt en waar het naartoe gaat, en wat betekent dat voor de producten en materialen voor verbeteringen.
E	Door middel van accountmanagement weten we wat er bij de klant speelt, en door er dicht tegenaan te zitten en echt hulpgericht te zijn. Je zult zien dat wij steeds meer verbonden raken met onze klanten en dat we steeds dichter in elkaar schuiven met die klanten om ons productieproces te koppelen aan hun behoefte. Wij zijn echt een productiepartner, dus je bent doorlopend met elkaar in gesprek en kijken of je de keten efficiënter, rendabeler kan maken.
F	Als ik kijk naar onze commerciële trajecten dan ligt onze informatiebron veel meer bij de klant die al een productontwikkeling in gang heeft gezet en die heel concreet met een ontwerp komt voor een chip die ze willen laten maken. Dan zitten we meer al op engineeringniveau te praten dan op fundamenteel niveau. Wanneer wij concrete feedback van onze klanten krijgen, […] dan is het op aangeven van de klant dat wij hun product proberen te optimaliseren. [Markt]informatie is voor ons natuurlijk ook weer relevant om te zien hoe wij ons kunnen positioneren in de markt en waar onze volgende generatie technologieontwikkeling naar toe moet.

The process of axial coding provides more detailed and in-depth results of the substance in practice. The results give an indication of relative importance of certain external sources in combination with specific examples from reality. Within the axial code ‘external sources of information’ the open code ‘customers as an external source of information’ is used two-thirds (67,9%) of the time. This clearly shows how important the customers are for the interviewed firms. The second most used open code here refers to the industry as an external source (17,3%). This code, however, can be seen as an overarching concept of many sources, such as competitors, suppliers, trading fairs and universities, although not directly mentioned. Together, those parties define the industry standards. The other 14,8% is directly related to either suppliers, trading fairs, universities or competitors (respectively from most to least mentioned).

As stated previously, firms C, D, E and F use customers as the primary source for new information. According to them, early involvement is very important to increase the amount of information and therefore be able to offer what the customer needs. As an example, this is mentioned by respondent C:

"Vaak is het zo dat als je vooraan in die ontwikkelingen meedoet, dan heb je veel meer kans om later een productieopdracht te krijgen. Want je hebt ervaringen, je weet waarom je iets gedaan hebt" [20]

and respondent E:

"Waarbij wij, zeg maar, meer aangekoppeld zijn als productiepartner en door middel van early involvement, zeg maar, de aansluiting vinden en hun van kennis voorzien over produceren." [21]

However, communication between manufacturing firms and customers exceeds the early phase. The role of many of the interviewed firms is changing from being a supplier to being a (production) partner. A partner has insights into and sometimes even influences on customers' internal processes in order to optimally design a custom value proposition. The dominant element of the value proposition is still physical products, though. For instance, firm F tries to cooperate with customers more and more in order to improve product development:

"Wij proberen wel steeds meer met onze klanten mee te denken, van: 'je zou ook die kant of die kant op kunnen gaan, dit is ook mogelijk'. Dus wij helpen onze klanten wel bij het bedenken en designen van hun producten, dat zeker wel." [22]

Firm A is the only firm that made a significant shift in the way they provide value and thus the way they use customers as a source. They shifted from being a supplier of machines to being a partner with almost complete insights into and even certain influences on customers' internal processes. Provision of a full solution (machinery and services) to unburden the customer is their company strategy and that defines the importance of external information from customers. That full solution is not only their value proposition, but also their means to gather new information (e.g. through services and digital technologies):

"Die assessments doen we natuurlijk om bedrijven te helpen, maar tevens hebben we ook een kijkje in de keuken bij die bedrijven. En alle bedrijven hebben een eigen denkwijze en werkmethodiek. En er zitten natuurlijk veel overeenkomsten in heel veel dingen, maar ook daar leren wij van, zowel goed als slecht." [23]

At firm A approximately 80% of the axial code 'external sources of information' is related to customers.

Other external sources that are mentioned in the interviews are the industry, competitors, suppliers, trading fairs and universities. For example, firm B indicates that continuous contact with (potential) suppliers is very important for new information on research and development on solar panels. Further, firm D gets product-related information from competitors through their

repair service, as they also offer to analyse and repair defective products from direct competitors:

> *"We krijgen informatie uit... van onze concurrenten, […] omdat we concurrerende producten repareren en uit analyses kunnen we daar ook informatie uit destilleren."* [24]

Moreover, firm F communicates with universities or other research institutes when they jointly start a fundamentally new project. The information from these sources is often related to science and literature, and is used to explore new technologies. Lastly, firms B, C and F specifically mention conferences and trading fairs as an external source (or event) for new information. For example, firm F states:

> *"Normaal gesproken hebben we maandelijks wel ergens een event, ergens in de wereld. En ook daar putten we natuurlijk veel informatie uit, want ook dan zien we waar onze klanten, leveranciers en concurrenten mee bezig zijn. En die informatie is voor ons natuurlijk ook weer relevant om te zien hoe wij ons kunnen positioneren in de markt en waar onze volgende generatie, zeg maar, technologieontwikkeling naar toe moet."* [25]

The application of external sources of information and specific examples from practical situations imply that customers are the most valuable source for information. This is rather similar to what theory states; namely that customers are a valuable, if not the most valuable source for new information. For example, the role of manufacturing firms is shifting from being a supplier to being a partner. By being a partner, the manufacturing firm is internally involved in customers' processes and therefore knows customers' needs and wants. New information mostly exists outside organizational boundaries and can provide information where internal sources cannot (Mol & Birkinshaw, 2009). Thereby, theory in chapter 3 states that other external sources are competitors, suppliers, research institutions and other firms in general. This also corresponds to the results, because suppliers, competitors, universities and trading fairs are all mentioned as important sources to gain information on trends and needs in the market. This suggests that H2 must be supported.

5.2.2.5 Digital solutions

While Industry 4.0 emerged, its first aim was to increase the value of internal processes through digital technologies. However, as described in chapter 3, opportunities arose by incorporating these technologies into services to increase the value of services for customers while serving as a means to gather information from customers (i.e. what value means for them). A perfect example of a manufacturing firm that took those opportunities is firm A. As seen in table 8, the ultimate goal of firm A is for customers to have a 'lights out' factory. They try to facilitate

herein by offering both high-tech machinery, as well as high-tech services in order to unburden the customers as much as they can.

In contrast, the other firms that were interviewed are not on that level of digitalization (yet). For instance, firm C, E and F indicate that digital solutions are solely used to develop and optimize internal production and administrative processes. Although this affects customers indirectly, direct effects of digitalization through services are not pursued on the short-term. Firm D also completely focused on manufacturing and administrative processes as of yet. However, respondent D indicated that their next phase of digitalization will focus on service provision. Last, respondent B simply indicated that their firm is too young and inexperienced to be digitalized. Although some adoption of digital solutions can be seen, it is in early stages and predominantly takes place in the production process.

Thus, in reality the small and medium-sized manufacturing firms are not as developed as theory suggests. The firms find themselves in an early stage of digitalization, according to theory. An exception is firm A, but it is important to mention that they have significantly more employees than the other firms and are the only firm in the machinery sector (where service provision is higher than other sectors).

Table 8: Application of digital solutions

Firm	Digital solutions
A	[Ons doel met betrekking tot digitalisering is] dat klanten een 'lights out' factory hebben.
B	[Firm B heeft] nog niet echt veel data. [Het bieden van remote services] ligt natuurlijk helemaal aan de schaal, maar voorlopig [doen we dat] nog niet. [In productie] zijn we daar wel mee bezig, maar nog niet echt als toepassing nu.
C	Wij hebben de strategie, de filosofie, dat daar over, ik noem maar, vijf jaar, dat wij helemaal 4.0 werken. Wij kopen robots, wij kopen machines, en het wordt allemaal intern aan elkaar geplakt en gekoppeld en geprogrammeerd en zo. Maar die robots worden allemaal ingezet in productieprocessen
D	Dus de hele digitalisering is geconcentreerd eigenlijk op het maken van producten en business processen. de volgende fase in heel ons digitalisering, dat is in teken tot service.
E	Je zult zien dat wij steeds meer verbonden raken met onze klanten en dat we steeds dichter in elkaar schuiven met die klanten om ons productieproces te koppelen aan hun behoefte.
F	Op het moment dat het product onze fabriek verlaat, houdt voor ons in feite datamanagement ook op. Bij ons ligt de nadruk op ons interne proces... om ons fabricageproces en ontwikkelproces te optimaliseren, zijn die digitale diensten heel belangrijk. Ook om aan de strenge eisen te voldoen die onze ISO-normering van ons vraagt. Dus een klant heeft een veel snellere feedbackcurve wanneer er iets dreigt mis te gaan.

To gain a better understanding of the practical meaning of digital solutions, the axial codes 'digital services' and 'digital technologies in production' are used to analyze the interviews. Similar to how theory on digitalization started, this section starts with the firms that adopt and integrate digital solutions in their own internal processes. This is mainly done in order to reduce

the cost price of products and to ensure reproducibility of complex products, sometimes even to become a 'lights out' factory (i.e. no human interaction needed):

> *"Wij hebben de strategie, de filosofie, dat daar over, ik noem maar, vijf jaar, dat wij helemaal 4.0 werken, […] waar hier de gietdelen aan de achterkant ingereden werden in het automatisch magazijn, waar een robot zelf het product pakt, naar de cel toe loopt, met behulp van bin picken […] die producten pakt, op machines legt en daarna ook weer afvoert."* [26]

For manufacturing firms, the concept of digitalization is highly related to the question of which production processes can be subject to automation. Automation of those processes reduces labour costs to a large extent, which is desired as employees are a relatively expensive resource in The Netherlands. For example, firm D actively searched for production processes that could be automated:

> *"Wij hebben ons eerder geconcentreerd eigenlijk over onze hele productieprocessen, wat we daar kunnen automatiseren en digitaliseren."* [27]

Firms are to a much lesser extent focused on utilizing digital technologies for collecting and analysing information from customers. The common argument is that it is simply not yet desired, either at the manufacturing firm or the customer. Respondent F mentioned this in the interview:

> *"Wij zijn een OEM leverancier en als wij ook nog eens zouden moeten gaan bijhouden wat de resultaten van onze producten nou uiteindelijk in de applicatie doen bij onze klanten met een klantendatabase van honderden klanten, dan wordt voor ons... wordt het einde zoek. Juist omdat wij custom specifieke producten leveren, willen wij daar eigenlijk niet naartoe, want ieder product is weer anders. Als wij een standaard product zouden leveren en dat onder eigen brandname zouden... naar onze klanten zouden sturen, dan is het iets anders want dan heb je die gegevens nodig voor de optimalisatie van je product."* [28]

Although this does not mean that exploration for upcoming opportunities and use-cases are being ignored. Firm B is a young firm with relatively few investment possibilities, yet willing to investigate digital solutions in service provision if customers want this and if it is on a large enough scale. Moreover, respondent D explicitly mentioned that this is their next phase of digitalization:

> *"De volgende fase in heel ons digitalisering, dat is precies wat jij zegt in teken tot service."* [29]

On the contrary, firm A is the only firm that facilitates digitalization in customers' processes through their product and service offering. Digital technologies in combination with service provision allows firm A to collect the information that is needed to give customers as much insight (i.e. information) into their own processes as possible. According to respondent A, that is the purpose of collecting and analysing data from customer processes:

> *"Ik kijk altijd naar de company values. Dat is een beetje voor de hand liggend: dus de flexibiliteit, kwaliteit, dat is een hele brede. Dan heb je continuïteit. En dan heb je inzichtelijkheid, visibility. En die laatste, dat is nu een slag die nu gaande is in productieland."* [30]

The majority of data is collected through digital technologies that are integrated into machines, the products of firm A. However, other digital solutions are integrated into services. Respondent A explicitly mentions digital planning software, product traceability and remote monitoring as current digital solutions. Also, remote maintenance is suggested multiple times, but not yet included in their service portfolio. Furthermore, they offer consultancy to firms that find difficulties in utilizing digital technologies. Respondent A concluded with the statement that in the electronic manufacturing sector, firms must be or quickly become software-driven to stay competitive.

> *"In de elektronicaproductie-industrie daar ben ik van mening, maar ook collega's van mij, als bedrijven niet software-driven zijn binnen de aankomende drie tot vijf jaar, kun je niet meer mee met je kostprijs."* [31]

When comparing the theoretical definition of digitalization to the empirical validation, it shows that theory is further than practice. In short, most manufacturing firms are still in a relatively early phase of digitalization, considering how developed digital technologies itself already are. An important reason for this phenomenon is simply related to firms' priorities still being focused on product and production processes development in contrast to service development. Only firm A is experienced in frequent service provision through digital solutions. Besides industry 4.0, theory is also starting to connect digitalization to other research areas, such as servitization. In practice, this connection is still mostly non-existent at small and medium-sized manufacturing firms. In short, the main purpose of digital solutions is to reduce the cost price of products and to improve reproductivity of products. Sometimes, these technologies are also used to enhance service provision, although it is not its main purpose. However, this suggests that digital solutions have a direct positive effect on service provision,

rather than synergizing the impact of internal sources on product-oriented and business model-oriented services. Therefore, qualitative results suggest a rejection of H4 and H5.

5.2.3 Hypotheses

In this section the hypotheses that were proposed in chapter 3 will be discussed. The analysis of each variable consisted of the application of the variables for the interviewed manufacturing firms, followed by a detailed explanation using the substances in practice and finally a comparison with theoretical characteristics. These results will now be brought together to support or reject the hypotheses.

In the first hypothesis (H1) it is proposed that the amount of internal sources of information has a positive impact on the amount of product-oriented services offered. To test this, the application (table 4) and substance in practice (axial codes) of product-oriented services is used to determine the amount of product-oriented services that the manufacturing firms offer. Additionally, table 6 and the axial codes related to internal sources show which internal sources are used and its purpose. The focus of product-oriented services on engineering and product development, and internal sources being used for product and process optimization indicate that H1 must be rejected.

H2 proposes that the amount of external sources of information at small and medium-sized manufacturing firms has a positive impact on the amount of product-oriented services offered. As previously described, table 4 and the axial codes indicate that the nature of the product-oriented services that are offered can be described as demand-pull. Thereby, table 7 (external sources) shows that customers are by far the most important source of information. They provide all kinds of information to which manufacturing firms can act. Concluding, qualitative results indicate that external sources are used significantly more in order to provide product-oriented services than internal sources. Hence, H2 is supported.

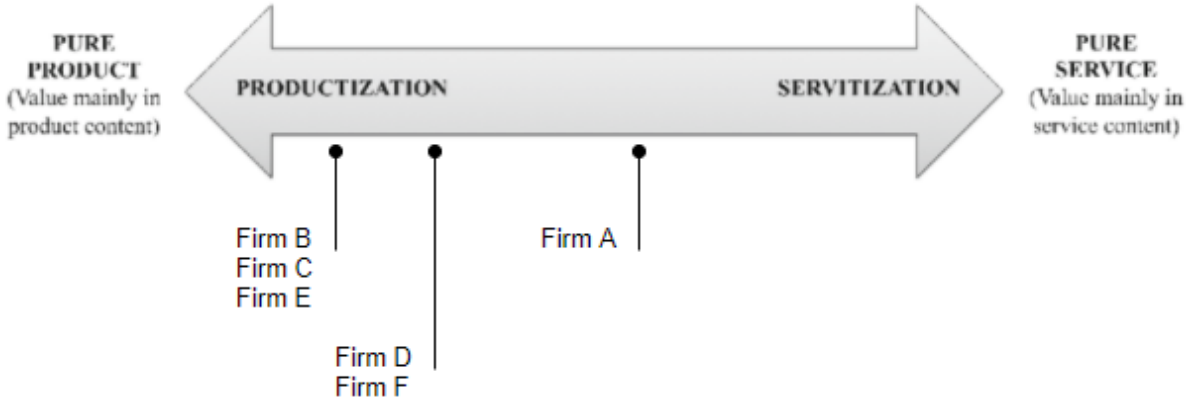
Consequently, the application and practical meaning of business model-oriented services is used to determine the amount of business model-oriented services that the interviewed firms offer. Namely, H3 proposes that the amount of external sources of information also has a positive impact on the amount of business model-oriented services offered. Although stated that external sources of information, especially customers, are important to define the value of utilization of products, only one interviewed firm actually defines this value. The other firms utilize external sources for other information, as it is not used to adopt and provide business model-oriented services. Thus, H3 must be rejected based on qualitative results.

Finally, it is expected that digital solutions have a positive interaction effect on the impact of (a) internal sources and (b) external sources on the amount of product-oriented services offered (H4a and H4b, respectively). Moreover, it is expected that they have a positive interaction effect on the impact of external sources on the amount of business model-oriented services offered (H5). The application and the substance in practice of digital solutions clearly show that the vast majority of the interviewed firms have their digitalization strategy focused on internal processes, especially production processes. There is no empirical evidence for this interaction effect and therefore H4a must be rejected. In a similar manner, the majority of interviewed firms do not gain an increasing amount of external information due to their digital solutions. An evident exception here is firm A. Their digital solutions give them the opportunity to have insights into customers' processes. This information enables them to fit their service provision (both product-oriented and business model-oriented) to customers' needs and wants. All in all, the empirical evidence leads to a rejection of H4b and H5, although the single case of firm A suggests otherwise.

5.3 Integration of results

As described in chapter 4, the research strategy of this study is to integrate the quantitative and qualitative research approach in the result section. The aim is to measure effects through the analysis of a survey database of 203 manufacturing firms, while gaining a better understanding of the underlying processes through semi-structured interviews at 6 manufacturing firms. When looking at the descriptives, there are many similarities between results. Quantitative analysis shows that firms offer an average of two to three (2.547) product-oriented services and far below an average of one (0.373) business model-oriented service. Regarding product-oriented services, the interviews indicate that the average is rather similar, although the focus is mainly on the presale phase (e.g. co-engineering). Business model-oriented services are only offered by one out of six interviewed firms and another firm experimented with these services, but did not succeed. Here, the average is also far below one business model-oriented service. It is important to mention that the only firm that offers these services, while also offering significantly more product-oriented services than average, is active in the machinery sector. The control variables in quantitative analysis show that manufacturing firms in this sector offer far more services than manufacturing firms in other sectors.

Figure 2: Estimated position of manufacturing firms on the product-service continuum



Next, the product-service continuum (Oliva & Kallenberg, 2003) can be used to identify to what extent services derive value in each interviewed firm (see figure 2 for estimated positions of interviewed firms on the product-service continuum). Based on the amount of services that are offered and their reasoning, firm C and E (metal sector) can be placed on the far left side of the continuum. Firm B can also be placed on the left side of the continuum as its core activity for value creation is through R&D projects and production afterwards. The core value proposition of firms D and F (electronics sector) are also still highly related to their products, but these firms also actively generate revenues from services. In short, firms D and F are positioned slightly more to the right compared to firms B, C and E. Then, according to respondent A, firm A and their customers are already depending on software and services and the dependency will only increase. This suggests that firm A can be positioned in the left half of the continuum and is slowly moving to the right side. Respondent A described the practical process of servitization at firm A nicely:

> *"Er is nu een kantelpunt, wat je nu ziet in de industrie, voorheen waren we alleen maar suppliers en nu ben je meer partner. Voorheen werd er alleen een machine geleverd en nu wordt er een oplossing geleverd."* [10]

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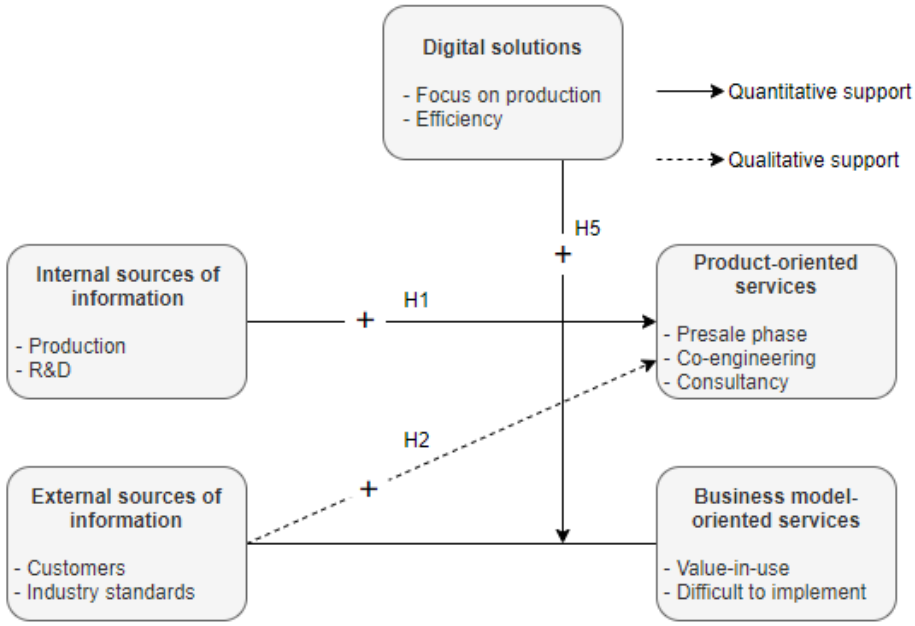
Figure 3: Integrated model



Note i: only significant hypotheses are included in this figure.

Note ii: the keywords describe the construct focus in practice, based on qualitative results.

Ultimately, the hypotheses are discussed by integrating the conclusions of quantitative and qualitative results (see figure 3 for an integrated empirical model). Remarkably, the role of the information sources differs between approaches. Namely, the quantitative results support H1 (hence, a positive effect of internal sources on product-oriented services) and reject H2 (hence, no positive effect of external sources on product-oriented services). On the contrary, for qualitative results the opposite applies – rejection of H1 and support for H2. The interviews indicate that the majority of firms use internal sources of information to internally improve products and production processes and therefore internal sources would only have a minimal impact on the amount of product-oriented services offered. As the strength of the quantitative relationship between these variables was already only moderate, integration of results suggests that this relationship is relatively weak. Additionally, qualitative results show that external sources are more important for new information than internal sources. Although other sources are mentioned in interviews, it is specifically customers that excel as a source of information, similar to what theory recognizes. During quantitative data collection, however, customers only counted as one category. This does not show the level of importance of customers as a source. Thus, quantitative analysis shows no significant relationship between external sources and product-related services, while qualitative analysis shows a high degree of importance of customers' information to determine needs and wants.

Next, H3 is rejected based on both the quantitative as well as qualitative results. This is most likely caused by the fact that very few manufacturing firms offer business model-oriented services. Qualitative results show why this is the case. Namely, many manufacturing firms produce consumable products or components, which are very difficult to offer through value-in-use models instead of the traditional business model (i.e. value exchange).

Last, the interaction effects of digital solutions are analysed through H4 and H5. Overall, H4a and H4b must be rejected. Quantitative results show that digital solutions do have a significant interaction effect on the impact of internal sources on product-oriented services, but this effect is negative which is opposed to what is hypothesized. No significant interaction effect exists on the impact of external sources on product-oriented services. No empirical evidence was found through qualitative research on these effects either. Digital solutions are mostly integrated in internal processes to become more efficient. This could be a reason for the negative interaction effect, as manufacturing firms fully focus on optimizing internal processes and therefore develop a tunnel vision hereon.

H5 is supported by quantitative results, although the interaction effect is only moderately significant. However, qualitative results show that only one of the interviewed firms offer business model-oriented services, and digitalization is mostly focused on production, not service provision. Hence, H5 is rejected based on qualitative results. Despite the rejection, firm A (active in the machinery sector) is a great example of a manufacturing firm that utilizes digital solutions to enhance the impact of external sources on service provision. Concluding, overall the interaction effect is relatively weak, but this effect could be more significant for manufacturing firms in the machinery sector.

6 Conclusion and discussion

This study examined the role of information sources at manufacturing firms in order to provide services. Further, it is examined to what extent digital solutions have an impact on this relationship. The aim of this chapter is to present the findings regarding this research topic, based on a mixed method approach. This chapter begins with a summary of the results by giving an answer to the research question. The next section provides the contributions of this study to theory, followed by several managerial implications. Then, the limitations of this study are elaborated, including suggestions for future research. Finally, the ethical considerations that played a role during this research are described.

6.1 Summary

This study began with theory stating the importance of information in the revolution towards the "New Economy" (Pohjola, 2002). During this revolution, manufacturing firms started to change their way to create value. Manufacturing firms started to think of combinations of products and services to increase the value offering. Different types of services emerged and this study distinguished two general types – product-oriented services and business model-oriented services. In this research, it is expected that information, which can come from both internal and external sources, is a key factor in order to develop and provide these services. To research this expectation, the following research question is composed:

- To what extent do internal and external sources of information at manufacturing firms have an impact on the amount of product-oriented services and business model-oriented services that they offer?

To answer this question, a conceptual model is proposed that includes a total of five hypotheses regarding the impact of information sources on the amount of services offered. The hypotheses are tested using two approaches – a quantitative and qualitative method.

Although there is a consensus on the general positive impact of information sources on service provision, contradictions are found in which information sources (i.e. internal and external) have this positive impact. The quantitative results support theory on the proposition that internal sources of information have a positive impact on the amount of product-oriented services that are offered by manufacturing firms (H1). Similarly, research on innovation argues that internal sources of information are important, where the development and provision of product-oriented services are seen as incremental innovations at manufacturing firms. Such innovations are partly driven by in-house R&D and continuous improvements through

information from production processes (Svetina & Prodan, 2008; Thorpe et al., 2005). Despite the arguments, qualitative results contradict theory by showing no significant importance of internal sources. These results indicate that in practice internal sources of information are barely used to develop and provide services.

The importance of external sources of information for service provision is also being recognized by theory, as new information mostly exists outside firms' boundaries (Damanpour, Sanchez-Henriquez & Chiu, 2018). Mol and Birkinshaw (2009) state that these sources are often required to innovate. More specifically, these sources are needed for both incremental innovations (product-oriented services) and radical innovations (business model-oriented services). These theoretical arguments cannot be confirmed by quantitative results. In practice, however, this relationship is partly confirmed. All interviewed firms mention customers as their most important source for new information. Regarding service provision, this information is predominantly used to offer product-oriented services. Business model-oriented services are not offered by the interviewed firms, except for firm A. Based on qualitative results, external sources of information (mainly customers) positively impact the amount of product-oriented services (H2).

An additional corresponding finding from both methods is the empirical validation that manufacturing firms in the machinery sector offer significantly more services. Qualitative results even show that product type (e.g. components, consumables, durables) determines service provision to a large extent.

Furthermore, this study examined the role of digital solutions in the collection of information, because Frank et al. (2019) state that they can facilitate or enhance the collection of information regarding customers' behaviour and product usage (e.g. through Internet of Things or big data analysis). Consequently, the following subquestion is proposed in this study:

- To what extent do digital solutions assist in the collection of information?

Quantitative results imply that digital solutions enhance the effect of external sources on the amount of business model-oriented services that are offered (H5). This is strongly contradicted by qualitative results, because in practice the manufacturing firms use digital solutions mainly for improving efficiency and streamlining internal production processes, not to improve service provision or information gathering. Firm A is an exception here.

6.2 Theoretical contributions and managerial implications

The resource-based view of the firm (e.g. Barney, 1991) mainly acknowledged the importance of internal sources for innovation on products and services. Later on, while the availability of

information and technologies emerged, the knowledge-based view of the firm emerged simultaneously which recognizes the importance of information from external sources too (e.g. Mol & Birkinshaw, 2009). This study uses the knowledge-based view of the firm to contribute to theory on servitization, first introduced by Vandermerwe and Rada (1988). More and more manufacturing firms rely on service provision to survive (Nijssen et al., 2006) and information plays an important role here. A conceptual model is proposed to gain insights into how information sources impact service provision. Specifically, two distinctions are made – information sources are divided into internal and external sources of information, and services are divided into product-oriented services and business model-oriented services.

In general, theory on servitization and digitalization has a relatively well-developed perspective on how manufacturing firms address these topics. Studies are mainly focused on large and successful firms, such as IBM and General Electric. Both the quantitative and qualitative results in this study show that the opposite is true for many small and medium-sized manufacturing firms. Their strategies regarding servitization and digitalization are far less developed than theory suggests, if they have a strategy at all. The product-service continuum in figure 2 shows the low amount of service provision in practice. This study shows a mismatch between theory and practice, where theory is far more developed than how manufacturing firms act in practice. An interesting topic of research for future academics is to study this mismatch and its cause, in order to potentially develop implementation or change strategies for manufacturing firms that are now clueless.

Despite the mismatch, the mixed method approach in this study also shows specific similarities. For instance, results from the survey correspond to the resource-based view of the firm, namely that information that comes from within the firm positively impacts the amount of product-oriented services. In practice, this would implicate that manufacturing firms can use their internal sources (e.g. production departments, R&D departments, managers) for new information in order to increase their service offering. Additionally, theory suggests that digital solutions would enhance this relationship. Remarkably, quantitative results contradict this proposition completely as they show a negative interaction effect. A possible explanation could relate to an information overload, where digital technologies collect too much information for small and medium-sized manufacturing firms to comprehend. Firm C and D also shortly mention this phenomenon. Before investing in digital solutions, manufacturing firms should compose an information management strategy in advance, where they define the type of information that they need. Such a strategy is closely related to absorptive capacity theory (e.g.

Ritala & Hurmelinna-Laukkanen (2012)), which determines to what extent firms are able to acquire and utilize information and subsequently create value from this information.

An information management strategy should also include information from external sources. Namely, Johansson, Raddats and Witell (2019) now recognize the importance of customers as information sources, as they argue that firms interact with customers for a relatively long time, which allows them to generate a lot of information about them. The interviews confirm this argument, as they show that manufacturing firms rely heavily on information from external sources, especially customers. Manufacturing firms shift toward a production strategy where they at least partly customize products and services. Most interviewed firms collaborate with their customers or even become production partners in order to learn customer needs and preferences. Mainly, the purpose of this close collaboration is specifically aimed at product-oriented information and therefore only benefits product-oriented services (e.g. co-engineering). As expected, empirical evidence shows that business model-oriented services are offered to a lesser extent. Theory argues that this relates to the need of a radical change in the business strategy in contrast to incremental changes for product-oriented services. Qualitative findings confirm that manufacturing firms have difficulties in developing business model-oriented services, while customers have difficulties in adapting to them. Firm D tried to implement an alternate business model-oriented service, but did not succeed as it did not work for them and their customers. Thus, it shows that service development and provision is an innovative process, either incremental or radical, that comes with uncertainties, especially for manufacturing firms that have to deviate from their regular way of doing business and communicating, which often still revolves around the transactional model.

Additionally, the findings show that successfully offering these services also depends on the type of product that is offered. Therefore, manufacturing firms should have their service strategy clearly defined, preferably with customers, before exploring and implementing business model-oriented services. It is important to mention that offering these services cannot be seen as a plug and play strategy, as they do not synergize with every firm, customer or product. For instance, this study shows that business model-oriented services fit very well in the machinery sector with durable products (machines), yet hardly works for manufacturing firms that produce consumable products or components.

Lastly, the interaction effect of digital solutions on the relationship between external sources and business model-oriented services is positive and significant, according to quantitative results. This is also clearly shown by firm A through their strategy of collecting information from customers, including assessments and periodically timed quality reports based

on digital data. This gives manufacturing firm A insights into the utilization of their products (machines) by customers in order to define the value of utilization and subsequently change their way of offering these products. Theory states that manufacturing firms should learn customers' needs and be adaptive to it. Digital solutions could facilitate this process if utilized correctly and in cooperation with customers. Respondent A and his colleagues even explicitly claim that firms should be software-driven in the next three to five years (at least in the electronic machinery sector) to be able to compete with competitors regarding cost prices. Respondent E, however, adds to this that it is very important for them to become more personal to customers in order to keep seeing and meeting each other, as life becomes more digital. This would strengthen the relationship between two partners – a manufacturing firm and its customer.

6.3 Limitations

This study took a mixed method approach of both quantitative and qualitative elements. The aim has been to use quantitative testing of hypotheses as well as qualitative exploration in practical circumstances. This compensated the weaknesses of one method with the strengths of the other. They complement each other in the way that quantitative analysis assumes the average manufacturing firm, while qualitative analysis shows the outstanding differences between firms. More specifically, generalization of results is sought through regression analyses, while semi-structured interviews provided more detailed understandings of the constructs and its relationships in practice. As this is a cross-sectional research, it represents a snapshot of a single moment and therefore no causality can be concluded. To gain a deeper understanding of the development process of servitization at small and medium-sized manufacturing firms, academics should conduct a longitudinal study in the future. Moreover, it should also be noted that the results in this study cannot be generalized across settings, due to a national nature of the sample. In the future, researchers could take into account cultural aspects by including manufacturing firms from multiple continents or countries.

Additionally, the reader should bear in mind that the quantitative parts of this study are based on a database from an existing questionnaire. This means that the questions are not specifically composed for this study and therefore may have influenced the reliability of the regression analyses. For instance, future research should include the product type into the questionnaire as qualitative results indicate that this is an important variable that determines service provision at manufacturing firms. An effective option would be to control the model for product types.

Regarding the qualitative method, it is important to mention that during the interviews, there were no direct questions that addressed the relationships between constructs that were proposed. The interpretation of results is based on the application and substance in practice of each construct and the relationships that were found during analysis. Including questions that directly address the relationships could improve reliability in future research. Thereby, the coding of transcripts is done by the researcher itself. The reliability of this study would be higher if the process of coding was tested on reproducibility by conducting this process by multiple people. In short, this study lacks intercoder reliability of qualitative data. Last, four out of the six interviews were done through video calls due to practical constraints. Video calls lack a large amount of nonverbal communication, which could have a negative influence on the analysis of the interviews due to potential misunderstandings.

6.4 Ethical considerations

A requirement for research is to conduct it responsibly. This is achieved by following an ethical protocol. First, theoretical references are based on articles from peer-reviewed journals. The reference list is carefully verified to secure that every author is referenced. Also, all sources and methods that are used to obtain and analyse data is fully included in this study. There is no deliberate misinterpretation of results and no data is excluded. Then, the semi-structured interviews are planned ahead in consultation with respondents. Location (or video call) and date of the interviews are decided according to respondents' preferences by phone or e-mail. Before the interviews, the topics and confidential issues of the interview and research are clearly elaborated in order to align them with respondents' demands. The data is used confidentially by fully anonymizing the transcripts and deleting audio recordings afterwards. Also, after the interviews it is secured that no confidential information is included in this study if not desired by the respondent.

References

Abernethy, M. A., Chua, W. F., Luckett, P. F., & Selto, F. H. (1999). Research in managerial accounting: Learning from others' experiences. *Accounting and Finance, 39*, 1–27.

Ardolino, M., Rapaccini, M., Saccani, N., Gaiardelli, P., Crespi, G., & Ruggeri, C. (2017). The role of digital technologies for the service transformation of industrial companies. *International Journal of Production Research*, *56*(6), 2116–2132.

Baines, T. S., Lightfoot, H. W., Benedettini, O., & Kay, J. M. (2009). The servitization of manufacturing. *Journal of Manufacturing Technology Management*, *20*(5), 547–567.

Baines, T. S., Lightfoot, H. W., Evans, S., Neely, A., Greenough, R., Peppard, J., … Wilson, H. (2007). State-of-the-art in product-service systems. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *221*(10), 1543–1552.

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99–120.

Bleijenbergh, I. (2015). *Kwalitatief onderzoek in organisaties* (2nd ed.). Den Haag, Nederland: Boom Lemma.

Boeije, H. (2005). *Analyseren in kwalitatief onderzoek: denken en doen*. Amsterdam, Nederland: Boom onderwijs.

Bubou, G. M., & Amadi-Echendu, J. E. (2018). The relationship between knowledge management practices and innovativeness: Insights from petroleum firms in Nigeria. *International Journal of Technology Management & Sustainable Development*, *17*(2), 169– 182.

Chase, R. B. (1981). The Customer Contact Approach to Services: Theoretical Bases and Practical Extensions. *Operations Research*, *29*(4), 698–706.

Choo, C. W., & Bontis, N. (2002). *The Strategic Management of Intellectual Capital and Organizational Knowledge*. New York, NY: Oxford University Press.

Cohen, W. M., & Levinthal, D. A. (1990). Absorbtive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, *35*(1), 128–152.

Coreynen, W., Matthyssens, P., & Van Bockhaven, W. (2017). Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. *Industrial Marketing Management*, *60*, 42–53.

Creswell, J. W., & Clark, V. L. P. (2011). *Designing and Conducting Mixed Methods Research*. Thousand Oaks, Canada: SAGE Publications.

Cusumano, M. A., Kahl, S. J., & Suarez, F. F. (2014). Services, industry evolution, and the competitive strategies of product firms. *Strategic Management Journal*, *36*, 559–575.

Daft, R. (2001). *Organization Theory and Design*. Cincinnati , OH: South-Western.

Damanpour, F., Sanchez-Henriquez, F., & Chiu, H. H. (2018). Internal and External Sources and the Adoption of Innovations in Organizations. *British Journal of Management*, *00*, 1–19.

Ehret, M., & Wirtz, J. (2017). Unlocking value from machines: business models and the industrial internet of things. *Journal of Marketing Management*, *33*(1–2), 111–130.

Eriksson, M. L. (2005). *Organising regional innovation support: Sweden's industrial development centres as regional development coalitions*. Linköping University.

Flick, U., Kardoff, E., Steinke, I., von Kardoff, E., & Jenner, B. (2004). *A Companion to Qualitative Research*. Thousand Oaks, Canada: SAGE Publications.

Frambach, R. T., Wels-Lips, I., & Gündlach, A. (1997). Proactive product service strategies: An application in the European health market. *Industrial Marketing Management*, *26*(4), 341–352.

Frank, A., Mendes, G., Ayala, N., & Ghezzi, A. (2019). Servitization and Industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective. *Technological Forecasting & Social Change*, *141*, 341–351.

Gallouj, F., & Weinstein, O. (1997). Innovation in services. *Research Policy*, *26*(4–5), 537–556.

Gebauer, H., & Friedli, T. (2005). Behavioral implications of the transition process from products to services. *Journal of Business & Industrial Marketing*, *20*(2), 70–78.

Gebauer, H., Friedli, T., & Fleisch, E. (2006). Success factors for achieving high service revenues in manufacturing companies. *Benchmarking: An International Journal*, *13*(3), 374–386.

Greene, J. C. (2007). *Mixed Methods in Social Inquiry*. San Francisco, CA: Jossey-Bass.

Hahn, G. J. (2019). Industry 4.0: a supply chain innovation perspective. *International Journal of Production Research*, *58*(5), 1425–1441.

Hermann, M., Otto, B., & Pentek, T. (2015). Design Principles for Industrie 4.0 Scenarios: A Literature Review.

Ibarra, D., Ganzarain, J., & Igartua, J. I. (2018). Business model innovation through Industry 4.0: A review. *Procedia Manufacturing*, *22*, 4–10.

Ihantola, E., & Kihn, L. (2011). Threats to validity and reliability in mixed methods accounting research. *Qualitative Research in Accounting and Management*, *8*(1), 39–58.

Issa, A., Hatiboglu, B., Bildstein, A., & Bauernhansl, T. (2018). Industrie 4.0 roadmap: Framework for digital transformation based on the concepts of capability maturity and alignment. *Procedia CIRP*, *72*, 973–978.

Johansson, E., Raddats, C., & Witell, L. (2019). The role of customer knowledge development for incremental and radical service innovation in servitized manufacturers. *Journal of Business Research*, *98*, 328–338.

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a Definition of Mixed Methods Research. *Journal of Mixed Methods Research*, *1*(2), 112–133.

Joshi, A., & Sharma, S. (2004). Customer Knowledge Development: Antecedents and Impact on New Product Performance. *Journal of Marketing*, *68*(4), 47–59.

Keeble, D., Lawson, C., Lawton Smith, H., Wilkinson, F., and Moore, B. (1998). Collective learning processes and inter-firm networking in innovative high-technology regions. Working Paper 86, escr Centre for Business Research, University of Cambridge.

Kohtamäki, M., Parida, V., Patel, P. C., & Gebauer, H. (2020). The relationship between digitalization and servitization: The role of servitization in capturing the financial potential of digitalization. *Technological Forecasting and Social Change*, *151*, 119804.

Kowalkowski, C. (2010). What does a service-dominant logic really mean for manufacturing firms? *CIRP Journal of Manufacturing Science and Technology*, *3*(4), 285–292.

Kowalkowski, C., Windahl, C., Kindström, D., & Gebauer, H. (2015). What service transition? Rethinking established assumptions about manufacturers' service-led growth strategies. *Industrial Marketing Management*, *45*, 59–69.

Lenka, S., Parida, V., & Wincent, J. (2016). Digitalization Capabilities as Enablers of Value Co-Creation in Servitizing Firms. *Psychology & Marketing*, *34*(1), 92–100.

Lillis, A. (2006). Reliability and validity in field study research. In *Methodological Issues in Accounting Research: Theories and Methods* (pp. 461–475). London, United Kingdom: Piramus.

Luz Martín-Peña, M., Díaz-Garrido, E., & Sánchez-López, J. M. (2018). The digitalization and servitization of manufacturing: A review on digital business models. *Strategic Change*, *27*(2), 91–99.

Malleret, V. (2006). Value Creation through Service Offers. *European Management Journal*, *24*(1), 106–116. https://doi.org/10.1016/j.emj.2005.12.012

Mathieu, V. (2001). Product services: from a service supporting the product to a service supporting the client. *Journal of Business & Industrial Marketing*, *16*(1), 39–61.

McIntosh, M. J., & Morse, J. M. (2015). Situating and Constructing Diversity in Semi-Structured Interviews. *Global Qualitative Nursing Research*, *2*, 1–12.

Meyer, M. H., & DeTore, A. (2001). PERSPECTIVE: creating a platform-based approach for developing new services. *Journal of Product Innovation Management*, *18*(3), 188–204.

Mol, M. J., & Birkinshaw, J. (2009). The sources of management innovation: When firms introduce new management practices. *Journal of Business Research*, *62*, 1269–1280.

Müller, J. M., Buliga, O., & Voigt, K.-I. (2018). Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting and Social Change*, *132*, 2–17.

Nijssen, E. J., Hillebrand, B., Vermeulen, P. A. M., & Kemp, R. G. M. (2006). Exploring product and service innovation similarities and differences. *International Journal of Research in Marketing*, *23*(3), 241–251.

Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science*, *5*(1), 14–37.

Norman, D. A., & Verganti, R. (2014). Incremental and Radical Innovation: Design Research vs. Technology and Meaning Change. *Design Issues*, *30*(1), 78–96.

Nunnally, J. C. (1967). *Psychometric Theory*. New York, Verenigde Staten: McGraw-Hill Education.

Oliva, R., & Kallenberg, R. (2003). Managing the transition from products to services. *International Journal of Service Industry Management*, *14*(2), 160–172.

Oztemel, E., & Gursev, S. (2020). Literature review of Industry 4.0 and related technologies. *Journal of Intelligent Manufacturing*, *31*(1), 127–182.

Park, S., & Huh, J.-H. (2018). Effect of Cooperation on Manufacturing IT Project Development and Test Bed for Successful Industry 4.0 Project: Safety Management for Security. *Processes*, *6*(7), 88.

Pavitt, K. (1998). Technologies, products and organisation in the innovating firm: What Adam Smith tells us and Joseph Schumpeter doesn't. *Industrial and Corporate Change*, *7*(3), 433–452.

Peterson, R. A. (1994). A Meta-Analysis of Cronbach's Coefficient Alpha. *Journal of Consumer Research*, *21*(2), 381–391.

Pohjola, M. (2002). The New Economy: facts, impacts and policies. *Information Economics and Policy*, *14*(2), 133–144.

Porter, M. E. (2001). Strategy and the Internet. *Harvard Business Review*, *79*(3). Retrieved from https://hbr.org/2001/03/strategy-and-the-internet

Ritala, P., & Hurmelinna-Laukkanen, P. (2012). Incremental and Radical Innovation in Coopetition-The Role of Absorptive Capacity and Appropriability. *Journal of Product Innovation Management*, *30*(1), 154–169.

Ryan, B., Scapens, R. W., & Theobald, M. (2002). *Research Method & Methodology in Finance & Accounting* (2nd ed.). London, United Kingdom: Thomson.

Schoonenboom, J., & Johnson, R. B. (2017). How to Construct a Mixed Methods Research Design. *KZfSS Kölner Zeitschrift für Soziologie und Sozialpsychologie*, *69*(S2), 107–131.

Seyedghorban, Z., Tahernejad, H., Meriton, R., & Graham, G. (2019). Supply chain digitalization: past, present and future. *Production Planning & Control*, *31*(2–3), 96–114.

Stentoft, J., Jensen, K. W., Philipsen, K., & Haug, A. (2019). *Drivers and Barriers for Industry 4.0 Readiness and Practice: A SME Perspective with Empirical Evidence*. Presented at the Hawaii International Conference on System Sciences . Retrieved from http://hdl.handle.net/10125/59952

Svetina, A. C. ˇ., & Prodan, I. (2008). How Internal and External Sources of Knowledge Contribute to Firms' Innovation Performance. *Managing Global Transitions*, *6*(3), 277–299.

Tan, A. R., Matzen, D., McAloone, T. C., & Evans, S. (2010). Strategies for designing and developing services for manufacturing firms. *CIRP Journal of Manufacturing Science and Technology*, *3*(2), 90–97.

Thorpe, R., Holt, R., Macpherson, A., & Pittaway, L. (2005). 4Original Article Using knowledge within small and medium-sized firms Using knowledge within small and medium-sized firms: A systematic review of the evidence. *International Journal of Management Reviews*, *7*(4), 257–281.

Tongur, S., & Engwall, M. (2014). The business model dilemma of technology shifts. *Technovation*, *34*(9), 525–535.

Vaivio, J. (2008). Qualitative management accounting research: rationale, pitfalls and potential. *Qualitative Research in Accounting and Management*, *5*(1), 64–86.

Valtakoski, A. (2017). Explaining servitization failure and deservitization: A knowledge-based perspective. *Industrial Marketing Management*, *60*, 138–150.

Vandermerwe, S., & Rada, J. (1988). Servitization of business: Adding value by adding services. *European Management Journal*, *6*(4), 314–324.

Vargo, S., & Lusch, R. (2004). Evolving to a New Dominant Logic for Marketing. *Journal of Marketing*, *68*, 1–17.

Varis, M., & Littunen, H. (2010). Types of innovation, sources of information and performance in entrepreneurial SMEs. *European Journal of Innovation Management*, *13*(2), 128–154.

Visnjic, I., Ringov, D., & Arts, S. (2019). Which Service? How Industry Conditions Shape Firms' Service-Type Choices. *Journal of Product Innovation Management*, *36*(3), 381–407.

Vuori, V., Helander, N., & Okkonen, J. (2018). Digitalization in knowledge work: the dream of enhanced performance. *Cognition, Technology & Work*, *21*(2), 237–252.

Zangiacomi, A., Pessot, E., Fornasiero, R., Bertetti, M., & Sacco, M. (2020). Moving towards digitalization: a multiple case study in manufacturing. *Production Planning & Control*, *31*(2–3), 143–157.

Appendices

Appendix A – Quantitative output tables

Control variables

Statistics

		Size number of employees 2017	lnSize number of employees 2017 (log)	Industry Industry sector	Metal	Food	Textile	Construction	Chemical	Machinery	Electronic
N	Valid	203	203	201	201	201	201	201	201	201	201
	Missing	0	0	2	2	2	2	2	2	2	2
Mean		81.4384	3.7695	4.2886	.1990	.0846	.1443	.0249	.1294	.1841	.2338
Std. Error of Mean		22.25454	.06028	.16063	.02823	.01968	.02485	.01101	.02373	.02740	.02993
Median		42.0000	3.7377	5.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
Mode		45.00	3.81	7.00	.00	.00	.00	.00	.00	.00	.00
Std. Deviation		317.0784	.85880	2.27735	.40025	.27895	.35225	.15613	.33643	.38852	.42432
Variance		100538.7	.738	5.186	.160	.078	.124	.024	.113	.151	.180
Skewness		13.537	1.038	-.238	1.519	3.008	2.040	6.147	2.226	1.643	1.267
Std. Error of Skewness		.171	.171	.172	.172	.172	.172	.172	.172	.172	.172
Kurtosis		189.273	3.356	-1.496	.311	7.122	2.183	36.148	2.983	.705	-.398
Std. Error of Kurtosis		.340	.340	.341	.341	.341	.341	.341	.341	.341	.341
Range		4490.00	6.11	6.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Minimum		10.00	2.30	1.00	.00	.00	.00	.00	.00	.00	.00
Maximum		4500.00	8.41	7.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sum		16532.00	765.20	862.00	40.00	17.00	29.00	5.00	26.00	37.00	47.00

Industry Industry sector

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1,00 Metals and Metal products	40	19.7	19.9	19.9
	2,00 Food, Beverages and Tobacco	17	8.4	8.5	28.4
	3,00 Textiles, Leather, Paper and Board	29	14.3	14.4	42.8
	4,00 Construction, Furniture	5	2.5	2.5	45.3
	5,00 Chemicals (energy and non-energy)	26	12.8	12.9	58.2
	6,00 Machinery, Equipment Transport	37	18.2	18.4	76.6
	7,00 Electrical and Optical equipment	47	23.2	23.4	100.0
	Total	201	99.0	100.0	
Missing	-99,00 niet industriele bedrijven: verhuur diensten	2	1.0		
Total		203	100.0		

Independent and dependent variables

Statistics

		InternSourcing index of Internal Sourcing	ExternSourcing index of External Sourcing	ProductServices index of product related services	Digi_Services index of digital solutions in service portfolio	Business Models index of business models offered
N	Valid	203	203	203	203	203
	Missing	0	0	0	0	0
Mean		3.8768	3.7291	2.5714	.7685	.3695
Std. Error of Mean		.18791	.19828	.16347	.08972	.05952
Median		4.0000	4.0000	2.0000	.0000	.0000
Mode		4.00	4.00	1.00	.00	.00
Std. Deviation		2.67730	2.82501	2.32902	1.27838	.84809
Variance		7.168	7.981	5.424	1.634	.719
Skewness		.374	.581	.852	1.864	3.686
Std. Error of Skewness		.171	.171	.171	.171	.171
Kurtosis		-.105	.283	-.285	2.835	18.697
Std. Error of Kurtosis		.340	.340	.340	.340	.340
Range		13.00	14.00	8.00	5.00	6.00
Minimum		.00	.00	.00	.00	.00
Maximum		13.00	14.00	8.00	5.00	6.00
Sum		787.00	757.00	522.00	156.00	75.00

Interaction variables

Statistics

		cInternSourcing	cExternSourcing	i_InternDigi_Services	i_ExternDigi_Services
N	Valid	203	203	203	203
	Missing	0	0	0	0
Mean		.0000	.0000	.4542	.4397
Std. Error of Mean		.18791	.19828	.21951	.22181
Median		.1232	.2709	.0285	.5257
Mode		.12	.27	-.09	2.87
Std. Deviation		2.67730	2.82501	3.12750	3.16033
Variance		7.168	7.981	9.781	9.988
Skewness		.374	.581	.239	-.159
Std. Error of Skewness		.171	.171	.171	.171
Kurtosis		-.105	.283	8.068	6.952
Std. Error of Kurtosis		.340	.340	.340	.340
Range		13.00	14.00	32.96	29.58
Minimum		-3.88	-3.73	-16.40	-15.78
Maximum		9.12	10.27	16.56	13.80
Sum		.01	-.01	92.21	89.27

Descriptives of regression analysis

Descriptive Statistics

	Mean	Std. Deviation	N
ProductServices index of product related services	2.5473	2.32573	201
BusinessModels index of business models offered	.3731	.85151	201
lnSize number of employees 2017 (log)	3.7713	.86288	201
Food	.0846	.27895	201
Textile	.1443	.35225	201
Construction	.0249	.15613	201
Chemical	.1294	.33643	201
Machinery	.1841	.38852	201
Electronic	.2338	.42432	201
InternSourcing index of Internal Sourcing	3.9154	2.66229	201
ExternSourcing index of External Sourcing	3.7662	2.81426	201
Digi_Services index of digital solutions in service portfolio	.7761	1.28243	201
i_InternDigi_Services	.4291	3.13284	201
i_ExternDigi_Services	.4156	3.16672	201

Correlations

		ProductServices index of product related services	BusinessModels index of business models offered	lnSize number of employees 2017 (log)	Food	Textile	Construction	Chemical	Machinery	Electronic	InternSourcing index of Internal Sourcing	ExternSourcing index of External Sourcing	Digi_Services index of digital solutions in service portfolio	i_InternDigi_Services	i_ExternDigi_Services
Pearson Correlation	ProductServices index of product related services	1.000	.429	.049	-.249	-.176	-.065	-.097	.535	.062	.170	.089	.499	-.064	-.077
	BusinessModels index of business models offered	.429	1.000	.078	-.134	.003	-.033	-.082	.230	.034	.122	.110	.370	-.062	.007
	lnSize number of employees 2017 (log)	.049	.078	1.000	.094	-.075	.029	-.104	.167	-.019	.106	.128	.206	.107	.164
	Food	-.249	-.134	.094	1.000	-.125	-.049	-.117	-.144	-.168	-.017	-.026	-.129	-.019	-.002
	Textile	-.176	.003	-.075	-.125	1.000	-.066	-.158	-.195	-.227	.040	.064	-.094	-.065	-.058
	Construction	-.065	-.033	.029	-.049	-.066	1.000	-.062	-.076	-.088	-.067	-.009	-.022	.034	.063
	Chemical	-.097	-.082	-.104	-.117	-.158	-.062	1.000	-.183	-.213	-.044	-.052	-.095	-.021	-.059
	Machinery	.535	.230	.167	-.144	-.195	-.076	-.183	1.000	-.262	.059	.058	.274	.031	-.049
	Electronic	.062	.034	-.019	-.168	-.227	-.088	-.213	-.262	1.000	-.013	-.042	.106	.021	.037
	InternSourcing index of Internal Sourcing	.170	.122	.106	-.017	.040	-.067	-.044	.059	-.013	1.000	.699	.126	-.042	-.020
	ExternSourcing index of External Sourcing	.089	.110	.128	-.026	.064	-.009	-.052	.058	-.042	.699	1.000	.116	-.019	-.027
	Digi_Services index of digital solutions in service portfolio	.499	.370	.206	-.129	-.094	-.022	-.095	.274	.106	.126	.116	1.000	.108	-.033
	i_InternDigi_Services	-.064	-.062	.107	-.019	-.065	.034	-.021	.031	.021	-.042	-.019	.108	1.000	.678
	i_ExternDigi_Services	-.077	.007	.164	-.002	-.058	.063	-.059	-.049	.037	-.020	-.027	-.033	.678	1.000
Sig. (1-tailed)	ProductServices index of product related services	.	.000	.246	.000	.006	.179	.085	.000	.190	.008	.104	.000	.184	.138
	BusinessModels index of business models offered	.000	.	.135	.029	.483	.323	.123	.001	.316	.042	.061	.000	.193	.459
	lnSize number of employees 2017 (log)	.246	.135	.	.093	.146	.340	.071	.009	.395	.066	.035	.002	.065	.010
	Food	.000	.029	.093	.	.039	.247	.049	.020	.009	.404	.359	.035	.394	.488
	Textile	.006	.483	.146	.039	.	.177	.012	.003	.001	.288	.182	.092	.180	.207
	Construction	.179	.323	.340	.247	.177	.	.193	.142	.106	.172	.447	.378	.314	.187
	Chemical	.085	.123	.071	.049	.012	.193	.	.005	.001	.270	.230	.090	.383	.201
	Machinery	.000	.001	.009	.020	.003	.142	.005	.	.000	.204	.207	.000	.330	.246
	Electronic	.190	.316	.395	.009	.001	.106	.001	.000	.	.425	.277	.067	.382	.303
	InternSourcing index of Internal Sourcing	.008	.042	.066	.404	.288	.172	.270	.204	.425	.	.000	.037	.278	.390
	ExternSourcing index of External Sourcing	.104	.061	.035	.359	.182	.447	.230	.207	.277	.000	.	.051	.395	.350
	Digi_Services index of digital solutions in service portfolio	.000	.000	.002	.035	.092	.378	.090	.000	.067	.037	.051	.	.064	.323
	i_InternDigi_Services	.184	.193	.065	.394	.180	.314	.383	.330	.382	.278	.395	.064	.	.000
	i_ExternDigi_Services	.138	.459	.010	.488	.207	.187	.201	.246	.303	.390	.350	.323	.000	.
N	ProductServices index of product related services	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	BusinessModels index of business models offered	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	lnSize number of employees 2017 (log)	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	Food	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	Textile	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	Construction	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	Chemical	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	Machinery	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	Electronic	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	InternSourcing index of Internal Sourcing	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	ExternSourcing index of External Sourcing	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	Digi_Services index of digital solutions in service portfolio	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	i_InternDigi_Services	201	201	201	201	201	201	201	201	201	201	201	201	201	201
	i_ExternDigi_Services	201	201	201	201	201	201	201	201	201	201	201	201	201	201

The correlations are used to demonstrate the correlations between all variables. First, manufacturing firms tend to offer more business model services the higher the amount of product-related services that are offered and vice versa, although the relationship is only moderate ($r = 0.429$, $p < 0.001$). Second, when manufacturing firms gather new information, they tend to use more internal sources of information when the amount of external sources of information is high, and vice versa ($r = 699$, $p < 0.001$). The same counts for the two interaction variables, represented as products of two variables (internal sourcing × digital solutions and external sourcing × digital solutions), that also positively correlate with each other ($r = 0.678$, $p < 0.001$). Third, when looking at the industry sectors, it is interesting to see that manufacturing firms in the machinery sector tend to offer far more services, especially product-related services ($r = 0.535$, $p < 0.001$), than firms in the other sectors. In contrast, the amount of product-related services is likely to be low for firms in the food sector ($r = –0.249$, $p < 0.001$). Last, the specific relationships proposed in the conceptual model are looked into. As proposed before, it shows that manufacturing firms with a high amount of internal sources of information tend to offer slightly more product-related services ($r = 0.170$, $p < 0.01$). Interestingly, this is also the case for the business models offered ($r = 0.122$, $p < 0.05$). However, in contrast to the proposed model, as manufacturing firms have more external sources of information, they do not necessarily offer more product-related services or business model services. There are no significant correlations found between external sourcing of information and services offered. Furthermore, the correlation matrix shows that the more services are offered by manufacturing firms, the more likely that those firms utilize digital solutions in their service provision, both for product-related services ($r = 0.499$, $p < 0.001$) and business model services ($r = 0.370$, $p < 0.001$). Besides digital solutions as a single variable, the analysis also includes two interaction variables. Both interaction variables do not significantly correlate with product-related services and business models offered.

Regression analysis with dependent variable: product-oriented services

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.593[a]	.351	.328	1.90678	.351	14.934	7	193	.000	
2	.692[b]	.479	.452	1.72209	.128	15.539	3	190	.000	
3	.703[c]	.494	.462	1.70598	.015	2.802	2	188	.063	2.093

a. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery

b. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery, InternSourcing index of Internal Sourcing, Digi_Services index of digital solutions in service portfolio, ExternSourcing index of External Sourcing

c. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery, InternSourcing index of Internal Sourcing, Digi_Services index of digital solutions in service portfolio, ExternSourcing index of External Sourcing, i_InternDigi_Services, i_ExternDigi_Services

d. Dependent Variable: ProductServices index of product related services

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	380.091	7	54.299	14.934	.000[b]
	Residual	701.710	193	3.636		
	Total	1081.801	200			
2	Regression	518.341	10	51.834	17.479	.000[c]
	Residual	563.460	190	2.966		
	Total	1081.801	200			
3	Regression	534.649	12	44.554	15.309	.000[d]
	Residual	547.152	188	2.910		
	Total	1081.801	200			

a. Dependent Variable: ProductServices index of product related services

b. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery

c. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery, InternSourcing index of Internal Sourcing, Digi_Services index of digital solutions in service portfolio, ExternSourcing index of External Sourcing

d. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery, InternSourcing index of Internal Sourcing, Digi_Services index of digital solutions in service portfolio, ExternSourcing index of External Sourcing, i_InternDigi_Services, i_ExternDigi_Services

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.143	.659		3.251	.001		
	lnSize number of employees 2017 (log)	-.080	.160	-.030	-.500	.617	.950	1.052
	Food	-1.172	.555	-.141	-2.111	.036	.757	1.320
	Textile	-.302	.465	-.046	-.649	.517	.677	1.476
	Construction	-.228	.906	-.015	-.252	.801	.909	1.100
	Chemical	.102	.481	.015	.212	.832	.695	1.439
	Machinery	3.346	.440	.559	7.603	.000	.622	1.608
	Electronic	.965	.410	.176	2.352	.020	.599	1.668
2	(Constant)	2.180	.611		3.566	.000		
	lnSize number of employees 2017 (log)	-.262	.148	-.097	-1.772	.078	.910	1.099
	Food	-.944	.503	-.113	-1.878	.062	.753	1.328
	Textile	-.325	.421	-.049	-.774	.440	.676	1.480
	Construction	-.113	.821	-.008	-.137	.891	.903	1.107
	Chemical	.107	.434	.016	.247	.805	.694	1.440
	Machinery	2.732	.409	.456	6.683	.000	.588	1.701
	Electronic	.627	.375	.114	1.673	.096	.586	1.706
	InternSourcing index of Internal Sourcing	.141	.064	.161	2.191	.030	.506	1.976
	ExternSourcing index of External Sourcing	-.060	.061	-.072	-.981	.328	.504	1.982
	Digi_Services index of digital solutions in service portfolio	.639	.103	.352	6.205	.000	.851	1.175
3	(Constant)	2.195	.608		3.608	.000		
	lnSize number of employees 2017 (log)	-.261	.149	-.097	-1.750	.082	.878	1.139
	Food	-.944	.500	-.113	-1.889	.060	.749	1.334
	Textile	-.343	.418	-.052	-.821	.413	.670	1.492
	Construction	-.103	.813	-.007	-.127	.899	.903	1.108
	Chemical	.130	.432	.019	.300	.765	.687	1.455
	Machinery	2.755	.407	.460	6.763	.000	.581	1.721
	Electronic	.625	.372	.114	1.682	.094	.585	1.708
	InternSourcing index of Internal Sourcing	.131	.064	.150	2.057	.041	.504	1.985
	ExternSourcing index of External Sourcing	-.056	.060	-.068	-.929	.354	.503	1.987
	Digi_Services index of digital solutions in service portfolio	.675	.104	.372	6.516	.000	.824	1.213
	i_InternDigi_Services	-.122	.054	-.164	-2.279	.024	.518	1.932
	i_ExternDigi_Services	.059	.054	.080	1.093	.276	.504	1.982

a. Dependent Variable: ProductServices index of product related services

Regression analysis with dependent variable: business model-oriented services

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.275[a]	.076	.042	.83340	.076	2.255	7	193	.032	
2	.412[b]	.170	.126	.79608	.094	7.174	3	190	.000	
3	.443[c]	.196	.145	.78737	.027	3.112	2	188	.047	1.999

a. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery

b. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery, InternSourcing index of Internal Sourcing, Digi_Services index of digital solutions in service portfolio, ExternSourcing index of External Sourcing

c. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery, InternSourcing index of Internal Sourcing, Digi_Services index of digital solutions in service portfolio, ExternSourcing index of External Sourcing, i_InternDigi_Services, i_ExternDigi_Services

d. Dependent Variable: BusinessModels index of business models offered

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.966	7	1.567	2.255	.032[b]
	Residual	134.049	193	.695		
	Total	145.015	200			
2	Regression	24.605	10	2.460	3.883	.000[c]
	Residual	120.410	190	.634		
	Total	145.015	200			
3	Regression	28.464	12	2.372	3.826	.000[d]
	Residual	116.551	188	.620		
	Total	145.015	200			

a. Dependent Variable: BusinessModels index of business models offered

b. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery

c. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery, InternSourcing index of Internal Sourcing, Digi_Services index of digital solutions in service portfolio, ExternSourcing index of External Sourcing

d. Predictors: (Constant), Electronic, lnSize number of employees 2017 (log), Construction, Food, Chemical, Textile, Machinery, InternSourcing index of Internal Sourcing, Digi_Services index of digital solutions in service portfolio, ExternSourcing index of External Sourcing, i_InternDigi_Services, i_ExternDigi_Services

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.043	.288		.148	.882		
	lnSize number of employees 2017 (log)	.050	.070	.050	.711	.478	.950	1.052
	Food	-.244	.243	-.080	-1.005	.316	.757	1.320
	Textile	.156	.203	.065	.769	.443	.677	1.476
	Construction	-.039	.396	-.007	-.097	.923	.909	1.100
	Chemical	-.027	.210	-.011	-.128	.899	.695	1.439
	Machinery	.538	.192	.245	2.797	.006	.622	1.608
	Electronic	.196	.179	.098	1.094	.275	.599	1.668
2	(Constant)	.072	.283		.256	.798		
	lnSize number of employees 2017 (log)	-.011	.068	-.011	-.165	.869	.910	1.099
	Food	-.167	.233	-.055	-.718	.474	.753	1.328
	Textile	.144	.194	.060	.742	.459	.676	1.480
	Construction	-.028	.379	-.005	-.073	.942	.903	1.107
	Chemical	-.024	.201	-.009	-.118	.906	.694	1.440
	Machinery	.339	.189	.155	1.794	.074	.588	1.701
	Electronic	.090	.173	.045	.521	.603	.586	1.706
	InternSourcing index of Internal Sourcing	.017	.030	.055	.586	.558	.506	1.976
	ExternSourcing index of External Sourcing	.007	.028	.024	.257	.797	.504	1.982
	Digi_Services index of digital solutions in service portfolio	.208	.048	.313	4.370	.000	.851	1.175
3	(Constant)	.108	.281		.384	.702		
	lnSize number of employees 2017 (log)	-.025	.069	-.026	-.367	.714	.878	1.139
	Food	-.148	.231	-.049	-.643	.521	.749	1.334
	Textile	.155	.193	.064	.803	.423	.670	1.492
	Construction	-.034	.375	-.006	-.090	.928	.903	1.108
	Chemical	.008	.200	.003	.039	.969	.687	1.455
	Machinery	.371	.188	.169	1.975	.050	.581	1.721
	Electronic	.096	.171	.048	.560	.576	.585	1.708
	InternSourcing index of Internal Sourcing	.013	.029	.039	.428	.669	.504	1.985
	ExternSourcing index of External Sourcing	.010	.028	.033	.361	.719	.503	1.987
	Digi_Services index of digital solutions in service portfolio	.229	.048	.345	4.790	.000	.824	1.213
	i_InternDigi_Services	-.061	.025	-.223	-2.449	.015	.518	1.932
	i_ExternDigi_Services	.050	.025	.186	2.021	.045	.504	1.982

a. Dependent Variable: BusinessModels index of business models offered

Appendix B – Interview script

Interview script – Servitization, digitalization and information management

Inleiding van het interview

- Stel jezelf voor, formuleer doel van het onderzoek
  Het doel van het onderzoek is om de effecten van informatiemanagement op dienstverlening te meten en hierbij de rol van digitalisering te achterhalen. Het interview zal uit drie thema's bestaan: dienstverlening, digitalisering en tot slot informatiemanagement. Ik zal bij elk thema kort uitleggen wat ik daaronder versta.

- Toestemming voor opname interview (anoniem, alleen voor transcriptie)

- Interview duurt ongeveer een uur. Zijn er vragen vooraf?

Algemeen – respondent en bedrijf

- 1.1 Wie bent u en wat is uw rol in het bedrijf?
  (*Functie, werkzaamheden, ervaringen*)

- 1.2 Wat voor bedrijf is [naam bedrijf X]?
  (*Grootte, leeftijd, sector*)

- 1.3 Welke soort klanten hebben jullie hoofdzakelijk?
  (*Geen klantnamen, maar soort klanten*)

- 1.4 Wat zijn jullie kernactiviteiten?
  - Hoe onderscheiden jullie je van concurrenten?

Servitization

- **Inleiding over het aanbieden en leveren van diensten**
  Maakbedrijven kunnen zich naast het produceren van producten ook richten op dienstverlening in combinatie met de producten. De soort diensten, de redenen, de doeleinden, en de manier waarop diensten worden aangeboden kunnen per maakbedrijf verschillen. In het interview gaat het om diensten naar de klant die gerelateerd zijn aan de producten die jullie aanbieden.

- 2.1 Wat is/zijn de hoofdproducten die jullie produceren?
  - Om wat voor productie gaat het hier?
    - Standaard- en massaproductie?
    - Op basis van klantwensen? Customized?

- 2.2 Op welke manier worden producten naar de klant verrekend?
    - Verkoop, pay-per-use, lease, of een andere manier?

- 2.3 Welke diensten bieden jullie je klanten aan?
    - Het gaat om diensten naar de klant die gerelateerd zijn aan jullie producten.

- 2.4 Waarom bieden jullie deze diensten aan?
    - In welke mate gaat het om…
        - Vergemakkelijken van verkoop en gebruik van producten.
        - Uitbreiden van productfunctionaliteiten of vernieuwen ervan, focus op de klant.

Knowledge management

- **Inleiding over informatiemanagement**
  Het verwerken van nieuwe informatie (informatiemanagement) is een proces dat bestaat uit drie delen: 1) het verkrijgen van nieuwe informatie vanuit verschillende interne en externe bronnen, 2) het delen/verspreiden van deze informatie binnen het bedrijf, en ten slotte 3) het tijdig gebruiken van of reageren op deze informatie.

- 3.1 Wat zijn voor jullie belangrijke bronnen voor nieuwe informatie?
    - Werknemers, klanten, kennisinstellingen, etc.
    - Om wat voor soort informatie gaat het

- 3.2 Hoe zorgen jullie ervoor dat deze informatie in het bedrijf terechtkomt?
    - Welke rol speelt dienstverlening hierin?

- 3.3 Op welke manier wordt deze informatie vastgelegd en verspreid binnen het bedrijf?
    - Geschreven documentatie, visueel, computers, cloud.
    - Groepsvergaderingen, bepaalde open cultuur, verticale communicatie.

- 3.4 Hoe wordt deze informatie benut in de ontwikkeling van producten, processen en dienstverlening? Met andere woorden, hoe wordt ervan geleerd?
    - Interne/externe expertise, samen met klanten, huidige technologieën.

Digitalization

- **Inleiding over digitalisering**
  Digitalisering, ook wel bekend als Industry 4.0, kan invloed hebben op hoe een maakbedrijf zich organiseert, zowel intern als naar de klant. Denk hierbij aan het gebruik van systemen als big data, cloud services, geavanceerde data-analyse, het verwerken van menselijk handelen naar machines en het omzetten van digitaal ontwerp naar fysieke producten.

- 4.1 Welke technologieën met betrekking tot digitalisering passen jullie toe?

- 4.2 Hoe wordt digitalisering gebruikt bij het leveren van diensten?
    - Interactie tussen bedrijf en klant.

        - Geïntegreerde interactie tussen product en klant.
        - Interactie tussen productieproces en klant.

- 4.3 Welke doeleinden hebben deze digitale technologieën?
        - Klantgericht: waarde van aangeboden dienst verhogen, proces van klant verbeteren.
        - Bedrijfsgericht: interne procesoptimalisatie.

Afronding van het interview

- Bedanken voor het interview en de medewerking

- Bespreken van vervolgcontact m.b.t. inzien transcriptie, opsturen onderzoek en eventuele vervolgvragen

- Herhalen van belangrijke afspraken (opname, anonimiseren)