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A Framework for Servitization: Enhance Value Proposition through Customer Engagement

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List of Abbreviations

AI: Artificial Intelligence
AS: additional service
ARIS: Architecture of Integrated Information Systems
AEPSS: Austrian Eco-efficient PSS
B2B: Business-to-Business
B2C: Business-to-Customer
CRM: Customer Relationship Management
CAD: Computer-Aided Design
DDTP: Development/ Design/Test/Prototyping
DES: Designing Eco-efficient Services
DEP: Design Exploration Process
DSR: Design Science Research
ERP: Enterprise Resource Planning
FTDP: Fast-Track Design Process
GE: General Electric
ICT: Information and Communication Technology
IPS: Industrial PSS
KIBS: knowledge-Intensive Business Services
MEPSS: Methodology for PSS innovation
PS: Products and Services
P/S: PS combinations
PPS: Product and Service System
P/IS: Product/Integral Service
P/AS: Product/Additional Service
P/IAS: Product/Integral Additional Service
SME: Small and Medium Entrepreneurs
SPE: Service Product Engineering
SSD: Service System Design
UML: Unified Modelling Language

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Xin Jiang

1. Introduction

1.1. Research background

1.1.1. Servitization as a growing phenomenon

Servitization has been gaining increasing attention, primarily in manufacturing industries. The term servitization was coined by Vandermerwe and Rada in 1988 and was later widely used to refer to the phenomenon of service offerings being increasingly merged with product development (Vandermerwe and Rada, 1988; Kinnunen and Turunen, 2012; Neely, 2008; Baines et al., 2009). In recent years, it has often been considered an organizational strategy or transition process that allows companies to create value for customers (Kinnunen and Turunen, 2012).

The cause and critical role of servitization have been extensively identified and discussed in the literature. Baines et al. (2009) claimed that the advent of servitization was triggered by increased wages and advanced welfare systems in Western economies, which resulted in companies losing competitive advantages. Furthermore, reduced returns on product-centered activities and increased emphasize on customer have been resulting to an increasing number of manufacturers to turn their attention more on the services side along the products and services value-adding process (Kinnunen and Turunen, 2012). Under the process of globalization, servitization is promoted as a method to add additional value to original product provision with the benefits of being difficult to imitate as well as beneficial for sustainable development (Oliva and Kallenberg, 2003). Thus, servitization is viewed as a crucial process for companies to gain advantages and improve their performance under today's harsh economic conditions (Neely, 2008; Visnjic and Van Looy, 2013).

Numerous real-world examples of servitization exist that elucidate the subject and encourage latecomers with practical experience. For example, prominent companies such as GE, IBM, Rolls Royce, Fujitsu, Siemens, and Samsung have already begun their servitization process at various levels. In addition, small and medium enterprises and startups have recognized the benefits of creating value for customers through services. Compared with large organizations, SMEs might have more flexibility regarding the adoption of technology, innovation strategies, and the mindsets of senior management, which would facilitate the process of servitization (Gebauer, Paiola and Edvardsson, 2010). In the servitization domain, the diversity of practical examples has always been considered a precious resource for research.

1.1.2. Crucial elements of servitization

Digital transformation

In the servitization process, digital transformation being a crucial element cannot be

underemphasized. Baines and Lightfoot (2013) identified that technology serves as the driving force for servitization. In general, both the service sector and product-focused industries (e.g., manufacturing) have gained unparalleled benefits from technology adoption (Rahman, Tootoonchi and Monahan, 2011). Specifically, as stressed by Lightfoot et al. (2011), the role of information and communication technology (ICT) is rather distinctive in enabling servitization in that it enables and supports conventional production. Digital tools assist companies not only by digitizing their business process but also transforming their business. However, although such digital transformation opens opportunities for customer value creation, challenges are generated because of its sophisticated nature. Limited awareness of the application of technologies in servitization (Paton, MacBryde, Clegg, 2013; Lightfoot et al., 2011) poses difficulties to the implementation of servitization strategies. Similarly, companies lack guidance on how to leverage various types of digital tools and platforms, which is another barrier to those interested in servitizing their business.

Customization

Customization is viewed as a key feature of servitization. Servitization has gained attention not only as a strategy for adding or creating value but also for fulfilling customers' expectations. Baines, Lightfoot, and Evans (2007) and Zahir, Kamoshida, and Inohara (2013a) identified strong customer centricity as the crucial characteristic of servitization. Because companies constantly seek customer interaction for tailored solutions, the foundation of customer interaction has changed from transaction-based to relationship-based (Oliva and Kallenberg, 2003). In other words, customers are involved in a broader-scale process of new product and service development. Thus, how to develop and maintain this customer relationship, which facilitates companies' customized products and services through the abovementioned process, is becoming critical for implementing a servitization strategy.

In summary, digital transformation and customization have been widely accepted as two crucial elements of servitization. Digital transformation plays an irrefutable role in enabling servitization in today's digital economy, whereas customization presents the indispensable dimension of the customer as value co-creator. Therefore, in this research project on servitization, these two elements are investigated in-depth to gain insights into servitization.

1.2. Research opportunity

1.2.1. Research opportunity in the literature

Through prescreening the literature, this study found that the current research streams are rich in

company-based case studies with detailed descriptions of successfully implementing the shift from product- to service-oriented strategies. However, despite recognizing the potential transformative power of servitization, the literature remains silent in terms of analyses of the links between servitization and companies' capabilities (European Commission, 2011). How to examine company capabilities and customer contributions over various stages of servitization have not been revealed in detail. As strongly suggested by Martinez and Bastl (2010), integrated product–service offerings should be fully understood over the whole product and service development process, as should how customers be involved in the process, to assess a company's capability for servitization (Brax, 2005).

Models have indeed been developed by scholars for assessing the premise and capability of servitization (Kinnunen and Turunen, 2012); however, holistic and coherent perspective intended for the entire product and service development process are rare. Specifically, academics have not yet offered empirical models and approaches to assess the degree of servitization or the roles of ICT and customers throughout the process. Therefore, a coherent understanding of how products and services are designed, produced, and delivered toward servitization is required.

More crucially, the current product and service design methodology fails to consider the two critical elements of servitization—customization and digital transformation (Coreynen, Matthyssens, and Vandenbempt, 2015). Therefore, this research project intends to fill this gap and extend the existing product–service system (PSS) design theory in this direction.

Furthermore, to fulfill the abovementioned demand, adopting accurate definitions of the terms involved is necessary. However, it is easy to spot previous attempts by scholars to conceive a definition for the combination of products and services using various terms that have been applied in other fields. This ambiguous terminology causes unnecessary difficulties for academics and industry partners. Figure 1 presents a table that summarizes the definitions from Chapter 2:

Name	Bundling	Product Service	Solution	Integrated Solution	Product–Service System (PSS)	Integrated Product and Service Offering (IPSO)
Author	<ul style="list-style-type: none"> Schmalensee (1982) Eppen et al. (1991) Venkatesh and Mahajan (1993) 	<ul style="list-style-type: none"> Samli et al. (1992) Frambach et al. (1997) 	<ul style="list-style-type: none"> Miller et al. (2002) Galbraith (2002) 	<ul style="list-style-type: none"> Davies (2001) Windahl (2007) 	<ul style="list-style-type: none"> Goedkoop et al. (1999) Tukker (2004) Baines et al. (2007) 	<ul style="list-style-type: none"> Sundin et al. (2006) Lindahl et al. (2006)

Figure 1. Various definitions of combined products and services in the literature.

Every attempt in this table is based on the perceptions of different researchers and originates from different application contexts. It is not beneficial for the consistency of conducting research in this field. Moreover, the current status has failed to provide a coherent definition that facilitates categorizing different types of products and services. Therefore, the present research project aimed to clarify the involved definitions and provide a degree of consistency for future relevant research.

1.2.2. Business challenges

Theoretically, for companies to keep pace with the servitization phenomenon, they are required to make fundamental changes. Specifically, they are required to manage their capabilities, organization structure, development process, and the relationship with both customers and suppliers (Gebauer and Friedli, 2005; Neu and Brown, 2008; Davies, 2004; Evans, Partidario and Lambert, 2007; Windahl and Lakemond, 2010). However, in reality, these challenges are not systematically managed or efficiently geared toward the expected destination of servitization. Service design, organizational structure, and transformation strategies have been identified as challenges faced by manufacturers, and they cannot be ignored (Baines et al., 2009). As a result, unclearly defined services, poor service portfolios, and failure to provide the required processes and resources have been identified as the corresponding consequences (Bullinger, Fähnrich and Meiren, 2003).

Despite more than 25 years of research on servitization, very few contributions have been made that provide models, analysis tools or guidance that could be directly applied by practitioners to overcome the abovementioned challenges (Baines et al, 2009; Kinnune and Turunen, 2012). In particular, scant studies have provided practical value for industry practitioners. Furthermore, the lack of guidelines for strategic implementation as well as model-based approaches have been stressed in the literature (Welp et al., 2008; Aurich, Mannweiler and Schweitzer, 2010).

1.3. Research questions

1.3.1. Field of research and focus

For this dissertation, the target research area mainly revolves around the servitization process. To be more specific, the research field considered involves the process of transformation from pure product to pure service. Throughout the servitization transformation process, the focus lies in the aspects of customization and digital transformation.

The concept of pure service was first mentioned by Chase (1981), when it was applied to distinguish from pure product. Since then, it has been further developed by scholars to better understand the transition from pure product to possibly pure service (Olivia and Kallenderg, 2003;

Clayton, Backhouse, and Dani, 2012.). This dissertation’s research field is structured along the well-developed logic of the product–service continuum, as shown in Figure 2 (Olivia and Kallenderg, 2003; Clayton et al., 2012). The product–service continuum exhibits two directions. The direction from providing pure product to pure service is named servitization, whereas the opposite direction is called productization (Baines et al., 2007).

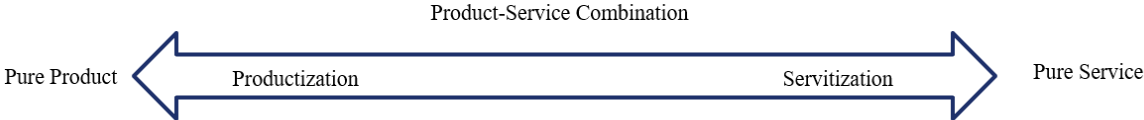


Figure 2. Product–service continuum (adapted from Chase, 1981; Olivia and Kallenderg, 2003; Clayton et al., 2012).

In this research project, upon the existing product–service continuum, two crucial elements were identified. As explained above, one of the most critical features of servitization is the customized product or personalized service offerings, which fulfills the customer’s expectations. Therefore, in this project, customization for either products or services is considered as a representative character of servitization. Accordingly, this research focuses on how customers can fulfill the value co-creator role during the product and service development process as well as how this can be assessed.

Furthermore, rapid development in ICT has provided the possibility of realizing the expectations of servitization and customization, which is another crucial element explained previously. Research in this area cannot leave the vital role of ICT out of the picture. How ICT influences the whole development process as well as how companies can improve their capability to facilitate servitization implementation are questions that should be answered.

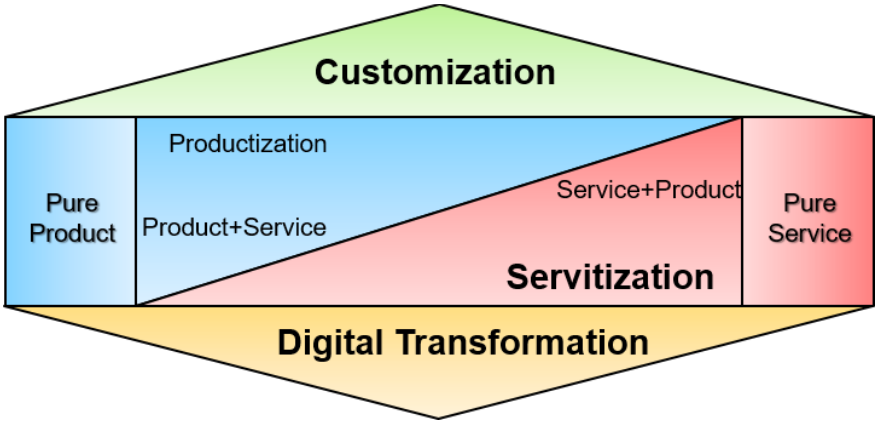


Figure 3. Research area and focus_Model_1.

As shown in Figure 3, customization and digital transformation are identified and emphasized as crucial supporting factors facilitating the process of companies’ transition toward pure service. In this manner, the three research focuses of servitization, customization, and digital transformation

were formulated. This figure is also Model_1 of the servitization framework used to illustrate the scope and focus of this research program.

1.3.2. Research questions and methodology

a) Research questions

This research intended to observe and assess how companies conduct servitization in practice, as well as how customer engagement and digital transformation contribute to the process. The intended outcome is a framework that provides industry practitioners and scholars with models and guidance to improve the servitization process and contribute to long-term strategic decision-making for product and service development. Motivated by evidence gained from industry and the current state of the literature, the following research questions were proposed:

1) How can the degree of servitization be assessed in practice?

The assessment of the degree of servitization has critical academic and practical value. Numerous studies have underlined the precious value gained from the transformation from being product-focused to service-focused. However, the question remains of how to conduct and manage the process of servitization. Therefore, assessing the degree of servitization is required, including monitoring the strategic direction of the transformation. Based on this assessment, providing suggestions for future strategies should also be possible.

2) What are the roles of customization and digital transformation and how can they be measured?

As mentioned previously, customization and digital transformation are two irrefutable factors in the servitization process. Specifically, the application of a wide range of technologies provides possibilities for customization along the value-adding process, providing a foundation not only for facilitating the business process within an organization but also for a variety of new digital products and services provided to customers. Therefore, an in-depth interpretation of the roles of customization and digital transformation is required. First, this study conducted a systematic literature review and empirical investigation of industry partners, and then it developed a model for assessing the degree of customization and digital transformation through a design science methodology. This model is required to provide the evaluation of the current status, assisting strategic decision-making and resource allocation.

3) What are the degrees of internal and external contributions along the value-adding process and how can they be measured?

Identifying the degrees of internal and external contribution is crucial for evaluating the involvement of customers. Along the value-adding process, it is not unusual to involve customers or consumers directly for a customized product or service. Targeted products and services could generate improved customer satisfaction and save unnecessary waste of diverse resources.

b) Methodology and approach

To answer the abovementioned research questions, design science was applied. A systematic literature review as well as close collaborations with industry partners were conducted. Specifically, a wide range of relevant literature together with related documents obtained from conferences, seminars, and company websites was systematically reviewed to gain insights into servitization and provide a holistic perception to fill the current literature gap. Through in-depth formal or semiformal interviews with industry partners, relevant data were collected and analyzed logically and systematically. Based on well-established perceptions in the literature as well as practice, design science was applied to develop models and guidance as the final output of this research project.

To answer the research questions, a framework consisting of models and analysis methods was developed. This framework was divided into two aspects. From a holistic perspective, it provides a generic view of and practical tools for the servitization process with a focus on customization and digital transformation. The question of how to assess companies' capability in targeted areas was answered. companies' competence and capability on the three important elements can be showed graphically. From a detailed perspective, the framework generated analyses at the phase and activity levels. For the phase-level analysis, the relevant business processes were analyzed within every step of the value-adding process, from idea generation to implementation. Activity-level analysis provided an opportunity to present detailed activities involved in the value-adding process. Together, this two-level analysis can provide companies with in-depth perspectives for spotting problems and measuring related capabilities. The overall framework provides practitioners and scholars with holistic and systematic perspectives as well as tools to observe and assess servitization. Moreover, it provides the possibility for systematically implementing servitization through customization and digital transformation.

1.4. Organization of the dissertation

This dissertation is structured into seven chapters. Chapter 2 lays the theoretical foundation and presents the relevant concepts in related areas. Chapter 3 discusses the methodologies and data collection processes. Chapter 4 presents the developed servitization framework and the data

analysis tool. Chapter 5 presents the results from the field study for building and evaluating the framework. Chapter 6 summarizes a step-by-step set of guidelines for the application of the servitization framework; furthermore, the chapter presents a conclusion featuring the main achievements and limitations of this research project. Finally, Chapter 7 highlights the contributions of this research project.

2. Literature

In this chapter, a systematic review of the literature on servitization is provided. It reviews the literature from both the horizontal and vertical dimensions. Specifically, from a horizontal perspective, the intention of the literature review is to obtain a broad perception of the definitions, the underlining principle of servitization, and the active research streams. Moreover, the relationships between servitization, customization, and digital transformation are revealed. Then, from the vertical perspective, the literature on PSS (the representative case of servitization) is reviewed to gain an in-depth interpretation through its definition, classification, and design methodology. In summary, the literature on servitization and PSS form the critical theoretical foundation for this research project.

2.1. Products and services

Before introducing the concepts and related aspects of servitization, it is essential to clarify the most basic definitions: products and services. Essentially, products and services are the basic elements of PSSs, which are applied most frequently in conjunction with servitization (Neely, 2008; Baines et al., 2009). Thus, an accurate interpretation of products and services as well as their integration is demanded before further discussion. Therefore, their definitions, integration, and classification are discussed in detail in the following subsections.

2.1.1. Definitions of product and service

Products and services are the basic elements of servitization. As identified by Baines et al. (2009, P3), they are “intrinsically linked” with servitization. However, the importance of services has received much more attention than their counterpart. In terms of a product, most scholars have defined one simply using its tangible feature (Shimomura, Nemoto, and Kimita, 2014; Ceschin, 2014), which has also been well understood by manufacturers (Baines et al., 2009). In the literature, no extraordinary differences are found in the definitions of a product. By contrast, the definitions of a service are highly diverse. Some scholars have agreed that the importance of servitization and PSSs is mainly because of the service part, not the product part (Vasantha et al., 2011). Zarco (2016) further stressed that the provision of services is the determining factor for servitization. However, this emphasis on services has made any attempt to define them rather complicated. Intangibility, heterogeneity, perishability, simultaneity, and customer interaction are the words most frequently used to capture the characteristics of a service (Fisk, Brown and Bitner, 1993; Metters and Marucheck, 2007).

Table 1. Definitions of service.

Definition	Author	Source
“A change in the condition of a person, or a good belonging to some economic entity, brought about as a result of some other economic entity, with the approval of the first person or economic entity.”	Hill (1977), p. 318	The Review of Income and Wealth
“We define services as the application of specialized competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself.”	Vargo and Lusch (2004), p. 2	Journal of Marketing
“A service is generally implemented as a course-grained, discoverable software entity that exists as a single instance and interacts with applications and other services through a loosely coupled (often asynchronous), message-based communication model.”	Brown et al. (2005), p. 728	IBM Systems Journal
“Any act or performance that one party can offer to another that is essentially intangible and does not result in the ownership of anything.”	Kotler and Keller (2012), p. 378	Marketing Management
“A process in which “the customer provides significant inputs into the production process.	Sampson and Froehle (2006), p. 331	Production and Operations Management
“Services are acts performed for someone else, including providing resources that someone else will use.”	Alter (2010), p. 201	Communications of the Association for Information Systems
“Service is value-creating support to another party’s practices.”	Grönroos (2011), p. 14	Marketing Theory

The definitions of a service vary depending on the discipline. As seen in Table 1, a service can be perceived as a software, process, or performance, which fulfills various expectations in different contexts. Among them, the notable points are as follows: (1) The customers’ input has been well realized. Katzan (2008) emphasized this feature by defining service as the intangible heterogeneous value-creating process that is co-produced or co-consumed with the customer at the point of production. This feature of service provides opportunities for more customer involvement. (2) The abovementioned definitions mention that no change of ownership is

involved in service provision, which is different compared with products (Kotler and Keller, 2012; Sampson and Froehle, 2006). These characteristics of no change of ownership together with the intangible feature of service have resulted in the perception that services are considered as assistance for reaching a desired goal (Baines et al., 2009). Furthermore, Maussang, Zwolinski, and Brissaud (2009) interpreted services as the entities that assist a system to deliver a desired function. (3) A raised awareness exists on the knowledge-intensive character of a service (Vargo and Lusch, 2004). The knowledge-intensive feature makes services not only harder to produce but also more difficult for competitors to imitate (Vendrell-Herrero et al., 2017.).

2.1.2. Taxonomy of services

As described previously, the process of servitization is basically the process of adding services to the value proposition. Therefore, understanding the different types of service that contribute to the process is crucial.

Vasantha et al. (2012) identified two types of service from traditional and broader perspectives. Both are perceived as a set of activities that satisfies different demands. According to the traditional perspective, a service is classified with the purpose of maintaining the availability of the product; for example, maintenance and repair services. According to the broader perspective, a service is delivered to satisfy customers' requirements. Therefore, the traditional extent of a service still focuses on delivering the function of a product; thus, it is product oriented. The broader extent of service is closer to a customer-centric view.

The servitization process depicts the transition process from pure product to pure service. According to the seminal work presented by Vandermerwe and Rada (1988), it is a transformation of a product-centric to customer-centric view. Therefore, the classification by Vasantha et al. (2012) depicts the transition of servitization as basically the transition from the traditional perspective of a service to the broader perspective of the service.

A more detailed discussion on the classification of services was presented by Baines and Lightfoot (2013). They classified three types of services based on the level of complexity and introduced the relationships between them. The intentions of the three types of services were identified to change from supporting products toward supporting customers. These two destinations are consistent with the abovementioned view of Vasantha et al. (2012).

Base services

The provision of *base services* complies with a product-centric view. The delivery of the product is the final outcome. Base services provide the spare parts that solely focus on the product.

Intermediate services

The term *intermediate services* is used to describe a group of services that guarantee the function of a product. This is a perspective of service that leans toward the application or usage context of the product. The services included in this category, such as maintenance, repair, and monitoring, ensure the function of the product.

Advanced services

This type of services is applied where the customer is involved. With *advanced services*, the product is able to deliver a solution for the customer, with which the capability is at the center of concern. With advanced services, customers pay more attention on the function of the products, and they themselves play the indispensable role in the process.

Clearly, this taxonomy of services is in line with the servitization transition process. The development from base to advanced services is basically a transition process from a product-centric view to a customer-centric one where the customer plays a key role. This also complies with the original view provided by Vandermerwe and Rada (1988). In their work, they identified the final stage of servitization as generating “goods + services + support + knowledge + self-services” (Vandermerwe and Rada, 1988, p. 316). Until the end of the servitization process, the capability is delivered through the combination of products and services, related support, knowledge, and customer involvement. In other words, by adopting a servitization strategy, along with the process of product provision, companies' transit from providing base services to advanced services. This taxonomy has been recognized and adopted by many scholars in the field of servitization (Cenamor, Rönnerberg and Parida, 2015; Rabetino, Kohtamäki and Gebauer, 2017; Kowalkowski, Kindström, and Witell, 2011), and a strong understanding of it facilitates research in this area.

Evidently, products and services are two basic elements in the arguments or discussions on the topic of servitization. However, a separate discussion of both is far from sufficient. As indicated by Vandermerwe and Rada (1988), the process of servitization demands that products and services transform from two separated concepts to a combined one, and until the end stage, an integrated concept. Therefore, more emphasis is placed on the combination or integration of products and services. Thus, it is necessary to investigate a combined or integrated definition of products and services in favor of servitization. In the following subsection, various attempts to define such a combination or integration of product and service are reviewed.

2.1.3. The integration of products and services

The evolution of definitions depicting the integration of products and services has come a long way. It begins with the concept of bundling or packages, which are used to describe a product and service that are simply coupled or combined. Later, attention turned more toward an integration of the two, adopting a customer-centric view. The evolution is briefly traced as follows.

Bundling was developed in the marketing research field, and the term is used to define two or more products and/or services combined into one package (Guiltinan, 1987). Examples range from a vocational package to combinations of computer hardware and software (Venkatesh and Mahajan, 1993).

Systems selling is somewhat similar to the concept of *bundling*. The difference between the two is that *systems selling* focuses on business-to-business (B2B), whereas *bundling* focuses more on business-to-customer (B2C) (Park, Geum, and Lee, 2012). Simple customization is possible with *systems selling* (Mattson, 1973).

Product and service was proposed as a concept that combines all additional services with product offerings, which results in gaining competitive advantages (Frambach, Wels-Lips and Gündlach 1997). Two types of *product and service* were identified as transaction-based and relationship-based products and services (Baines et al., 2009).

Solutions were defined as the customized integration of products and services, created to fulfill customers' demands or solve a specific problem (Miller et al., 2002). Although other attempts have been made to link *solutions* with *bundling*, which simply defines *solutions* as a bundle of products and services, they are far from sufficient (Galbraith, 2002). Clearly, a solution by definition is a tailored integration of a product and service. Therefore, its customization toward customers' needs can possibly occur as early as the design phase, whereas bundling by definition is more feasible after the production phase. Based on their interpretation of *solutions*, Shepherd and Ahmed (2000) proposed the demand for a solution-based business model.

Integrated solutions, similar to *solutions*, were developed and applied to describe the combination of products and services. In the literature, an integrated solution that consists of such a combination is usually created with the purpose of satisfying a customer's requirements (Windahl, 2007). Evidently, *integrated solutions* also take the customer-centric view. The difference between *integrated solutions* and *solutions* is that *solutions* are applied mainly in the computer and electronics industry, whereas *integrated solutions* are not limited to any particular application contexts (Park et al., 2012).

Product-service systems (PSSs) have been developed and discussed broadly in the literature. Various research streams target the definitions, benefits, classification, and design approaches of PSSs. The first definition in a publication was by Goedkoop et al. (1999, p. 18), who defined a PSS as "a marketable set of products and services capable of jointly fulfilling a user's need".

Based on this foundation, scholars have been able to identify a PSS as “a system of products, services, supporting networks, and infrastructure for gaining sustainability, competitiveness, customer satisfaction, or a lower environmental impact” (Mont, 2001, p. 34; Centre for Sustainable Design, 2001; Brandstötter et al., 2003, Wong, 2004; Baines et al., 2007; UNEP, 2002). Notably, the application of a PSS is no longer linked solely to fulfilling customers’ needs but has become broader. For example, the term “dematerialization” has been applied to introduce the opportunity provided by a PSS, with which the link between the required amount of physical materials and the delivered value is broken down (Baines et al., 2007). Through the dematerialized integration of products and services, the importance of services has arisen. They are no longer the additional element that assists the function of others. Service in the definitions of PSS enjoys an equally important status to product, as stressed by Goedkoop et al. (1999).

Through a brief review of definitions on the integration of products and services in the literature, it is evident that the abovementioned definitions have many similarities. Among them, a certain degree of combination or integration is reached. The intention of satisfying customers’ needs is commonly agreed upon. The difference lies in the degree of integration and the application contexts of different terms. The development of the integration of products and services follows a path toward adopting a more customer-centric view, which is consistent with the features of servitization. The evolution of the integration of products and services reveals a trend of integrating them earlier in the value-adding process instead of only during the application phase, which provides more opportunities for customization.

2.2. Servitization as a transition process

2.2.1. Servitization as a rising phenomenon

Servitization is defined as a transition process that allows companies to create value for customers (Vandermerwe and Rada, 1988; Kinnunen and Turunen, 2012). Over the past decades, companies have started to add services to their value proposition, driven by the pressure of increased costs and globalization. The phenomenon of companies creating value through discovering and adding potential services to their core product portfolio was first observed in the manufacturing industry. As mentioned previously, this phenomenon was named servitization by Vandermerwe and Rada (1988). Afterwards, the term was applied to describe the transition process of manufacturing companies transforming from a product-centric to service-centric view. Three overlapping stages exist in the servitization process (Vandermerwe and Rada, 1988): (1) goods or services; (2) goods + services; and (3) goods + services + support + knowledge + self-services. Based on this interpretation, other scholars have further defined servitization as the process of establishing

revenue streams through service provision (Johnstone, Dainty and Wilkinson, 2009; Smith, Maull, and Ng, 2014).

A representative example of servitization in manufacturing can be found in Rolls Royce. The multinational company based in England has successfully conducted the transition process of servitization through providing its customers with “total care” and “Power by the Hour” (Baines et al., 2007; Baines and Lightfoot, 2013; Isaksson, Larsson, and Ronnback, 2009, p. 329). The customer rents the aircraft engine instead of buying. In this way, the company provides the customer not the aircraft engine itself but the function it delivers. During the usage of the engine, Rolls Royce is allowed to collect data from the engine and provide maintenance work to make sure that the required function is guaranteed. Apparently, the interests of customers and producers are aligned through a servitized business model (Neely, 2008).

In addition to the manufacturing industry, companies from across other industries are seeking opportunities to transform their business from product- to service- or customer-centric (Kinnunen and Turunen, 2012; Rabetino et al., 2017; Kowalkowski et al., 2017). For example, in the music industry, services such as Spotify and Apple Music provide customers with access to music that is no longer in physical form (i.e., CDs), but now in a digitalized form by paying a monthly fee (Parry, Bustinza and Vendrell-Herrero, 2012). This transition from providing physical products to digitalized services has revolutionized the traditional music industry and fostered numerous startups that were previously not possible.

Although perceiving servitization as a transition process has been widely accepted, other perceptions with different focuses do exist. It is essential to examine different perspectives to gain a comprehensive interpretation of the subject of servitization. For example, Visnjic and coworkers described servitization as a business model, with which the offer of the product could be extended to the service (Visnjic, Neely, and Wiengarten, 2012; Visnjic and Van Looy, 2013). Ahamed, Inohara, and Kamoshida (2013, P20) recognized servitization as a strategic approach that allows manufacturers to offer “value package” in which a combination of goods and services is fostered. Baines et al. (2009, p. 4) defined servitization as “the innovation of an organization’s capabilities and processes to better create mutual value through a shift from selling product to selling PSS.” Dahmani, Boucher, and Peillon (2016) recognized servitization as a strategic decision-making process, which supports the organization to move toward a service-centric business model that facilitates the integration of products and services. Kinnunen and Turunen (2012) stressed the nature of continuity and the importance of top management for the decision-making process of servitization. Lachiewicz et al. (2018) proposed servitization as modern concept for management where it demands critical changes in a company’s management system.

Evidently, these different interpretations of servitization do not conflict with the definition proposed by Vandermerwe and Rada (1988). The difference comes from the diverse focuses or application contexts. To summarize, the provision of the integration of product and service is always at the center of these definitions, which is driven by customer demand (Baines et al., 2009). In all abovementioned definitions, a common and basic understanding is that servitization is a transition process of moving toward a customer-centric perspective.

2.2.2. Concepts applied to describe the servitization phenomenon

Diverse attempts have been made to describe the servitization phenomenon in the literature. Although the term servitization has been widely adopted by academics and practitioners, it is not the only term that appears in the academic literature to depict the transitional phenomenon. Terms such as *service infusion*, *product–service system (PSS)*, and *service transition* can also be commonly seen in the literature and are interchangeable with servitization (Mont, 2002; Davies, 2004; Brax, 2005, Oliva and Kallenberg, 2003; Fang, Palmatier, and Steenkamp, 2008; Gebauer, Paiola and Saccani, 2013).

Service infusion is defined as “an organization-wide embracement of a basic set of relatively enduring organizational policies, practices, and procedures intended to support and reward service-giving behaviors that creates and deliver services excellence” (Lytle, Hom and Mokwa, 1998, p. 459). It is applied in the context of servitization because it depicts the increasing importance of service in business (Kowalkowski et al., 2017). As Kowalkowski, Witell, and Gustafsson (2013) indicated, *service infusion* is conducted from a market-led perspective and has a focus on the strategic level. The concept is in line with the product–service continuum (Chase, 1981) as well as the original definition of servitization developed by Vandermerwe and Rada (1988). However, as indicated by Kowalkowski et al. (2017, p. 7), *service infusion* can be used to describe the servitization process (Ville and Taija, 2015), but servitization as “an overarching concept” covers a wider range compared with *service infusion*.

The term *service transition* mainly appears in marketing and strategy literature. It is applied to illustrate the shift of manufacturers toward a solution or service offered to gain differentiation and improve competitiveness (Fang et al., 2008). Kowalkowski et al. (2015) emphasized that *service transition* depicts the transition process from a product-oriented service to a process-oriented solution, which includes customized services based on the product–service continuum. Therefore, the nature of the final outcome is transmitted from transactional products to relational services. Regarding the concept of *PSS*, it is the one most closely related to servitization (Baines et al., 2009), but with a focus on the engineering perspective (Kowalkowski et al., 2017). The basic principle of a *PSS* is identical to servitization (Tukker and Tischner, 2006), only the motivation and origin of its development is different (Baines et al., 2009). Baines et al. (2009) indicated that

PSSs originated in North Europe with the purposes of sustainability and reducing the impact on the environment. Considering the popularity of PSSs and their close relationship with servitization, they are introduced and discussed in more detail in the following section.

Evidently, all of the abovementioned concepts share an important feature, which is the logic of the product–service continuum. Having this fundamental principle in common provides the possibility that they are, under some circumstances, interchangeable. Therefore, in the following section, an introduction to the product–service continuum is provided.

2.2.3. Product–service continuum

Servitization is defined as a transition process that depicts the shift from offering pure products to pure services (Baines et al., 2007; Olivia and Kallenderg, 2003; Clayton et al., 2012). The logic of servitization is based on the product–service continuum, in which pure product and pure service offerings are defined as two extreme ends. This logic was first promoted by Chase in 1981, who distinguished the concept of pure product from that of pure service. Later, Vandermerwe and Rada (1988) coined the term servitization to illustrate the phenomenon of manufacturers who transition their business from a product- to service- or customer-centric view. The demand for manufacturers to offer a service component or a packet of product, service, and knowledge to gain economic advantage is emphasized.

A series of research associated with servitization along the product–service continuum is thriving. Specifically, Tukker (2004) classified different types of product and service systems based on the interpretation of product–service continuum. Baines et al. (2007) then raised attention for the concept of “productization,” the process toward the opposite direction of servitization, which was stressed as being for service providers to include a product or a service that can be marked as a product in their portfolio. Since then, the transition process toward pure product as productization and that toward pure service as servitization has been clearly defined. Some scholars have used *service infusion* and *service transition* interchangeably with *servitization* to illustrate the transition process that focuses on service growth toward the pure service end (Brax, 2005; Fang et al., 2008; Oliva and Kallenberg, 2003; Kowalkowski et al., 2015). Others have applied *deservitization* and *service dilution* to present the productization process toward the pure product direction (Kowalkowski, et al., 2015; Kowalkowski et al., 2017; Valtakoski, 2017).

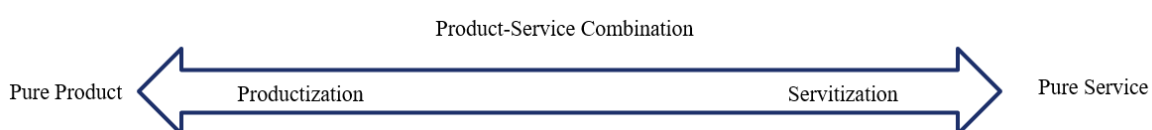


Figure 4. Product–service continuum (adapted from Chase, 1981; Olivia and Kallenderg, 2003; Clayton, Backhouse and Dani, 2012).

Olivia and Kallenberg (2003) applied the product–service continuum logic and expanded the current research stream to how organizations manage the transition process from products to services (see Figure 4). Numerous research studies have appeared on such topics as servitization strategy and servitization approaches (Tran and Park, 2014; Isaksson, Larsson and Johansson, 2011; Vasantha et al., 2011; Böhmman, Möslein and Leimeister, 2014). Later, more scholars discussed how to add value by incorporating service offerings into the product development process (Morelli, 2002; Oliva and Kallenberg, 2003; Baines et al., 2009; Rabetino et al., 2015).

As argued in Chapter 1, the transition direction toward servitization is the main research field, where the logic of the product–service continuum is deeply rooted. However, numerous research streams exist that include diverse definitions applied in different research communities. To gain a holistic view and avoid unnecessary confusion, reviewing the relevant research streams thriving in different research communities and investigating the related definitions are necessary.

2.2.4. Literature streams on servitization

Servitization is a rather complex research field that fosters research streams in a wide range of research communities. Researchers are working in a distinct manner but generating complementary contributions. This section presents a brief introduction to each community to provide an organized and cohesive overview that will facilitate the positioning of related contributions in the servitization field.

a) Servitization research

Five research communities were identified in the research field of servitization (Baines et al., 2009). Each of the research communities and its principle are introduced as follows.

➤ *Service marketing*

In service marketing research, the goal of servitization is discussed from a service-oriented perspective and a systematic consideration. Among the various arguments, the seminal work was that of Vargo and Lusch (2004). They premised the concept of service systems within the scope of service science based on the principle of value co-creation, which has a focus on customer involvement. A plethora of research has originated from this domain, which enriches the concept and indicates the future research direction (Spohrer and Maglio, 2010; Alter, 2012; Böhmman et al., 2014).

➤ *Operation management*

The operational concerns on the production and strategy delivery of products and services or an

integrated/combined product and service belong to this research community (Baines et al., 2009). As indicated by Baines et al. (2009), after the term servitization was introduced by Vandermerwe and Rada (1988), a series of contributions have arisen from the operation management research community, in which the service-centric competitive strategy is a hot topic (Manzini, 1999; Slack, 2005; Brax, 2005; Manzini, Vezzoli and Clark, 2001; Kowalkowski et al., 2015).

➤ *Service management*

With the advent of service factories and the industrialization of services, the awareness of service management was brought to light (Levitt, 1976; Chase and Garvin, 1989; Gummesson, 1994). Since then, the unique character and differentiation of the service industry compared with the traditional manufacturing industry were well realized (Gummesson, 1994); furthermore, the necessity of treating service operation and service management differently beyond the range of operation management of manufacturing was established (Heineke and Davis, 2007). Baines et al. (2009) grouped the operation and strategy domains service management community, which has a focus on service-related organizational matters.

➤ *PSS*

The PSS concept emerged from Scandinavia with a focus on environmental impact, sustainability, as well as social and economic issues. The grounded work was by Goedkoop et al. (1999) who provided the fundamental definition of a PSS. The customer-centric view and the importance of performance rather than ownership have been profoundly discussed. A wide range of contributions can be observed within the PSS community on such subjects as the definitions, classifications, and design approaches of PSSs (Baines et al., 2007; Tukker, 2004; Isaksson et al., 2011; Kimita and Shimomura, 2014). Baines et al., (2009) stressed that a PSS is a special case of servitization.

➤ *Service science*

Service science originated from information system research and has provided a fundamental interpretation for complex service systems (Baines et al., 2009). Here, the system view has been taken for the perception of service. Vargo, Maglio, and Akaka (2008) believed that service-dominated and value co-creation logic are the basic principles of service science. Alter's series of research (2008, 2012) partially adopted the view of service systems from Vargo and Lusch (2008) but focused more on the role of IT systems.

b) Servitization research streams

Increasingly, along with economic growth, servitization has been discussed and analyzed in

literature extensively. However, the complexity of the servitization process posits difficulties in the areas of organization transformation, business models, risk, and financial return (Pistoni and Songini, 2017). Thus, a positive return is not guaranteed (Neely, 2008). The success of servitization strategy implementation requires endorsement from supply chain, customer relationships, knowledge, and organization (Hou and Neely, 2013). It is not uncommon that the streams of research targeting subjects related to servitization are interdisciplinary. Therefore, a logical and comprehensive method of examining the literature is required. Vendrell-Herrero and Wilson (2017) developed servitization taxonomy to investigate the linkage between servitization and territorial competitiveness. This taxonomy could also facilitate a holistic review of servitization literature.

Table 2. Taxonomy of servitization literature (Vendrell-Herrero and Wilson, 2017).

		Mainstream Servitization			
Internal analysis		Quadrant I		Quadrant II	External analysis
		<i>Organizational process</i>		<i>Company performance</i>	
		Baines and Lighfoot (2013) Cusumano Kahl and Suarez (2015) Vandermerwe and Rada (1988)		Benedetti <i>et al.</i> , (2015) Neely (2008) Visnjic and Van Looy (2013)	
		Quadrant III		Quadrant IV	
		<i>Digitization</i>		<i>Knowledge-intensive business services</i>	
		Parry <i>et al.</i> , (2012) Porter and Heppelmann (2015) Suarez <i>et al.</i> , (2013) Schroeder and Kotlarsky (2015)		Czarnitzki and Spielkman (2003) Muller and Zenker (2001) Doloreux and Shermaur (2013)	
		Alternative approaches of servitization			

Vendrell-Herrero and Wilson (2017) divided servitization literature into four quadrants with two defined axes. The vertical axis compartmentalizes servitization using mainstream and alternative approaches, whereas the horizontal axis differentiates servitization through external and internal organization analyses.

The mainstream internal analyses focus on the organizational transformation of servitization implementation, which is presented in Quadrant I. It was identified as the most popular stream of literature and mainly observed in the manufacturing industry (Vendrell-Herrero and Wilson, 2017). Organizational transformation is considered necessary when conducting servitization strategy implementation (Pistoni and Songini, 2017). Accordingly, organizational structure and organizational change have also been analyzed in the context of servitization (Baines *et al.*, 2016; Baines and Lightfoot, 2013, Pettigrew, Woodman and Cameron, 2001; Self, Armenakis and Schraeder, 2007).

Quadrant II concerns the relationship between servitization and companies' performance. Driven by globalization, industries are constantly under pressure to enhance their value proposition, which leads to competitive advantages. Customer-centric service infusion normally results in superior customer experience, cost-effective value provision, and enhanced financial return, which provide companies with the opportunity to be more competitive (Vandermerwe and Rada, 1988; Neely, 2008). However, despite the positive link, other studies have revealed the failure of servitization. Articles investigating the reasons for servitization failure or a service paradox have been written from the perspectives of investment and profit, knowledge and capability, and customer and culture perspectives (Visnjic et al., 2012; Valtakoski, 2017; Hou and Neely, 2013, Neely, 2008,).

Digitalization, or digital transformation, is always a hot topic in association with servitization. Vendrell-Herrero and Wilson (2017) grouped these studies into a sub-topic of servitization under Quadrant III. In this area, the discussion on servitization is extended from manufacturing to a broader scale with the help of digital technologies, for example, in the software, music, eBook, and e-commerce industries. Research thrives with discussions on digital music, the transition of a traditional software provider to a solution provider, and the adoption of the Internet of Things (IoT) (Parry et al., 2012; Suarez, Cusumano and Kahl, 2013; Spohrer, 2017; Porter and Heppelmann, 2015; Rymaszewska, Helo and Gunasekaran, 2017).

Quadrant IV is knowledge-intensive business services (KIBS), which is defined as an alternative approach to servitization. KIBS extend the boundary of servitization research by integrating products and services within an organization. Co-produced knowledge plays the role of an intermediary between a KIBS provider and customers with the collective goal of product or service innovation (Hertog, 2000; Figueiredo et al., 2017). In particular, in the manufacturing sector, small and medium-sized companies that do not possess the resources and capability to implement a servitization strategy are prone to adding knowledge-based or intellectual value-added services (Muller and Zenker, 2001; Kowalkowski et al., 2013; Opresnik and Taisch, 2015; Lachiewicz et al., 2018). The external contribution generated by KIBS becomes a desirable alternative approach to servitization (Lafuente, Vaillant and Ferran, 2015).

2.3. Servitization and customization

2.3.1. Servitization and customization

Customization enjoys a close relationship with servitization. It is a crucial aspect of the servitization transition process, which is aimed at achieving customer-centric view. This means the customer must be at the center of consideration for a company's strategy, development, and business model among others. Fulfilling the demands of customers is the first priority. Mass

production and standardized designs can no longer lead to customer satisfaction.

The importance of customization has been well realized and discussed in the literature. As indicated by Vandermerwe and Rada (1988), the customer is the driving force behind servitization. Furthermore, Ahamed et al. (2013) argued that the customer-centric view is the key character of servitization because customized product and service (PS) offerings and the capability it delivers are the outcomes that interest customers. Furthermore, long-term customer relationship is one of the objectives of servitization (Oliva and Kallenberg, 2003) and resulted from fulfilled customer expectations. Therefore, servitization implementation must be geared toward meeting customer expectations (Armistead and Clark, 1993). Therefore, the urgent need for customization appears (Vandermerwe and Rada, 1988), and accordingly, the question to answer for companies who are implementing a servitization strategy is how to customize.

2.3.2. The role of customer as value co-creator

The crucial role of the customer as value co-creator or co-producer has long been recognized. The service-dominant logic followed by researchers in both the service marketing and service science research communities emphasizes co-creating value with customers (Vargo and Lusch, 2004; Ng, Nudurupati and Tasker, 2010). The role of customer as value co-creator stresses the central position of the customer in the servitization process. Therefore, value is essentially co-created or co-produced, which provides the possibility for realizing customization during the servitization process.

Although numerous studies targeting customer involvement during the value-adding process can be found in the literature, customer involvement in the product development process tend to be discussed separately from the service development process. Studies that have emphasized customer involvement during product development have a long history and are more than those studies on service development; therefore, they are more mature than the focus on service development or the PSS value-adding process. For example, Kaulio (1997) established a framework analyzing methods that support customer involvement in different phases of product development, namely the specification, concept, and prototyping phases. Hoyer et al. (2010) proposed a conceptual framework for assessing the degree of customer contribution in the process of developing new product; moreover, O'hern and Rindfleisch (2010) identified four types of customer co-creation activity during the same process.

Along with the emergence of PSS, the focus of the literature accordingly shifted to the importance of the customer co-creating role during the value-adding process of PS combined. For example, the Fast-Track design processes developed by Alonso-Rasgado and Thompson (2006) aimed to generate a PS design concept together with customers from the very beginning of the development process. The agreed output of each stage guaranteed that the solution delivered at the end is based

on the mutual agreement of involved parties. Kimita et al. (2016) further discussed the possibility of customer involvement during the PSS development process. A framework was then presented for analyzing customer involvement in the context of PSS. Notably, in the PSS research field, P/S are discussed from an integrated perspective, which is demanded for research on servitization. These previous works on PSS provide a solid foundation in the servitization field with an emphasis on customization, and therefore, they are reviewed in detail in a later section.

2.4. Servitization and digital transformation

2.4.1. Digitization, digitalization, and digital transformation

In recent years, along with the development of new technologies such as cloud computing and big data, the terms digital transformation, digitization, and digitalization have become buzzwords mentioned in research across disciplines. However, terminological confusion exists in the literature. Digitization has not uncommonly been used interchangeably with digitalization and digital transformation in a servitization context (Brennen and Kreiss, 2016). Nevertheless, the term is, for all intents and purposes, not inter-replaceable.

a) Digitization

In the Oxford English Dictionary, *digitization* refers to “the action or process of digitizing” the analog data into digital form. Therefore, the term *digitization* is applied in this study to describe the technical action or process. This is the main idea engendered by computerization (Tilson, Lyytinen and Sørensen, 2010). Dematerialization of information from its physical carriers for enhanced storage, transformation process, and usage are the core principles behind it (Brennen and Kreiss, 2016).

b) Digitalization

Digitalization, by contrast, refers to the increasing trend of the application of computer-related technology by a community or society (Parviainen et al., 2017). The term is used mainly for sociotechnical phenomena regarding the adoption and application of technologies in private, social, and environmental contexts (Schumann, Tittmann, and Saxon, 2015). Therefore, it is the sociotechnical process of adopting digital technologies. Digitalization transforms, structures, shapes, and influences private lives, society, and businesses, and thus, calls for more responsibility and efforts from a broader scale of society (Brennen and Kreiss, 2016; Tilson et al., 2010). This difference between digitization and digitalization should be correctly and carefully interpreted. The application of the terms should also be used in the accurate contexts.

c) Digital transformation

Digital transformation is applied to describe the automation of tasks through the adoption of information technologies (Hess, 2016). Legner (2017) stressed that digital transformation is a technology-related and goal-oriented transformation process that requires efforts at the individual, organizational, managerial levels. Böhmann et al. (2014) further emphasized that the success of digital transformation of a business requires changes in an organization's structure, IT infrastructure, people's mindsets, methods, processes, and business model (among others). In reality, the transformation also means companies are equipped with possibilities to connect and communicate with customers more efficiently through, for example, digital devices or social media. However, this transformation is not limited to businesses but also other organizations or communities.

To summarize, digitization, digitalization, and digital transformation represent three levels of transition. Digital transformation includes digitization and digitalization, whereas digitization and digitalization are two elements of digital transformation. However, digitization and digitalization are not indispensable for conducting digital transformation.

2.4.2. Waves of digital transformation

In terms of digitally transforming business and society, Legner (2017) identified three waves along the development of technology. The three waves provide a general view of the history and evolution of digital transformation.

- The first wave was observed in the transformation of workplaces. It focused on the replacement of physical objects; for example, paper with computers.
- The second wave was caused by the advent and development of the Internet. It fundamentally transformed the means of communication, information, and knowledge acquisition. Companies are provided with possibilities to create, for example, value and new revenue models through the application of the Internet. E-commerce is the evident result of this wave, which has radically transformed business and society.
- The third wave concerns the transformation engendered by social, mobile, analytics, and cloud computing technologies. Furthermore, digital technologies enable new PS offerings or improve existing ones as a result of digitalized business models. The difference of the third wave compared with the previous two is that the driving force is people instead of newly developed technologies.

2.4.3. Targeted areas for digital transformation

As indicated above, digital transformation is similar as digitalization but more goal-oriented. Therefore, to reach the goal of any digital transformation, the scope of the transformation should

be defined, with which a forward-looking strategy can be identified, and an execution plan can be put in place before actions are taken.

Therefore, companies must understand the targeted fields for digital transformation. Research conducted by Capgemini Consulting and the MIT Centre for Digital Business (2011) may elucidate these fields. The framework for the areas of digital transformation in Table 3 has widely been accepted and followed in practice.

Table 3. Areas of digital transformation (MIT Centre for Digital Business & Capgemini Consulting, 2011).

Customer Experience	Operational Process	Business Model
<i>Customer understanding</i>	<i>Process digitalization</i>	<i>Digitally-modified business</i>
·Analytics-based segmentation ·Socially-informed knowledge	·Performance improvement ·New features	·Product/service augmentation ·Transitioning physical to digital ·Digital wrappers
<i>Top-like Growth</i>	<i>Worker enablement</i>	<i>New digital business</i>
·Digitally-enhanced selling ·Predictive marketing ·Streamlined customer processes	·Working anywhere ·Broader and faster communication ·Community knowledge-sharing	·Digital products ·Reshaping organizational boundaries
<i>Customer touchpoints</i>	<i>Performance management</i>	<i>Digital globalization</i>
·Customer service ·Cross-channel coherence ·Self-service	·Operational transparency ·Data-driven decision-making	·Enterprise integration ·Redistribution decision authority ·Shared digital services
·Unified data and processes ·Analytics capability	Digital capabilities	·Business and IT integration ·Solution delivery

This framework consists of three main areas: customer experience, operational process, and business model. Each area has three subfields embracing digital transformation. Together with digital capability as fundamental elements, the total of 10 fields illustrate the most common areas targeted for digital transformation in- and outside an organization. Details of each main area are provided as follows:

- Customer experience

Companies apply social media and online communities to understand customer behavior more effectively. Digital tools such as tablets and mobile apps are used to promote sales and simplify the purchase process. Customer service is enhanced through social media platforms and self-service is enabled through the application of diverse digital technologies.
- Operational process

Software, such as enterprise resource planning (ERP) and customer relationship

management (CRM), is significantly improving companies' internal-process efficiency and customer relationship management. In-depth collaborations enabled by digital tools benefit interdisciplinary and collaborative teams, despite the location of the office. Data gathered through multiple channels and locations better equip business executives for strategic decision-making. As indicated by the MIT Centre for Digital Business and Capgemini Consulting (2011), improvements to companies' internal performance are the most highlighted advantage of digital transformation.

➤ **Business model**

With the assistance of digital technologies, it is possible for companies to either partly digitally modify their business model or provide a disruptive one. Innovative digital products or services are enabled alongside the traditional PS portfolio. Digital globalization is supported by centralized as well as decentralized companies through centralized data and locally customized business with help from digital transformation.

To enable and support digital transformation in the abovementioned areas, digital capability is the fundamental factor (MIT Centre for Digital Business & Capgemini Consulting, 2011). Specifically, it is crucial for companies to possess and process unified data, which allow them to develop advanced analytical capabilities and reduce the difficulty for further transformation. Digital platforms such as ERP and CRM systems are seen as being beneficial in terms of unifying data and processes. To enable and improve digital capabilities, IT departments require a specific skillset for emerging technology and its application. Furthermore, a solid connection between IT and business is mandatory.

2.4.4. Toolkit for digital transformation

The Gartner Report on the top 10 strategic technology trends for 2018 predicted technology trends arising that year, which can serve as a toolkit for servitization and customization in the present research (Gartner, 2018). In this subsection, details on the categories of technology are introduced. The Gartner Report classified three main categories of technology trends, namely intelligent, digital, and mesh. Each category includes three or four technology trends.

Table 4. Trending technology for 2018 (Gartner, 2018).

Intelligent	AI Foundations
	Intelligent Apps and Analytics
	Intelligent Things
Digital	Digital Twins
	Cloud to the Edge

	Conversational Systems
	Immersive Experience
Mesh	Blockchain
	Event-Driven
	Continuous Adaptive Risk and Trust

Intelligent.

This group comprises artificial intelligence (AI) foundations, intelligent apps and analytics, and intelligent things.

- AI foundations can improve strategic decision-making and customer experience, as well as enhance innovative business models with learning, adaptive, and predictive functionalities, which eventually lead to autonomous operation. Digital innovation could be driven by the adoption of AI and advanced machine learning within diverse business contexts.
- Intelligent apps and analytics including virtual personal assistants, security software tools, and enterprise software such as ERP could transform the workplace to have greater potential and assist companies to perform more effectively. The report indicated that enhanced customer satisfaction could be expected, which would result from the adoption of a full range of intelligent apps and data analytics tools in the world’s biggest companies in the following year.
- Intelligent things include Internet of Things supported by AI and machine learning. AI and machine learning underpin the physical devices to intelligently interact with people and the environment. The application contexts are immersed into peoples’ private, business, and public lives. Liability and privacy are expected concerns that demand more attention and will potentially slow the development process.

Digital.

The boundary between the digital and physical worlds is becoming increasingly blurred. Advanced technologies enable the digital world to reflect on the real world more vividly and in greater detail. Specifically, digital twins, cloud to the edge, and conversational platforms are infused into this category.

- Digital twins enable a company to establish a digital model from a physical object and operate it in a virtual environment. Together with people and processes, digital twins provide the possibility for stimulating and analysing the real world in response to different conditions and changes.
- Edge computing is a computing technology with which information can be collected,

processed, and computed in a place at the edge of a network near the information source. The implementation of cloud systems with edge computing will enhance the creativity of service-oriented models as well as the disconnected parts of the cloud system.

- Conversational platforms range from bidirectional text or voice conversations to a more computer-interactive conversation between people and machines. Conversational systems are expected to evolve in the future to generate people's desired outcomes. The shortfall of current conversational platforms is that communication between computers and humans must be strictly structured to yield optimal results.
- Immersive experiences enable people to be immersed in an environment that simulates the real world, whereas augmented reality transforms the real world into an interactive and digitally manipulated environment. Virtual and augmented reality provide the possibility for immersive experiences and are transforming how individuals interact with the real world.

Mesh.

Mesh refers to digital ecosystems that consist of connected people, processes, and things. To enable the development of a mesh, the supporting technologies and platforms must be accordingly adjusted.

- Blockchain is a distributed ledger that adds transparency and trust to transactions in an industry. It contains a series of blocks that include lists of records between two parties. The suitable application contexts of blockchains include identity management and transaction management.
- Event-driven refers to a thinking pattern that should be embraced by digital businesses. At present, business events such as the location and completion of a purchase can be traced and analysed effectively by technologies such as AI and the IoT. Accordingly, this has urged businesses to adopt event-driven thinking into their business strategy.
- Continuous adaptive risk and trust are necessary for the challenging and quickly evolving digital environment. The development of digital technology platforms from the IoT, mesh apps, and service architecture require adaptive adjustments in the security architecture. Continuous adaptive risk and trust allow a people-centric security strategy that empowers the developer with security responsibility. The continuous adaptive security concerns should be included in the daily DevOps process.

The strategic technology trends provided by Gartner are indeed helpful for providing an overview of the current status of trending technologies. The report presents possible paths for a company that intends to gain competitive advantage. However, it serves as only part of the technology toolkit in terms of servitization and customization. In fact, all digital tools that can assist companies in the three targeted areas (i.e., customer experience, operational management, and business model) regardless of whether they are trending or not, are considered relevant.

2.5. Representative case of servitization: PSS

2.5.1. Servitization and PSS

Servitization is viewed as a transition process that allows companies to compete through adding services (Fang et al., 2008). It is not uncommon that servitization is exclusively discussed by researchers and practitioners in different research communities or industry contexts. Servitization can be observed in service marketing, PS systems, service and operation management disciplines, as well as in the manufacturing, hospitality, and music industries (Kohtamäki et al., 2013; Kindström, Kowalkowski, and Alejandro, 2015; Witell and Löfgren, 2013; Smith, Maull, and Ng, 2014). Among academics and practitioners, the term PSS is frequently mentioned interchangeably with servitization (Baines et al., 2009). Not only does it comprise one of the five research streams in the servitization field, but it is also the concept applied most frequently in association with servitization (Neely, 2008; Baines et al., 2009).

Some scholars consider a PSS to be a special case of servitization and commonly refer to it directly as servitization (Neely, 2008; Baines et al., 2009; Vasantha et al., 2011). Ahamed et al. (2013) maintained that PSS is the destination of servitization (Baines et al., 2007 and Zahir, Inohara and Kamoshida, 2013b) and emphasized that servitization is a value-creating process achieved through the shift from pure product provision to a PSS offering. Akram (2012, p. 1) perceived PSS as a “strongly related phenomenon” to servitization. As shown in Figure 5, the classification of PSS developed by Tukker (2004) illustrates a strong connection between PSS and servitization, which have irrefutable similarities. The three types of PSS are directly based on the product–service continuum, which is also the underlying logic of servitization.

Perceptions of the link between servitization and PSS by the abovementioned academics demonstrate an intrinsic connection between them. Although the application contexts can be diverse, discussing servitization and PSS is basically a discussion on the same theme.



Figure 5. Main PSS categories (adapted from Tukker, 2004).

Therefore, in this research project, I used PSS as the main concept to describe the transition process of servitization; that is, it is applied in this dissertation interchangeably with the term servitization. Furthermore, because PSS has been accepted, applied, and worked on broadly in literature and practice (Beuren et al., 2012), the concept provides a solid theoretical foundation as well as practical value for research in the servitization field. Thus, in this research project, PSSs were chosen to gain an in-depth interpretation of servitization. Its definition, classification, and design approach are discussed in detail in the following subsections.

2.5.2. Definition of a PSS

Most of publications on PSS are from North Europe during the late 1990s. The first publication was by Goedkoop et al. (1999), who coined the term PSS. Since then, a variety of literature targeting PSS has been published. Great contributions were made by Manzini and Vezzoli (2003), Manzini, Vezzoli, and Clark (2001), and Baines et al., (2007) in publications such as the *Journal of Manufacturing Technology Management* and *Computer Integrated Manufacturing Systems*. Table 5 provides detailed definitions extracted from multiple authors.

Table 5. PSS definitions in the literature.

Authors	PSS Definition
Goedkoop et al. (1999)	A PSS is normally designed to satisfy customers' desire, which includes products, services, factors of networks, their relations and the underlining infrastructure.
Centre for Sustainable Design (2001)	A PSS comprises three elements, which are products, networks and infrastructure. It is designed based on the wish of the customer and better suits the sustainability requirements of environment.
Mont (2002)	A PSS is a better business model compared with traditional ones, which includes products, services, networks and infrastructure. It is normally generated to fulfill customers' requirements.
UNEP (2002)	PSS is the outcome of strategic decisions that transforms the focus of traditional businesses from the transaction feature of the product to the provision of the product and service combination in order to satisfy a specific demand.
Manzini and Vezzoli (2003)	A PSS is an innovative strategy that is developed to satisfy customers' needs. It assists company to transform their business from only product-focused to products- and services-focused mindset.
Tukker (2002)	A PSS integrates products and services to satisfy special requirements from the clients.

Brandstötter et al. (2003)	A PSS is a combination of products and services, which is generated to satisfy the customer. It has a lower environmental impact and is helping to fulfill the sustainability requirements.
Wong (2004)	A PSS consists of products and services is designed as an outcome that fulfill a certain function demanded from the customer, which is originally developed to improve revenue.
Baines et al. (2007)	A PSS is a combination of products and services that is only valuable when it is applied by the customer. It creates possibility for PS provider to increase sales not only with the tangible products but also with the intangible services, which helps to achieve the goal of sustainability.
Maussang et al. (2009)	A PSS is a system of tangible products and intangible services that are working together. The tangible product is responsible for the basic outcome of the system whereas the intangible services support and guarantee the delivery of the outcome.

As asserted by Baines (2007), the PSS concept of Goedkoop et al. (1999) demonstrates the necessity of a combined PS within the scope of a system. The three key elements are emphasized as being a product, service, and system, namely all involved elements and their relations. It has provided a solid starting point for others to work from. Many scholars have taken after this view and introduced a variety of PSS definitions. Among the definitions listed in the table, the important points can be summarized as follows:

- A PSS is often described as system, strategy, business model, offering, or solution.
- A PSS includes products, services, network of players, and a supporting infrastructure.
- A PSS is designed with the purpose of fulfilling customers' needs or specific demand or delivering a required functionality.

A PSS is created for various purposes but does not necessarily have to cover all functions. With the different emphases and diverse expectations of PSSs, many scholars have defined a PSS as a method for achieving economic gains in the market (UNEP, 2002; Wong, 2004), whereas others have focused on the sustainability perspective to lower environmental impacts (Goedkoop et al., 1999, Centre for Sustainable Design, 2001, Mont, 2002). However, as argued by Ceschin (2014), a PSS designed with environmental benefits cannot necessarily obtain sustainability. A specifically defined, developed, and delivered PSS is required to incorporate environmental requirements into the process, whereas one designed to achieve sustainability demands a socio-ethical dimension. As underlined by Baines (2007), a balance between the economic, environmental, and social aspects is the key for achieving sustainability. This assertion provides a more holistic and coherent perspective on the observation of PSS development and attempts to define a PSS.

In several definitions, products and services are mentioned as both combined or integrated in the system. The integrated aspect is further stressed by Baines (2007, p. 3) who stated that the product and service are integrated to form PS offerings, with which value is delivered in the process of its application; this is called “value-in-use.” This definition demonstrates that a PS offering can be considered the outcome of a PSS. The value is created through the delivery of the PS offering. A shift in focus is implied in the definition, in that the ownership of the product is no longer the focus of business but the utilization and application of it are (UNEP 2002; Manzini and Vezzoli, 2003; UNEP, 2009).

Based on their perception of previous definitions, Komoto and Tomiyama (2009) indicated that the PSS is a methodology based on which an innovative business model can be developed. Similarly, Meier (2010) stressed that a PSS enables result-oriented business models, and those generated business models are also considered to be a PSS.

Tan et al. (2010) described a PSS as a business strategy that assists the transition from the product-oriented to service-oriented perspective. Baines (2007) also emphasized that value is delivered to customers not through products but through their application and performance.

The concept of dematerialization has been mentioned by many scholars (Mont, 2002; Ehrenfeld, 2008; Manzini and Vezzoli, 2003; Wong, 2004; Tomiyama, 2001). The intention of dematerialization is to decouple the value delivered to the customer from its physical form and shift the focus to the importance of the service. Therefore, attention is given to optimize the efficient selection and application of the physical resources required to produce the products. Accordingly, lower environmental impacts and competitive advantages can be achieved.

The tangible and intangible features of products and services were mentioned by Tischner, Verkuijl, and Tukker, (2002), with which Brandstötter et al. (2003) and Aurich, Fuchs, and Wagenknecht (2006) agreed. They referred to products and services as physical and nonphysical components. Distinguishing products and services by adding tangible and intangible features provides the possibility to further incorporate various types of product and service integration or PS offering.

In sum, the basic definition of a PSS can be summarized as “an integrated system of products and services, delivered by one or more socioeconomic actors, and designed to fulfill a specific need” (Ceschin, 2014, p. 21). Because the PSS concept is based on the logic of the product–service continuum, the system in this definition embraces elements of pure product and pure service, and the combination of a product and service, namely a PS offering. Furthermore, the system is composed of a network of actors that have influences on the PSS and the infrastructure supporting it (Mont, 2002). Accordingly, the four crucial elements of a PSS can be summarized as follows:

- Product: a tangible artefact produced by a PPS (Goedkoop et al., 1999; Ceschin, 2014).
- Service: a service generated by a PPS alone and the service associated with the whole life cycle of the product (Goedkoop et al., 1999; Tischner et al., 2002).
- Network of actors: all the required socioeconomic actors used to generate a PSS, including the relations and interactions between them (Baines, 2007).
- Infrastructures: the infrastructures that influence the development and configuration of the PSS. The internal and external organizational structures, resources, and capabilities should all be considered in this category (Gaiardelli et al., 2014).

Here, one terminology-related problem that must be addressed is the term *PS offering*. *PS offering* is commonly applied in conjunction with *PSS*. Scholars have argued that a *PS offering* is the outcome of a PSS (Baines et al., 2007), whereas others have adopted the view that the term *PS offering* can be applied interchangeably with *PSS* (Frambach et al, 1997; Gaiardelli et al., 2014). A PSS is also considered as a “specific” type of PS offering (Tukker, 2004, p. 254). Although the application of different terms will not affect the core of the research in the servitization field, it can sometimes generate unnecessary confusion, and thus not be beneficial. Therefore, taking a clarified and coherent stand when conducting research in this area is necessary.

This research took the view of Baines et al. (2007) and applied the term PS offering to mean the outcome of a PSS. As mentioned previously, an integrated PS is not the only outcome of servitization. Theoretically, pure products and pure services should also belong to the set of outcomes, only under different requirements and conditions. Thus, to avoid unnecessary ambiguity, the concept of PSS in this research incorporates combined or integrated products and services as well as the two pure product and pure service ends. *PS offerings* were adopted as the outcomes generated by a PSS. Accordingly, a *PS offering* embraced pure products, a combination or integration of products and services, and pure services.

2.5.3. Classification of PPS

Different approaches exist for classifying PSSs in literature from different dimensions (Brezet et al., 2001; Zaring et al., 2001). In this research project, the two most relevant dimensions were selected and fully discussed. Specifically, the first dimension concerns the change of ownership, whereas the second dimension refers to the nature of interactions between the PS provider and customer.

1) First dimension for classifying PSSs: Change of ownership

Baines et al. (2007) merged other scholars' contributions and differentiated them into three main categories and eight subcategories (Hockerts and Weaver 2002; UNEP, 2002; Tukker and Van Halen, 2003; Tukker, 2004; Vezzoli et al., 2013). Based on interpretations of the product–service continuum, the three main categories of PSSs and eight subcategories are illustrated as follows:

a) Product-oriented PSS

A product-oriented PSS refers to a PSS that place sales of tangible products at the center. Accordingly, this PSS business model is geared toward the sale of the product. The ownership of the product is transferred to the customer as soon as the transaction is completed. The service is generated as an additional or extra package attached to the product. Product-related services, advice, and consulting belong to this category as subcategories. Customers are usually involved in the application and disposal phases of the value-adding process (Ceschin, 2014).

- Product-related service. This can be defined as additional services and provided in the use or end-of-life phases of the product life cycle. For example, documentation of the product, repair and maintenance services, upgrading service, and supply of consumables.
- Advice and consulting. This refers to the advisory and consulting services associated with products. Notably, such services that are not connected with products cannot be categorized into a product-oriented PSS. Supported by Tukker (2004), the advice and consulting that are linked with the product, such as advice on improving the efficiency of application of the product, as well as consultancy on the construction of the team applying the product belong to this category. By contrast, the pure consulting services targeting customers' strategy and process that are not directly related to the product's application or utilization do not belong to a product-oriented PSS.

b) Use-oriented PSS

A use-oriented PSS is defined as PS offerings that focus on the provision of the function of the tangible product rather than its physical form. Therefore, the ownership of the product remains with the product producer. Although the main focus of such a PSS is still on the product, the intention of it is to help companies meet the demands of customers through the application of the product (Ceschin, 2014). Customers are involved only in the use phase of the value-adding process. Product lease, renting and sharing, pooling, and pay-per-service are the four subcategories.

- Product lease. The product ownership does not transfer to the customer. Customers pay only for the use of the product, but the provider is responsible for such things as its function, maintenance, and disposal. With regular payments, the customer's free access is guaranteed.
- Product renting and sharing. The difference between product lease and product renting and

sharing is that, for product renting and sharing, unlimited and individual access is not possible. The product will be used by others at different times.

- Product pooling. The feature of product pooling is similar to product renting and sharing; only the time of use differentiates the two types. With product pooling, the product will be used by other users at the same time.

c) *Result-oriented PSS*

A result-oriented PSS is used to describe the selling of the outcome or capability of a product. The ownership of the product remains untouched. A combination of different services is offered to customers to fit their demands in different contexts. It has been considered the most complicated PSS in that companies must offer accurate outcomes of the PSS to satisfy customers (Ceschin, 2014). There is no predetermined product, but an agreed outcome between the PS provider and customers. The three subcategories are activity management/outsourcing, pay-per-service unit, and functional result.

- Activity management/outsourcing. In this subcategory, the company can choose a certain type of activity and outsource it to another party who has the capability to deliver the required outcome. The performance method is normally not the focus but the result. The third party must deliver the result of the activity with the required quality that fits the outsourcing contract. Common examples range from call centers and web design to cleaning.
- Pay-per-service unit. This subcategory concerns the outcome of a product rather than its physical form. Instead of providing the product, the PS provider simply delivers the application of the product but keeps the product itself with them. The classic example is a copy shop. The customer pays for the printed paper while the PS provider owns the machine. In recent years, this type of service has been extended with the help of the Internet to online copy shops, similar to online photo printing.
- Functional result. This type of PSS delivers a promised or agreed result to the customer. It is more abstract compared with activity management/outsourcing. The product, technology, equipment, or material used are not limited, whereas the focus is mainly on the result. Examples include a PSS that delivers thermal comfort or a pleasant climate in an office.

Table 6. Features of the three types of PSS.

Type of PSS	Ownership	Phases of the value-adding process that involves customers
Product-oriented PSS	Customer	Use and end-of-life phase
Use-oriented PSS	PS provider	Use phase
Result-oriented PSS	PS provider	Use phase

Through the abovementioned classifications, value creation is clearly not necessarily associated with the sale of the product for all PSSs. Table 6 clearly indicates that the ownership stays with the PS provider for two types of PSS, and customers are involved mainly in the use phase of the value-adding process. Clearly, the transaction on the ownership of the product is no longer the only critical factor for gaining economic growth and sustainable development. Baines et al. (2007) stressed that all three types of PSS are a combination or integration of product and service, designed to meet customers' satisfaction. However, the focus has shifted from the ownership of the product to performance and utilization. Therefore, the term value-in-use has been promoted as a notable feature of PSSs.

2) Second dimension for classifying PSSs: Interactions between the PS provider and customer

This dimension is introduced to provide another perspective on PSS classification. Here, the interaction between the PS provider and customer in the servitization process transforms from being transaction- to relationship-based (Frambach et al., 1997; Oliva and Kallenberg, 2003; Gaiardelli et al., 2014).

a) Transaction-based PSS

This type of PSS focuses on the sales of PS for customer-specific requirements, such as installation, spare parts, and delivery of consumables. Economic value is generated based on the completion of every transaction (Oliva and Kallenberg, 2003). When linked with the product-, use-, or result-oriented PSSs proposed by Baines et al. (2007), the product-oriented PSS evidently has great similarities compared with the transaction-based PSS. In terms of product advice and consulting, only the advice and consulting services that are directly related to products are considered as transaction-based PSSs; for example, advice, training, or consulting regarding product choice, configuration, and use (Gaiardelli et al., 2014). The use-oriented PSS, which includes product leasing, renting, sharing, and pooling, can be configured on a short- or long-term basis. On a short-term basis, a transaction is made at every use. Therefore, a short-term use-oriented PSS that encompasses transactional features should be more appropriately classified as a

transaction-based PSS.

b) Relationship-based PSS

A relationship-based PSS is generated with the purpose or effect of obtaining a closer and long-term relationship with the customer (Oliva and Kallenberg, 2003). To be more specific, extended warranties, preventive maintenance, and consulting on customers’ business processes that are associated with the application of the product are relationship-based PSSs. Therefore, a result-oriented PSS would be considered a relationship-based PSS. In terms of use-oriented PSSs, those that are provided on a long-term basis have the possibility of forming a closer and more stable relationship with the customer. Thus, long-term use-oriented PSSs have more relational characteristics to be grouped under relationship-based PSSs.

Table 7. Relationships between different types of PSS.

Type of PSS	Product-oriented PSS		Use-oriented PSS			Result-oriented PSS		
	Product-related service	Advice and consulting	Product lease	Product renting and sharing	Product pooling	Activity management/outsourcing	Pay-per-service unit	Functional result
Transaction-based PSS	x	x	x (short-term)	x (short-term)	x (short-term)			
Relationship-based PSS			x (long-term)	x (long-term)	x (long-term)	x	x	x

Table 7 demonstrates the relationships of the two dimensions for classifying PSSs. From a product-oriented service to a result-oriented PSS, the focus of PSS development transfers from transaction-based to relationship-based. Accordingly, the emphasis shifts from products to services, and eventually to outcomes that are desired by the customer. In the long-term, the PS offering provide could obtain economic value through forming a long-term relationship with the customer. This represents the customer-centric feature of servitization. That is, the possible destinations of the servitization transition process are either providing a relationship-based or result-oriented PSS.

2.6. PSS design approaches

Servitization is a rather complicated transition process that occurs across industries. Therefore, it is not unusual that various design approaches and methodologies have been developed with different focuses, intentions, and application contexts. Previous attempts have provided methods of analyzing them from different angles. Therefore, for an in-depth review of the literature in this

field, different dimensions are necessary. In the following subsections, PSS design approaches are illustrated using three dimensions. The first dimension starts with an introduction of PSS design approaches, which provides the generic significance; in other words, they are not tailored for a specific project. The second dimension introduces PSS design approaches that have a focus on designs with the value-adding process. The last dimension introduces the PSS design approaches that focus on stakeholder involvement.

2.6.1. A holistic perspective on PSS design approaches

a) Introductions to eight PSS design approaches

To obtain a generic view on PSS design approaches, those that are not case-specific will be chosen for reviewing. As indicated by Tran and Park (2014), plenty of PPS design methodologies are case-specific (Luiten, Knot and van der Horst, 2001; Manzini and Vezzoli, 2003; Morelli, 2003), and these are generated from (and most suitable for) an appointed project. Thus, these methodologies are not suitable for applications in a broad context, nor is their adoption beneficial to a wide range of industry practitioners. Under this consideration, I selected eight PSS design approaches, mainly identified by Vijaykumar et al. (2012), to compensate for the lack of extensive applications. The eight design approaches attempt to address PSS design from different domains and different perspectives.

Table 8. List of eight PSS design methodologies (Vijaykumar et al., 2012).

Approach	Description
Service CAD Description	Adopts system thinking to create a business model and enhance efficiency.
Service Model Service Explorer	Enhances value proposition through integrating services into the product design process.
Integrated Product and Service Design Processes	Integrates a design approach that links the service development process with the product design process.
Fast-Track Total Care Design Process	Develops services based on hardware development principles to fulfill the desired function that satisfies the customer together with the hardware.
PSS Design	Adopts a system perspective to design and develop products and services.
The Design Process for the Development of an Integrated Solution	Adopts a systematic approach to generate an integrated solution that embraces customer involvement.
The Dimensions of PSS Design	An integrated product, service design, and development approach that includes the crucial aspect of customer involvement.
Heterogeneous IPS ² Concept Modeling	Adopts a model-based approach that integrates products and services heterogeneously to generate Industrial Product-Service Systems (IPS ²) concept models.

Service CAD, Service Model, and Service Explorer

The design approaches of service CAD, Service Model, and Service Explorer were generated in the service product engineering (SPE) discipline, which was first introduced by a research group from Tokyo Metropolitan University. Arai and Shimomura (2004) proposed the PSS design approach *service CAD* under the concept of SPE. Service models and design tools are developed to combine product and service design activities to create value. The computer-aided visualized design tool Service Explorer was generated based on service CAD for service designer to enhance existing services or define new service concepts (Sakao and Shimomura, 2007; Arai et al., 2007). Researchers in the SPE field defined service as an activity, through which a change of desired status can be achieved (Tomiyama, 2001; Sakao and Shimomura, 2007; and Shimomura Hara and Arai, 2009). SPE indicates that the service design process should be integrated with the product design process (Hara et al. 2009) and service CAD-related tools can be adopted for PSS design and development (Pezzotta, et al., 2013).

Integrated Product and Service Design Processes

Aurich, Fuchs, and Wagenknecht (2006a, 2006b) introduced a lifecycle-oriented systematic PSS design methodology based on the principle of modularization. The existing product design process was analysed and adapted for integration with the service development process. In their concept, service was defined as mainly a technical service that provides support, acquires information, and satisfies customer demand (Aurich et al., 2006). The importance of lifecycle engineering is emphasized, and six phases are identified for technical service development. Unified Modelling Language (UML 2.0) is applied for the purpose of presenting.

Functional Product and Fast-Track Design Process

Alonso-Rasgado, Thompson, and Elfström (2004, p. 12) has developed a “total care product,” which is a functional product. It is composed of hardware and a support system with integrated software for the purpose of delivering a function desired by customers. In this concept, service is defined as activities including maintenance, strategic decision-making, and management of operations, to support or guarantee the expected function of the hardware. The importance of satisfying customers is emphasized and the demand for a close collaboration between the customer and the PS supplier throughout the entire product life cycle is indicated (Isaksson et al., 2009). Alonso-Rasgado and Thompson (2006) proposed a five-stage design approach called the Fast-Track Design Process (FTDP), which develops different phases for functional product development. The integral role of the customer during the development process is stressed. The FTDP was developed based on the recognition and admission that the service design process is, to a great extent, similar to the hardware design process. The FTDP is triggered when the first

contact between the customer and PS supplier occurs, with the aim of understanding the customer's requirements. The process is considered complete when a contract commitment is achieved. Therefore, the customers' requirement is integrated "simultaneously" during the concept development process (Vijaykumar et al., 2012, p. 15).

A computational tool is applied during the adoption of the FTDP to accelerate the process and achieve a certain degree of efficiency. Although the FTDP could reduce the complexity usually caused by the decision-making process, Alonso-Rasgado and Thompson (2006) admitted that a greater challenge comes from achieving the agreed solution between the two parties at each stage of the development process.

PSS Design

Maussang et al. (2009) proposed a design approach for assisting engineering designers to accommodate technical specifications of their product into PSS requirements. A PSS has long been recognized as a complex system (Alonso-Rasgado and Thompson, 2006; Neely, 2008). Scholars have therefore taken a system-based approach to PSS development (Halen, Vezzoli and Wimmer, 2005; Morilli, 2002). The main problem targeted in Maussang et al. (2009) study was the integration of the product development process with a PSS design approach. Service here referred mainly to a technical service defined as a supporting activity ensuring the performance of the PSS. They argued that technical services, such as maintenance, that are created to prolong product life spans, should be involved in the early phase of the design process. The focus of this approach is solely on the requirement identification phase of PSS development. Tools and techniques included in their functional analysis approach, namely a graph indicator and functional block together with use and operational scenarios, were adeptly and jointly applied.

The Design Process for the Development of an Integrated Solution

Morelli (2003) proposed a service concept development based on an adaptation from the work of Ulrich and Eppinger (2000), who specified product development activities from the design to production phase. Morelli (2003) and Alonso-Rasgado and Thompson (2006) adopted the same principle to identify customer needs and generate an agreed concept between the customer and PS provider, which is an iterative process. Furthermore, services were identified by Morelli (2003) as processes that are time sensitive and intangible. The similarity between the service concept design and product concept design is well recognized, which indicates no significant differences between the two. Compared with products, the notable differentiation is that the ownership of services is not transferrable (Morelli, 2003).

Morelli (2006) introduced the design methodology of Integration Definition for Function Modelling (IDEF0). Morelli believed that service components have added complexity to the

system approach of PSS design, which differentiates itself from the product design process. IDEF0 provided the possibility for system engineers to model the functions, activities, and relationships, which represent the system nature of a PSS. The information system aspect of PSS design was well embraced through IDEF0 together with the application of scenarios and use case techniques.

The Dimensions of PSS Design

Tan, McAloone, and Andreasen (2006) believed that services are always associated with products and must be integrated with products to deliver value. They argued that the common manner of withdrawing the service development process from the existing product development process is far from sufficient because of the different nature of both. They promoted an integrated development method for PSS design with customer involvement as an inevitable element.

Tan et al. (2010) identified four dimensions of PSS design: value proposition, the product life cycle, the actor network, and the activity modeling cycle. These elements cover the basic aspects of PSS development. The four dimensions and their relations are equally crucial, and a certain degree of consistency among them is needed. They argued that the success of a PSS design lies in the coherent development of the four dimensions. PSSs that occur in business practice can cause organizational and managerial issues among others, which are essential but were not touched upon by the four dimensions (Tan et al., 2010).

Heterogeneous IPS² Concept Modeling

An industrial PSS (IPS²) was defined as a customized solution for satisfying specific customer demands and generating value along the IPS lifecycle (Welp et al., 2008). The services here are identified as the industry services that are intangible and indispensable to an integrated solution.

b) The limitation of the existing PSS design approach

In general, the abovementioned PSS design approaches answer the question of how to design a PSS. They provide a solid starting point for research in the PSS design field. However, common deficiencies can be identified, which provided this research project with room for improvement.

Lack of consistency in terminology

As mentioned previously, service is the indispensable element of PSS, and it is the determinant of PSS classifications. Therefore, a consistent definition of service is not only beneficial for the interpretation of PSS in general, but also for PS classification and the design methodology. However, in the above introduction to PSS design approaches, the definitions of service are highly diverse. Thus, the application of design approaches could be limited by the various perceptions of service. This is supported by Baines and Lightfoot (2013), who argued that the ambiguous

definitions and terminology create barriers for communication not only between academics but also practitioners from different industries. Therefore, consistent definitions of service, PS offering, and its classification are urgently required.

Lack of concurrency for PS design and development

A PS offering, as previously discussed, is generated under the concept of PSS during the servitization process. As basic elements of PSS, products and services have equally important influences on the system. The design approach for a PSS should be able to identify the requirements for both as well as deliver the competence to fulfill the demands for both. As underlined in the literature, when a product and service are integrated, they must be designed concurrently (Alonso-Rasgado et al., 2004; Kimita et al., 2009). However, traditionally products and services are designed and developed in quite a separated manner. On the one hand, before the significance of service had been realized by academia and industry, product design approaches were developed and discussed for a long time and solely focused on product development-related issues (Royce, 1970; INCOSE, 2007; NASA, 1995; Boehm, 1988). On the other hand, the development of service design methodologies is far from mature compared with its counterparts (Alonso-Rasgado et al., 2004). The traditional way of developing services solely focuses on the service and is separated from product design (Scheuing and Johnson, 1989; Edvardsson and Olsson, 1996; Bullinger et al., 2003, Clayton et al., 2012). Some scholars have considered the difference between the two types of approach as they are not applicable for each other (Ian Stuart, 1998; Reinoso et al., 2009).

Furthermore, after the emergence of PSSs, scholars identified that more aspects to be included in terms of PSS design, considering the separated paths of product and service development. Morelli (2006) indicated that services add different variables to the design principles than solely product development because of their unique nature, which includes time sensitivity, interactions with customers, and social and cultural elements. Therefore, an integrated PSS design approach is essential to include the related factors from both products and services (Alonso-Rasgado et al., 2004; Alonso-Rasgado and Thompson, 2006; Shimomura et al., 2009). Isaksson et al. (2009) and Wang et al. (2011) further stressed that a coordinated development process is required for PSS design to avoid imbalanced considerations on the influence of products and services on PSS.

Therefore, numerous studies have aimed to combine or integrate either product- or service-oriented methodologies. For example, within the aforementioned eight PSS design approaches, *the integrated Product and Service Design Processes* developed by Aurich et al. (2006a, 2006b) attempted to integrate product and service development based on the existing product design process. Similarly, the IDEF0 introduced by Morelli (2006) applied a system perspective to create service concept development based on the product development processes previously developed

by other scholars. Other contributions could also find in the literature; for example, Zhao et al. (2008) developed service design tools could withdraw useful information from product development. Furthermore, Shimomura et al. (2009) extended the service design process with the product development process.

However, these attributions have only attempted to combine or integrate product development with service development from either the existing product or service design process, which may fail to consider the system characteristics of PSS (Fuchs, 2007). As confirmed by Wang et al. (2011), the current development approaches of PSS are mainly from either trying to provide modified product provision that facilitates service development or include services into the existing product development to create value. Nevertheless, products and services enjoy an equally important status in a PSS system. Therefore, the simultaneity and concurrency of the product and service development processes are crucial from the beginning, which was not presented thoroughly in the aforementioned studies.

Two causes could be identified for the lack of concurrency in PSS design approaches. One is in the way in which products are developed. A product is usually produced with the purpose of a trade-off function (Isaksson et al., 2011). Thus, the economic gain is at the center of consideration. Driven by this intention, companies often take the products as the starting point, based on which the design, configuration, and delivery processes are addressed (Aurich et al., 2009). Servitization strategy is then adopted upon the existing product development process for a PS offering (Morelli, 2003). The second cause relates to the service development process. A service is always defined as either an activity or a contract that is highly abstract and difficult to measure. The intangible feature of service is the main difficulty in modeling the service development process ((Baines and Lightfoot, 2013). Therefore, it is more complicated to describe the service value-adding process. Moreover, the long history and mature status of the product development process make it easier to start with. By contrast, the shift of attention toward service is relatively shorter and the service development process is considered more complicated to formalize due to the interactive nature in relation to customers (Isaksson et al., 2011).

In fact, the possibility and principle of developing products and services concurrently and simultaneously have already been proposed in the literature. Ulrich (2011) introduced the logic of designing products and services with the same processes. He identified products and services as artefacts that can be developed through the same procedure. As further argued by Bhavnani and Sosa (2006), no fundamental difference exists between the two. This basic principle provides the interpretation that an integrated design process concerning the whole life cycle of both products and services is possible and is the most suitable solution for concurrent PSS development. An integrated PS life cycle rather than a single life cycle for each unlocks the economic potential of

a PSS (Manzini and Vezzoli 2003, Aurich, Schweitzer and Fuchs, 2007). Wang et al. (2011, p. 6872) identified PS lifecycle management as the “shortcut” for PS strategy implementation. Through the PS lifecycle or value-adding process perspective, a PSS could be discussed or designed with a systematic view that considers the related actors within the system concurrently and simultaneously.

Therefore, despite the simple combination or integration of the service design process with the existing product development process, the demand exists for researchers to consider PS development concurrently. More efficiency could be achieved by an integrated PS lifecycle or value-adding process perspective.

Insufficient focus on stakeholder involvement with the value-adding process perspective

Although the important roles of the customer and other stakeholders have been identified in the abovementioned design approaches, some problems were observed. First, the role of the customer is not presented during the whole value-adding process. It is not uncommon for PSS design methodologies in the literature to attempt to integrate the influence of customers into the PS design process. However, the emphasis is mainly on the early phase of the value-adding process, namely the design phase. Among the abovementioned design approaches, Alonso-Rasgado and Thompson (2006) provided a PSS design approach that aimed to integrate customer involvement into the PS concept development process. Maussang et al. (2009) identified external contributions and attempted to integrate them into the PS design process, but the focus was also only on the concept development stage. Nevertheless, as stressed by Beuren, Ferreira, and Miguel (2013), the involvement of customers is critical in the whole value-creation process of a PSS. Second, there is a lack of attention to other stakeholders who have influence in the value-adding process or PS lifecycles (Tran and Park, 2014; Vijaykumar, Lelah and Brissaud, 2012). Even though the role of the customer is critical for PSS development, the impact of others should not be ignored. In fact, all the external contributions to PS development should be taken into account along the value-adding process. This would provide the possibility of specifying the factors that are influential for a PSS and analyzing PS design capabilities holistically.

In summary, three main deficiencies were identified in the literature review on PSS design approaches, which are not project specific. These three challenges provided a direction for the present research project and were specifically targeted to fill the gap in the literature.

In the following two sections, literature is delicately selected that could provide existing contributions targeting the aforementioned challenges, namely the lack of concurrency and the lack of stakeholder involvement. Some of the design approaches are case-specific, and therefore,

might lack generic value to other scenarios. The intention is to obtain interpretations and extract precious value from previous contributions.

2.6.2. PS offering design approach with the PS value-adding process

a) The current challenge

The necessity of an integrated PS lifecycle or value-adding process perspective is evident. It realizes the possibility of a concurrent and simultaneous development of products and services. However, scholars have indicated that, in the broader scale of PS development, most of the PSS design approaches that paid attention to the value-adding process are fragmental (Mont, 2002). The insufficient methodologies or approaches attempting to cover the whole PS life cycle can be observed in the literature (Mont, 2000). The majority of work has focused mainly on the idea generation process (Clayton et al., 2012.), such as the abovementioned *Functional Product and Fast-Track Design Process* and *PSS design*. This lack of completeness in the whole value-adding process may lead to inconvenience for adoption by industry practitioners. It is also not beneficial for designing products and services concurrently and giving them equal attention throughout the PS value-adding process.

Therefore, to overcome the aforementioned challenge and to review tools or techniques that can be easily and directly applied by companies, in the next subsection, the six PSS design approaches that embrace all stages of the value-adding process are introduced. They provide this research project with precious input to work upon.

b) The six approaches proposed from the value-adding process perspective

Clayton et al. (2012) summarized six PSS design approaches that cover the whole value-adding process of PS development, namely designing eco-efficient services (DES); Austrian Eco-efficient PSS project (AEPSS); the methodology for PSS innovation (MEPSS); the Kathallys method; the design exploration process (DEP); and service system design (SSD) (Brezet, et al., 2001; Engelhardt et al., 2003; Van Halen, Vezzoli and Wimmer, 2005; Luiten et al., 2001; Morelli, 2002, 2003; Kar, 2010). These design approaches are introduced and applied in different contexts with different purposes.

Table 9. The six design approaches from the value-adding process perspective (Clayton et al., 2012).

Name of the Artifact	Author	Focus of the Artifact
Designing Eco-Efficient Services (DES) Austrian Eco-efficient PSS project (AEPSS)	Brezet et al., (2001)	Sustainable PS offering
Methodology for PSS innovation (MEPSS)	Engelhardt et al., (2003)	Eco-efficient PS offering
The Kathallys Method	Van Halen et al., (2005)	Sustainable PS offering
The Design Exploration Process (DEP)	Luiten et al., (2001)	Sustainable PS offering
The Service System Design (SSD)	Morelli (2002, 2003)	Methodological issues for design profession
	Kar (2010)	Mobile information services

Here, two aspects were identified as the most relevant to this research project. The first is the synthesized PS development process provided by Clayton et al. (2012). In Figure 6, the value-adding process is grouped into six stages, illustrating the value-adding process from receiving customer requirements to providing a desired PS offering. This value-adding process represents the general phases of PSS development. Although in reality not all the companies are able to summarize their process into the same six value-adding stages (Clayton et al., 2012), this attempt at defining the PS value-adding process for PSS design is recommendable for conceptualizing and unifying the design and development process as well as providing a solid foundation for further discussion and analysis.

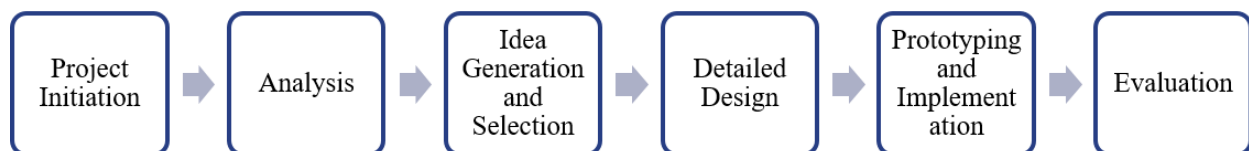


Figure 6. PS value-adding process (adapted from Clayton et al., 2012).

The second aspect is the analysis on inputs and outputs perspective with detailed activities contained in each stage of the value-adding process. Within the six approaches, the inputs and outputs of each value-adding phase could be identified and further broken down into different design and development activities. Specifically, DES and Kathallys defined inputs and outputs based on well-defined different stages (Brezet et al., 2001; Luiten et al., 2001), providing the opportunity for an in-depth analysis along the process; furthermore, the MEPSS provided the possibility for analyzing the value-adding process at the activity level (Van Halen et al., 2005). For example, the inputs at the idea generation stage were identified as interpreting customer requirements or/and illustrating the system where the innovative PS offering will be developed and applied. A PS concept has been defined as the output of the idea generation stage. The principle of the inputs and outputs perspective is generally sequential. The output of one stage is

basically the input of the next stage, which also serves as the checkpoint for every stage. This is favorable for defining each stage and providing a clear start and finish point for each stage of the value-adding process.

This inputs and outputs perspective demonstrates the potential for analyzing in detail the activities involved at each stage of the PS value-adding process. This provides the opportunity to systematically analyze issues such as the involved stakeholder and applied digital tools along the value-adding process.

2.6.3. PSS design with stakeholder involvement

An inherent relationship between servitization and customization has been proposed. Customers are undoubtedly fundamental (or on a larger scale, the stakeholders' involvement is) for PSS design to realize customization. It is rather crucial to illustrate the role and activity of stakeholders in the PS development process. Therefore, in this section, two PS design approaches that focus on stakeholder involvement are illustrated.

Vasantha et al. (2011) proposed a PSS design framework in which the role and activities of different stakeholders, namely the customer, provider, and supplier, are specified. The activities of stakeholders are demonstrated in a sequential manner.

This framework was developed based on a recognition of the importance of stakeholder involvement, especially the capabilities brought by different parties. It starts with identifying the customers' needs, followed by recognizing their existing capabilities. The desired outcome is the assessment of the customer's capability. Then, the capabilities that are demanded but not yet possessed by the customer are stressed. The development of the PS offering can be geared toward satisfying the identified customer requirements and filling the gap created by the missing capabilities. Within the framework, the capability, resources, and responsibility of the provider and supplier are also specified for achieving a mutually agreed outcome. The process of implementing the framework is sequential as well as iterative. Every step is iterative itself until the desired outcome is achieved. At the end of the process, the feedback is fed back to the first step.

Notably, this framework emphasizes stakeholder involvement through a capability perspective. It highlights the important influence of stakeholders' capability in designing a PSS. However, it is not structured along the PS value-adding process. Therefore, difficulties might be created for industry practitioners in aligning the framework directly with their existing PS development process. Although the analysis of stakeholder involvement in PS concept generation is well stressed by this framework, the lack of attention on other phases of the value-adding process could cause inconvenience for real-world application.

Tran and Park (2014) proposed a PSS design approach that claimed to include all essential elements of a PSS, such as the PS offerings, stakeholders, business model and organizational structure. The approach was also aimed at designing a PSS that can reflect the three types of PSS identified by Tukker (2004). The notable feature of this design approach is that it is structured along the PS value-adding process, from PSS idea generation to the retirement or recycling stage. In terms of relevance to the present research, the intact model proposed by Tran and Park (2014) will not be discussed in detail; however, how the stakeholder is involved in every step of the value-adding process and what the identified design activities based on the proposed PSS design approach are will be fully illustrated. Figure 7 was created based on this study’s interpretation of the design approach development by Tran and Park (2014), for specifying “the design activities, characteristics and the involvement of various stakeholders” (Tran and Park, 2014, p. 41).

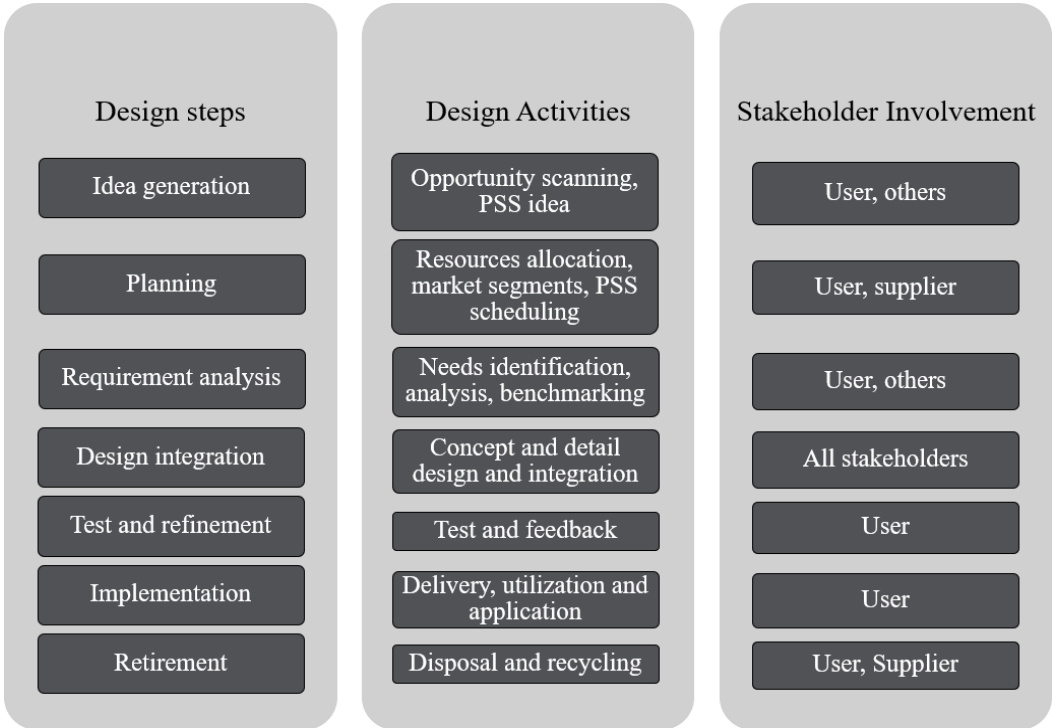


Figure 7. Design steps, activities, and the stakeholder’s involvement (adapted from Tran and Park, 2014).

In Figure 7, the PS value-adding process is divided into seven phases. The highlight of this design approach is not only developing PS offerings through the PS lifecycle perspective, but also identifying the design activities included in each phase. The identification of design activities is crucial because it reduces complexity and abstraction. Moreover, the involved stakeholder’s activity is specified. The responsibility of each stakeholder associated with every activity is then demonstrated. In fact, the ideal circumstance is to also associate involved stakeholders’ activities with the business process model. In this way, stakeholders’ involvement is indicated in a more logical manner and is easier for industry practitioners to analyze with their existing business process. The last notable point to draw from this design approach is the concept of a checkpoint.

Tran and Park (2014) adopted an inputs and outputs perspective, which was similar to DES and the Kathallys approaches. The checkpoint assists in indicating the achievement of an agreed outcome of every value-adding process. It also serves as a starting point for triggering the next step.

3. Research Methodology

3.1. Design science and relevance

This research project followed design science research (DSR) in the information system field as the main research methodology, which was developed by Hevner and his colleagues. In this section, the relevance of design science in information systems to this research project is revealed. Based on the previous contributions and following the seminal work of Herbert Simon (1996), *The Sciences of the Artificial*, in which technical systems were consolidated into design science as a problem solving paradigm, Hevner and his colleagues defined and articulated the design science paradigm as problem solving in the information system research field. Detailed explanations and guidelines were provided in a series of publications (Hevner et al., 2004; Hevner, 2007; Hevner and Chatterjee, 2010).

The relevance of adopting DSR in information systems is determined by digital transformation being a crucial element of servitization. As mentioned in Chapter 2, digital transformation plays an elemental role in the servitization research field. The adoption of ICT-enabled systems is the fundamental supporting factor for servitization and has an enormous impact on servitization and customization transformation (Brennen and Kreiss, 2016; Lightfoot et al., 2011). This is determined by the increasingly digitized economy and society, where design science has been identified as being at the center of driving innovation and solving business problems (Goes, 2014). As underlined by Goes (2014), the implementation of ICT-enabled systems must take account of economic, social, behavioral, and organizational aspects. As supported by Avgerou (2000), research in the information system field has an interdisciplinary feature that differentiates it from conventional academic perspectives. Design science has the capability and strong academic record to tie social, economic, and organizational aspects together and bridge the gap between engineering and social science (Hevner et al., 2004; Hevner, 2007; Costa, Sousa, and de Sousa, 2016). As a result, this research project selected DSR in information system research because it was highly relevant, and closely followed as the basic approach.

3.2. Design science methodology and the three-cycle view

Based on the awareness obtained from previous contributions and following the seminal work of Herbert Simon (1996), Hevner (2007) developed a three-cycle view that presents the design science methodology through three research cycles. The three research cycles that are introduced in the following section are rigorously complied in this research project. Figure 8 below describes the adoption of the three-cycle view in this research project.

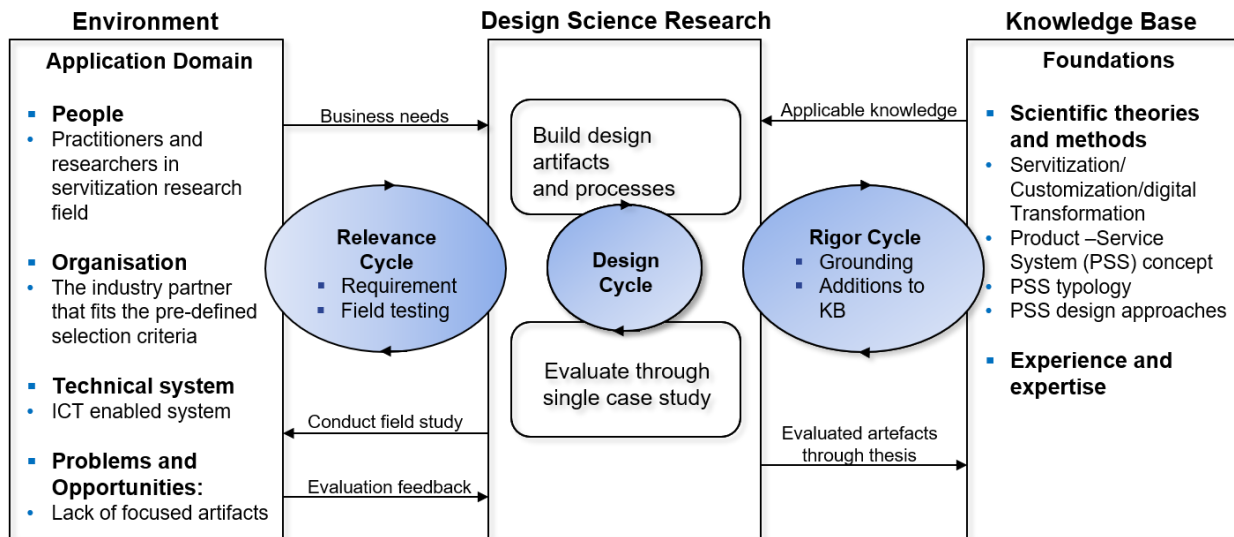


Figure 8. The Three-Cycle view applied in this research (adapted from Hevner et al., 2004; Hevner, 2007).

The three-cycle view proposed by Hevner (2007) comprises three main fields, namely *environment/application domain*, *DSR*, and the *knowledge base/foundations*. The three fields are connected through three research cycles, specifically the *relevance cycle*, the *design cycle*, and the *rigor cycle*.

The *environment* is defined as the application domain that consists of people, organization, existing or planned technology systems, and problems or opportunities. In the application domain, through the *relevance cycle*, business needs are assessed to identify the problems and opportunities, whereas feedback from practice are provided for evaluating the artifacts generated through *DSR*. Therefore, the practical requirements for the research and evaluation criteria are drawn from the *environment* through the *relevance cycle*. Along with the process of *DSR*, the iteration of the *relevance cycle* between *environment* and *DSR* will continue until the desired artifacts are in place. The *environment* of this research is specified by the industry practitioners and researchers in the field of servitization and focuses on customization and digital transformation. The technology system that assists the process is specified in this research project as an ICT-enabled system. The opportunity for initiating this research project was identified as a lack of focused artifacts that are dedicated to assisting the servitization process. To be more specific, no focused artifacts target the linkage of servitization, customization, and digital transformation with applicable models, tools, and guidance.

In the *DSR* area, research is conducted through *build* and *evaluate* activities with the purpose of addressing the business needs drawn from the *environment*. Artifacts and processes will be initiated, developed, and eventually evaluated through *design cycle*.

The *design cycle* is located at the center of the three-cycle view as well as this research project. It

has been recognized as the most frequently iterated activity in terms of the construction of the artifacts and processes (Hevner, 2007). The design activity iterates along all stages of this project. The *DSR* regarding the present research project is to generate targeted constructs, artifacts and processes, including definitions, analysis methods, models and guidelines that satisfy the requirements. They are produced to solve the business problem arisen from the practice and evaluated through single field study selected in *application domain*.

The *knowledge base* domain introduced by Hevner et al. (2004, p. 80) provides the “raw materials,” based on which the *DSR* can be accomplished. Scientific theories, methods, and existing artifacts from previous research contributions together with experience and expertise drawn from specific fields form the theoretical foundation. Therefore, through the *rigor cycle*, the most relevant knowledge, methodologies, models, and tools from academia are systematically reviewed, based on which an extended or refined theory could be generated. In the end, the outcome of *DSR* will generate a theory through a thesis or publications, which contributes back to the *knowledge base* domain. The *rigor cycle* ensures that the output of *DSR* is indeed a valuable research contribution instead of a simple implementation of existing theories (Hevner et al., 2004; Hevner, 2007; Iivari, 2007).

The most relevant *knowledge base* in the present research project is selected in the field of servitization; specifically, it is the general concept of servitization, its relationship with customization and digital transformation, and the definitions of PSSs with their classifications and design approaches.

Clearly, in terms of the connection of the three cycles, the output of the *relevance cycle* provides the *design cycle* with business requirements and evaluation criteria/feedback, whereas the output of the *rigor cycle* gives the *design cycle* the grounding theory as the *knowledge base*. The three cycles are iterative along the *DSR* research process. The iteration between the three cycles ensures that the output of the *design cycle* does improve the *environment* by solving the practical problem and contribute to the *knowledge base* through generating a valuable theory. Therefore, as long as problems exist such as deficiency, quality, and incorrect matching found during the field test through the field study, the iteration of the *design cycle* will continue for further design activities. Ultimately, whether the artefacts produced by this research project are useful to practitioners and can be recognized as a contribution to the *knowledge base* will be measured and assessed through the *relevance cycle* and the *rigor cycle*. As emphasized by Hevner (2007), the contribution to the *application domain* is as crucial as the contribution to the *knowledge base*. Only when balance is achieved can the research be considered effective *DSR*.

3.3. Guidelines for design science in information systems research

3.3.1. Guidelines for design science in information systems

Seven guidelines exist for DSR, which were introduced by Hevner et al. (2004). The intention is to assist researchers who are conducting DSR in acquiring requirements accurately and thoroughly. In other words, the seven guidelines aim to give detailed guidance that could aid design science researchers to understand DSR logic accurately. The seven guidelines cover topics from drawing requirements through the application domain to successfully conducting design activities, evaluating, and delivering innovative contributions to the knowledge base. Notably, the application of these guidelines is, as underlined by the author, individualized. Fulfilling every step mandatorily is not recommended; however, a certain degree of accomplishment is necessary.

Table 10. Application of the seven DSR guidelines. (adapted from Hevner et al. 2004, p. 83).

Guideline	Description	Application
Guideline 1: Design as an Artifact	“DSR must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.”	<p>Through this research project, a framework for servitization is developed. Within the framework, definitions, models, tools, and guidelines are produced for assisting the servitization process and facilitating customization and digital transformation. The details can be divided as follows:</p> <ul style="list-style-type: none"> • Definitions and typology. An innovative way of defining a PS offering as an output of the value-adding process ranging in the PS continuum is clearly introduced. Based on the definitions, the typology with linkages to grounding theory is presented. • Models. Based on the definitions and their typology, new models that link servitization with customization and digital transformation are produced. With the models, companies will be able to visualize their status and assess their direction of development at the strategic level. The models aim to improve the decision-making process and enhance efficiency for strategy development. • Analysis tools. The analysis at the phase and activity levels generated by this research project intends to provide viable tools for companies to conduct detailed analysis through their value-adding process. The analysis provides companies with a solid foundation for applying the models. • Guidelines. Articulated guidelines are produced for the application of the framework. The guidelines will guide the way for companies to implement the artifact generated by this research project step by step.
Guideline 2: Problem relevance	“The objective of DSR is to develop technology-based solutions to important and relevant business problems.”	<p>The business needs identified for this research project from the application domain are the demand for a systematic and comprehensive framework with models, tools, and guidelines for companies to generate innovative PS offerings, as well as realize digital transformation that facilitates customization and servitization.</p> <p>The practical value lies in the areas of: (i) visualizing and understanding the process of servitization with the involvement of the customer and the application of digital tools; (ii) systematically deconstructing the value-adding process with a focus on internal and external contributions; (iii) providing the possibility for companies to systematically analyze their business process and the included activities from servitization transition perspective.</p>

Guideline 3: Design evaluation	“The utility, quality, and efficacy of a design artifact must be rigorously demonstrated through well-executed evaluation methods.”	Evaluation of the artifact is one of the two most important activities within the design cycle. Hevner et al. (2004) suggested five evaluation methods: observational, analytical, experimental, testing, and descriptive evaluation. Among them, the most appropriate for this research project is considered to be the observational evaluation method through field study. Observational evaluation is accomplished through a field study by monitoring the utility of the designed artifact in a business environment. Interviews with practitioners will also provide crucial information or feedback concerning the adjustment of the design work. Moreover, as mentioned above, the produced artifacts are constructed on the basis of carefully selected theories, the review of existing design approaches, and so on. The reviewed literature could also provide the evaluation criteria that contribute to the evaluation metrics.
Guideline 4: Research contributions	“Effective DSR must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.”	The artifacts developed by this research project are presented as a framework including definitions, models, analysis tools, and guidelines. The aim is to provide solutions to problems observed in real business and contribute to the knowledge base in the related areas. The details of the research contributions are as follows: <ul style="list-style-type: none"> • The framework provides an opportunity for companies to logically classify their PS offerings, which are in favor of servitization transition and digital transformation. • The framework provides researchers and practitioners with a way of assessing their servitization transition, customization, and digital transformation readiness and capabilities. Current statuses and future directions are visualized and analyzed. • The framework contributes to the design approaches category, which assists companies in generating innovative and digitalized PS offerings.
Guideline 5: Research rigor	“DSR relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.”	The research rigor concerning this research project can be viewed from the following aspects. First, the artifacts developed through this research project are based on peer-reviewed literature. This served as solid foundation for the construction of the artifacts as well as for their evaluation. Moreover, regular meetings with the supervisors of this research project have provided valuable academic input. Last but not least, workshops and interviews with industry partners offer concrete feedback from practitioners for the iteration of the design activities.
Guideline 6: Design as a search process	“The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.”	Design is a solution searching process for a specific problem (Hevner et al., 2004). As mentioned previously, the three research cycles are iteratively conducted during the research process. Periodical interviews with practitioners ensure that this research is moving in the direction of its desired destination. Along the way, feedback is gained from regular meetings with supervisors on the adaption of new definitions and adjustment of new models.
Guideline 7: Communication of research	“DSR must be presented effectively to both technology-oriented and management-oriented audiences.”	The framework will be open to companies or research communities that are interested in servitization through customization and digital transformation. It could be further used by SMEs who are interested through workshops.

3.4. Publication schema for design science in information systems research

Guidance and recommendations on the presentation of DSR work have been presented by scholars in many different disciplines (Alexander, Ishikawa, and Silverstein, 1977; Bem, 2003; Neumann,

2006; Hevner et al., 2004; Zobel, 2005; Sein et al., 2011). This research project complies with the guidance proposed by Gregor and Hevner (2013) for articulating and communicating DSR results and findings in the information system field.

At the end of the DSR process, the role and importance of presenting DSR findings should not be ignored. Much of the focus of DSR work was indicated to be on the development or the invention of the artifact itself (Hevner et al., 2004). How to articulate the findings and results as knowledge contribution has received insufficient attention (Gregor and Hevner, 2013). This is harmful not only for the dedication to the knowledge base but also to communication in the research community. (Gregor and Hevner, 2013). Therefore, Gregor and Hevner (2013, p. 349) provided researchers with patterns for articulating their research findings, called the “publication schema.” Before illustrating the application of the publication schema, one thing to mention is that not every section and its detailed requirements must be included and followed; other patterns or possibilities are also acceptable for the effective presentation of DSR findings (Gregor and Hevner, 2013).

According to Gregor and Hevner (2013), DSR results and findings can be presented in seven sections with a certain order: (1) Introduction; (2) Literature review; (3) Methodology; (4) Artifact Description; (5) Evaluation; (6) Discussion; and (7) Conclusion. This research complies, although not completely, with the order and requirements of each section to a high degree. The details of the application of requirements in each section for this research project can be found in the Appendix.

3.5. Cooperation with an industry partner through a field study

3.5.1. Selection criteria

Critical to the success of this research project is the identification and selection of an appropriate industry partner. In this section, the selection criteria for the single field case are presented. The intention is to make sure that the industry partner selected is applicable to the research fields of this project and suitable for generating rich but focused information. Therefore, applicability ensures the business environment provided by the company can comply with the research scope of this project, whereas suitability guarantees the focus will not drift from the DSR *build* and *evaluate* activities because of irrelevant factors.

The applicability selection criteria

In practice, the complexity of the servitization process and the diversity of involved parties poses difficulties to the applicability of this research. Servitization is a rather complex process involving companies across industries. It is not uncommon that different organizations and industries have highly diverse challenges to tackle. Therefore, servitization also refers to various research

communities as multidisciplinary (Weeks and Benade, 2015). As discussed in Chapter 2, the involved research communities include marketing, management, and operation, which emphasizes organization, performance, and technology. Therefore, to be applicable for serving as the application domain of DSR, limiting the industry partner to a specific focus is necessary. As indicated in Chapter 1, this research project is for companies adopting a servitization strategy and have a focus on customization and digital transformation. Therefore, a company that attempts to generate value by adding services and customizing its PS offerings through adopting ICT-enabled tools will provide the most relevant applicable domain. Therefore, the applicability is mainly determined by the scope of this research project.

The suitability selection criteria

Critical to the success of this research project is the identification and selection of an appropriate industry partner that provides rich and focused information. It would be ideal if a generic framework could be developed and adopted directly by companies to guide the way in servitization. However, in reality, even the most generic framework cannot satisfy all the requirements demanded by various companies. As indicated by March and Smith (1995), the operation in a business environment is one of the challenges faced by the artifacts developed by DSR. Thus, to ensure a sound and uncomplicated start, developing selection criteria for the industry partner for the field study ensures a more goal-oriented and efficient approach, which will ultimately provide rich and relevant information. To ensure such suitability criteria for the relevant information without influence from irrelevant factors, the size of the company and the details of the PSS will be limited.

- Small and medium-sized enterprises

The term of small and medium-sized enterprises (SMEs) was coined by the European Commission in 2003 and eventually came into effect in 2005. The determining factors that qualify an SME are staff headcount and turnover or balance sheet total. Details can be seen in the Table 11. Definitions of SMEs (European commission, 2003, 2005):

Table 11. Definitions of SMEs (European commission, 2003, 2005)

Company category	Staff headcount	Turnover	or	Balance sheet total
Medium-sized	< 250	≤ € 50 m		≤ € 43 m
Small	< 50	≤ € 10 m		≤ € 10 m
Micro	< 10	≤ € 2 m		≤ € 2 m

The main reason for choosing an SME as an industry partner is to avoid distraction from unrelated factors that can influence the servitization process. The intention is to eliminate unnecessary barriers and make this research more efficient and goal-oriented. The servitization process poses difficulties in various aspects; one is related to the organization and its operational challenges (Baines et al., 2009). As clearly seen in Chapter 2, the organizational process research stream including topics on organization structure and organizational transformation and constitutes one of four major research streams of servitization. Challenges posed by organization transformation during servitization are undeniably crucial; however, they are not the focus of this research. Therefore, it is necessary to reduce the attention that might be caused by the organization aspect and purely observe the effect and impact of the most related factors, such as the design of PS offerings and the digital transformation process.

SMEs enjoy a relatively simple hierarchy in their organizations, which might be beneficial when observing the implementation of a new transformational strategy. When the company size is limited, it is possible that the hierarchy of the company will not be complicated. Then the redefinition and adjustment of a strategy caused by servitization can be conducted more quickly as well as the effect can be observed more quickly than in larger corporates, which is beneficial. It is not uncommon for smaller organizations to react to change relatively faster and more efficiently, which is dependent on the fact that they have less legacy to handle (Thomas, Barton and Chuke-Okafor, 2008). Therefore, selecting an SME for designing, analyzing, and evaluating the desired artifacts and transition process is necessary.

- The simplicity of existing PSSs

A certain degree of simplicity in SMEs' existing PSS is required. A relatively simple PSS ensures that the attention will be focused on the servitization process itself, rather than drift away because of the complex PS offering and its design process. It is always beneficial to start with a simple application context and then extend it to a more complicated environment by adding other influencing factors step by step. According to the definitions of PSS from the literature, a PSS includes four basic elements: product, service, network of actors, and infrastructures. When determining the simplicity of a PSS, all four elements should be considered.

For the success of this research project, a thorough and in-depth analysis of the PSS in the case study must be conducted. Therefore, a thorough investigation on the PS value-adding process, involved actors, and infrastructure is mandatory. Except the PS offering itself, the various stakeholders, their relationships, competencies, or knowledge should all be taken into account. To limit the complexity that could be engendered by a PSS, the PS offering should not be so

complicated that it poses barriers to the perception of its design process. Furthermore, the number of actors should be limited. Ideally, one or two types of production line with limited contributions from suppliers is a strong start for a noncomplicated PSS.

3.5.2. Data collection methods

Data collection is a critical part of a research project. Through employing multiple data collection methods, the same information can be gathered through interviews, documentation, and observation in the field. The deployment of multiple data collection methods facilitates and enhances data triangulation (Eisenhardt, 1989; Paré and Elam,1997; Barratt and Barratt, 2011). Bonoma (1985) stressed that the different forms of data collected through different research activities are favorable for providing a holistic description of the phenomenon. This research project adopted three main data collection methods.

Semistructured interview

Semistructured interviews were employed to obtain an in-depth interpretation of the industry partner. Interview questions were predefined based on the literature review as well as insights obtained through workshops and a conference. Different rounds of interviews were conducted with a diverse focus to collect data before and after transformation.

Observations

Observation took place during several field visits. Detailed field notes were taken to capture information and the researcher's insights. Observation as a common and vital method of collecting data during a field study is irreplaceable (Yin, 1994; Bell, 1992). It can enrich and triangulate the information gathered through interviews and documentation (Eisenhardt, 1989; Barratt and Barratt, 2011). Thus, field notes generated through observation within different research events are valuable data sources.

Documentation

Although the most commonly applied data collection methods are interviews and observation (Bell, 1992), documentation is a valuable qualitative data source (Miles and Huberman 1994; Paré and Elam,1997; Eisenhardt, 1989). It provides the possibility to validate and support the information withdrawn through other methods. In this research project, the documentation that contributed to the field study included well-documented press releases of the industry partner, texts from the company's websites, and other relevant organizational documents.

3.5.3. Data collection procedure

Data collection from the industry partner is crucial for this research project because it provides

the research with precious input from practice. This subsection introduces the data collection procedure, which is divided into six steps. The six steps were iterated until the data were sufficiently collected. The data analysis was accomplished during the six steps and the artefacts were developed and evaluated along the process. Details can be seen in Figure 9.

Step one: Analyze the company's PS offerings and value-adding process

After systematically reviewing the related literature and analyzing the data from the company's documentation, the design cycle is triggered for designing the constructs, specifically the related definitions. Therefore, suitable definitions, concepts, and their typology are generated in response to the urgent demand apparent in the literature and practice.

From the website of the industry partner, its relevant press releases, the information on the company's PS offerings, and its value-adding process are comprehensively reviewed and analyzed. They serve as the basic information from which new definitions and concepts are developed and applied. Furthermore, how the new definitions can be linked and served back to the literature with practical examples is analyzed at this stage.

Step two: Conduct initial analysis for the models

The data collected from the first step is sufficient for conducting an initial analysis for models that concern the servitization process with customization and digital transformation aspects. After the initial analysis, the draft of all models was formed. The new definitions and concepts generated from step one can be applied in these models. The models also provide an opportunity and foundation that lead to the first round of interviews with practitioners. Here, the main activities are within the design cycle based on the requirements from the application domain, the grounding theories, and previous research results.

Step three: Conduct a field study with practitioners

In this stage, structured or semistructured interviews in the form of face to face meetings, emails, and phone or skype call are conducted. Here, the initial models must be carefully reviewed with practitioners. The realization, utilization of the models and their availability, feasibility, and efficiency are the main concerns. This is the relevance cycle, through which the produced design work from the design cycle is evaluated in the application domain. The field testing is iterated.

Step four: Begin the in-depth analysis

The precious feedback data collected from the field study provide the standard and guidance for the adjustments on the models. With the results from the field testing, the models developed thus far will be amended to simulate the real business world. When the models do not match the real

world, the iteration between steps three and four should continue; through doing so, the models are built and evaluated through the design and relevance cycles as required by DSR.

Step five: Finalize the in-depth analysis

Based on the in-depth analysis from the last step, the highlights of the detailed analysis can be summarized. Furthermore, the models can be finalized based on the focused information provided from the analysis highlights.

Step six: Discussion and conclusion

Here, step-by-step guidance should be summarized to guide further application of the models. The achievements of this research project will be concluded to contribute back to the knowledge base through the rigor cycle. With the completion of the thesis, the articulation and communication of the outcome of this research project can be provided.

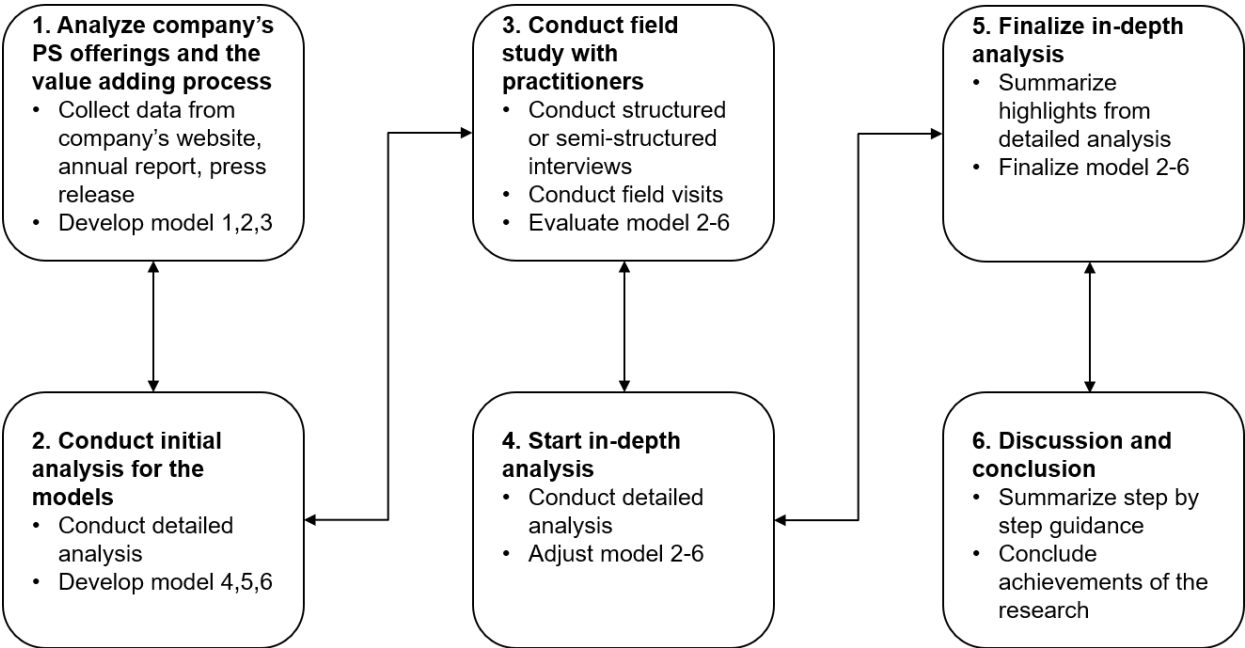


Figure 9. Data collection procedure.

4. Artifacts Developed in the Research Project

Complied with Hevner's DSR publication schema, Chapter 4 presents a description of the created artifacts (Gregor and Hevner, 2013). The artifacts created by this research project is named the servitization framework. It consists of a servitization definition framework, three models, and a set of tools for detailed analysis, which allow companies to measure, assess, and analyze their performance in the context of servitization with focuses on customization and digital transformation.

The servitization definition framework provides unified definitions that can be applied in this research project in response to solve the inconsistency challenge identified through the literature review. The models provide companies with the opportunity to visualize the strategy development for their decision-making process, as well as to analyze the PS value-adding process with a specific emphasis on internal and external contributions. The set of tools provided by the detailed analysis analyzes the business process and business activity of each value-adding stage, providing a solid input for applying the abovementioned models.

4.1. Development of the servitization definition framework

As argued in Chapter 2, it is necessary to define a unified servitization definition framework before conducting research within the scope of PSSs. The diverse definitions generated by various research streams with manifold intentions have created unnecessary confusion for both academia and industry practitioners. Although the concepts and definitions are given with diverse focuses along the process of servitization, no significant differences are observed. Therefore, to gain consistency that benefits industry adopters and future research work, a unified servitization definition framework was developed, which is introduced in this section. The definitions coined in this framework were consistently applied for conducting the field study with the industry participant as well as for articulation and communication with research communities. Therefore, it is introduced here at the beginning for the application of other artifacts.

4.1.1. Introduction to the service definition framework

The *servitization definition framework* developed in this research project includes six definitions and three layers. The six definitions describe all possible outcomes of a PSS along the process of servitization. The three-layer layout portrays potential combinations of products and services and their relationships.

Servitization is a transition process based on the PS continuum (Vandermerwe and Rada, 1988; Kinnunen and Turunen, 2012). During the process, products and services are two basic outcomes generated, which can be simply coupled, combined, or integrated in a PSS. Therefore, pure

products, pure services, or a combination of both are all possible outcomes of servitization. Accordingly, the servitization definition framework as shown in Figure 10 defines these possible outcomes into three main types as product (P), service (S), and PS combinations (P/S). Within the category of P/S, service (S) is further divided into integral service and additional service (AS) according to their different nature. Layer I presents a congregated concept, aiming to cover all possible forms of PSSs; the following two layers delineate the possible subsets of layer I.

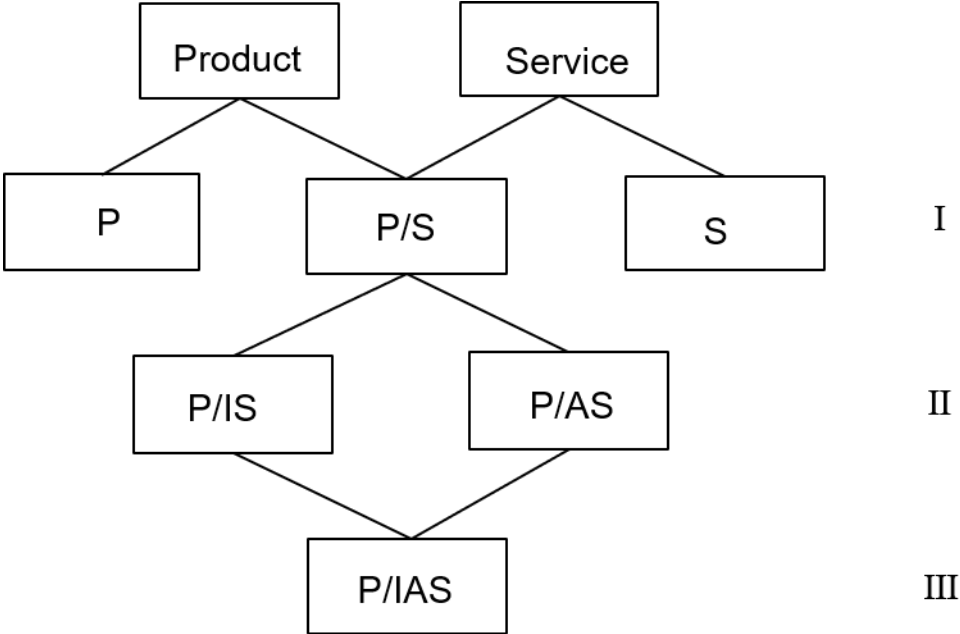


Figure 10. The servitization definition framework_Model_2.

4.1.2. Definitions

a) P, S, and P/S

In the servitization definition framework, layer I consists of definitions of the elements of P, P/S, and S, which cover the whole range of the PS continuum. Along the PS continuum, creating value streams by embracing more products is termed “productization,” whereas adding value by service provision is defined as servitization (Baines et al., 2007). Linking to Tukker (2004)’s theory on the three classifications of PSS, the relationships between them are illustrated in Figure 11. The two extreme ends of productization and servitization foster P or S from either a product-oriented or result-oriented PSS, which is used to describe companies that provide either only physical products without any kind of services or services without any types of physical entities. What is generated in between is defined as P/S, which could be generated by a use-oriented PSS.

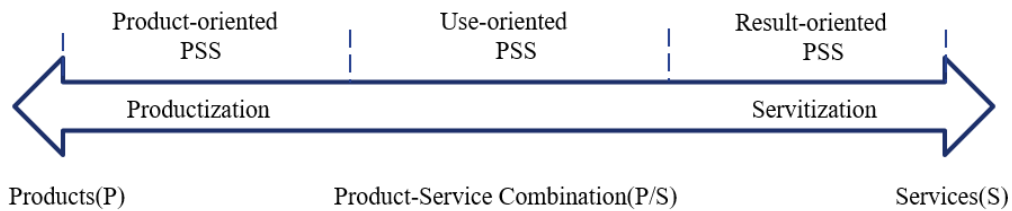


Figure 11. PS continuum, type of PSS, and P/S (adapted from Tukker, 2004).

b) Product/integral service (P/IS)

P/IS located at layer II as one of the subsets of P/S at layer I. With P/IS, the product's features are adapted or customized to meet customers' requirements. Customer's role as value co-creator is possible before the production starts. The integral service is therefore inherently connected with the P. In fact, in the definition of integral service, the P is an indispensable entity. The value of the integral service can only be achieved when it is delivered together with the P. This inseparability is the most recognizable feature that distinguishes an integral service from an AS. Therefore, the Integral Service occurs only in the upstream of the value chain before production; that is, it is engineering-oriented. Evidently, a P with the configuration/customization service option belongs to the P/IS category.

c) Product/additional service (P/AS)

Another type of P/S in layer II is a P/AS. AS refers to mainly sales promotion services; for example, maintenance, repair, delivery, or applicable advices. The AS is not relevant before the production process but rather after. Clearly, a P/AS can be generated in the downstream of the value chain. Market-orientation is the critical feature of an AS. Compared with an Integral Service, an AS can be generated and delivered without a physical entity. For example, a repair or maintenance service can be generated and delivered to a customer before such an activity is required from the P. The different features between P/IS and P/AS are listed with details in Table 12:

Table 12. Different features between P/IS and P/AS.

P/IS	P/AS
Engineering-oriented	Marketing-oriented
Upstream Value Chain	Downstream Value Chain
Inseparable	Separable

d) Product/integral additional service (P/IAS)

P/IAS at layer III represents when a P/IS and P/AS are provided simultaneously by the PS provider.

A P/IAS is located at a separate layer for the purpose of emphasizing this type of P/S combination, which separates them from P/AS and P/IS. The company providing the P/IAS has included all the possible services, including Integral service and AS. For example, companies offering customization service options, maintenance, consulting or delivery services together with their product provision are providing P/IAS.

4.1.3. The servitization definition framework and classifications of PSSs

In Chapter 2, two dimensions for classifying PSSs were reviewed. In this section, the second dimension, which concerns the interaction between the PS provider and customer, is applied to link the servitization definition framework back to the literature and strengthen ties with the knowledge base.

In the second dimension, PSSs are divided into two types: transaction-based or relationship-based (Frambach et al., 1997; Oliva and Kallenberg, 2003; Gaiardelli et al., 2014). The trade-off function is the crucial aspect for transaction-based PSSs. Economic value can only be created until the transaction of a PSS is completed (Oliva and Kallenberg, 2003). In reality, the selling, delivery, and installation of the product with the provision of its spare parts (among other things) are good examples of a transaction-based PSS. By contrast, the relationship-based PSS focuses on improvements to the relationship between the PS provider and customer (Gaiardelli et al., 2014). Therefore, a PSS that is relationship-based has the specific purpose of satisfying the customer, and thus enjoys a closer relationship with the customer. For example, when the selling of a product is complemented with extended warranties, preventive maintenance, and consulting on the customer process or business, it is considered a relationship-based PSS.

When the servitization definition framework is linked with the PSS classification drawn from the literature, it is clear that P and P/IS belong to transaction-based PSS category. An integral service is inseparable from the product; therefore, its value can only be realized together with the product. That is, only when the purchase from the customer is completed can the value of the PSS be realized.

The classifications of P/IAS, P/AS, and S depend mainly on the nature of the S or AS. When the AS or S are associated with the purchase of the product and related to a short-term application of the product, it will be considered as transaction-based. The AS that is offered based on a long-term basis is prone to being relationship-based. That is, when the AS included in the PS offering tends to be long-term, it is possible that the intention of the provision of the P/S is transformed from a one-time trade-off to maintain a long-term relationship with customers. Therefore, P/IAS and P/AS can be fostered by transaction- or relationship-based PSSs or both at the same time. The type of service serves as the variable that has a strong influence on deciding the type of PSS. The

details can be seen in Table 13:

Table 13. Typology of PS offerings

Type of P/S Type of PSS	P		S		
	P	P/S			S
		P/IS	P/IAS	P/AS	
Transaction-based PSS	X	X	X	X	X
Transaction- and Relationship-based PSS			X	X	X
Relation-based PSS			X	X	X

4.2.Process-oriented model

The *process-oriented model* investigates and analyzes the degree of customization through the PS value-adding process. The degree of external/internal contribution at each stage of the process is assessed. The model also serves as a fundamental step for applying strategic models through assisting companies to determine the strategic position regarding servitization transformation.

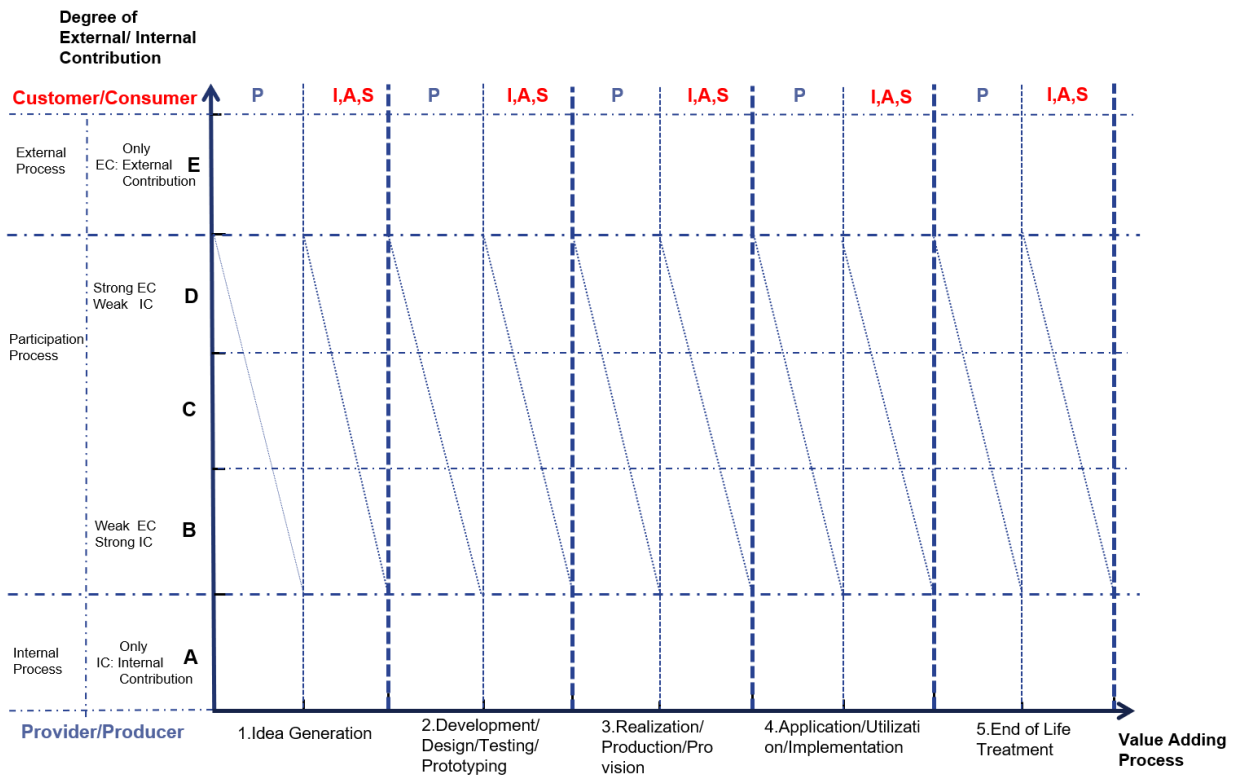


Figure 12. Process-oriented model_Model_4.

With a process-oriented model, the degree of internal/external contributions at each stage of the PS value-adding process will be revealed. The model consists of two main dimensions, describing the value-adding process and the degree of external/internal contribution, which are presented by two axes. Here, I take the previously discussed view of Ulrich (2011), that products and services are designed and developed concurrently. Therefore, the horizontal axis describes the value-adding process for both products and services.

As seen in Figure 12, the vertical axis represents the degree of internal and external contribution from the provider/producer and customer/consumer. The contribution is measured by five degrees (A-E), from only internal contributions achieved by the PS provider to only external contributions accomplished by the customer/consumer. Through the five-degree measurement, it is possible to assess the customer involvement and empowerment during the value-adding process.

The horizontal axis represents the five stages of the value-adding process from idea generation to end-of-life treatment. The value-adding process is identified and analyzed through the detailed analysis phase included in the servitization framework.

Notably, to obtain a detailed perspective on products and services, the *process-oriented model* divides the PS offering based on its application of the servitization definition framework. Thus, in each stage of the value-adding process, the possibility exists to investigate product and integral/additional services separately, analyzing the influence of contribution for each of them and visualizing the relationship between them.

By applying process-oriented models, companies can gain in-depth interpretations of customization along the PS value-adding process. Since customization is critical aspect of servitization, the analysis of the process-oriented model will assist companies in gaining strategic perceptions of their servitization transformation.

4.3. Strategy-oriented models

Two strategy-oriented models are provided by the servitization framework, concerning the degree of servitization, customization, and digital transformation. The intention is to align the company's current strategic position on servitization with its future target in the customization and digital transformation fields. Therefore, the core elements of the two models are servitization, customer involvement, and digital transformation.

4.3.1. The degree of servitization and customization model

The *servitization and customization model* provides the possibility to measure the degree of customer involvement along the servitization process. The model as showed in Figure 13 consists of two axes representing servitization and customization. The horizontal axis depicts the servitization process from pure product to pure service based on the PS continuum. The vertical axis depicts the intensity of customer involvement, from no involvement to fully engaged customer contribution. The company can visualize the current transformation achievement and the gap between their status and future strategic target for servitization and customization, thereby facilitating the daily decision-making process as well as the sustainable development of the company.

The four colored building blocks in the model portray four relatively extreme situations in terms of servitization and customization. The yellow block is the beginning of both the servitization and customization process with no customer involvement and only product provision. The red block depicts a situation where the product as a physical entity is no longer involved, and the service proposition can be fully generalized and customized by the customer. In other words, the PS provider will no longer take part in any stage of the value-adding process. The gray block represents a situation where the company is able to deliver a fully customized product, but no service is involved. Finally, the black block represents a P/S that is fully servitized with no physical entity as a product; however, the service delivered does not involve contribution from the customer.

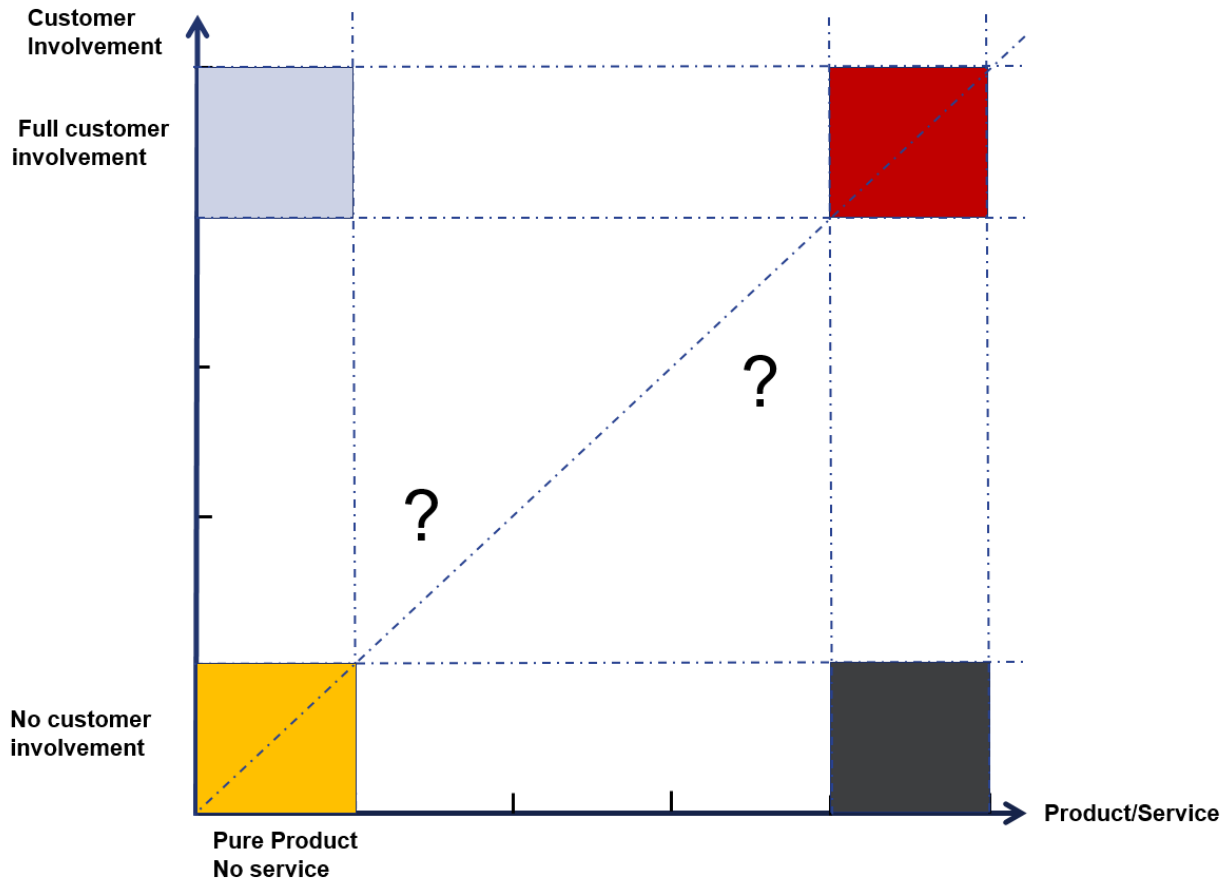


Figure 13. Servitization and customization model_Model_5.

Through locating the company's capability status before and after the servitization transformation process as well as the future strategic goal in the model, the following questions are raised:

- What are the previous and current strategic positions of the company's performance along the process of servitization and customization in the model?
- What is achieved in terms of customization and servitization?
- Is the current PS provision more customized or servitized?
- What is the future strategic target of servitization and customization and what is the current challenge regarding that future target?
- Is the current customization and servitization strategy in line with the company's future strategy?
- How can the gap between the company's current status and future strategy be overcome?

4.3.2. Degree of customization and digital transformation model

The *customization and digital transformation model* provides companies with the opportunity to combine the elements of customization, servitization, and digital transformation into one model at the strategic level. This model is applied to provide a holistic perspective for assessing the performance of digital transformation, which supports the process of servitization and

customization. The model assists companies visualize their digital transformation achievements and the gap between their current status and future target in customization and servitization. It intends to facilitate the decision-making process on the selection and application of digital tools.

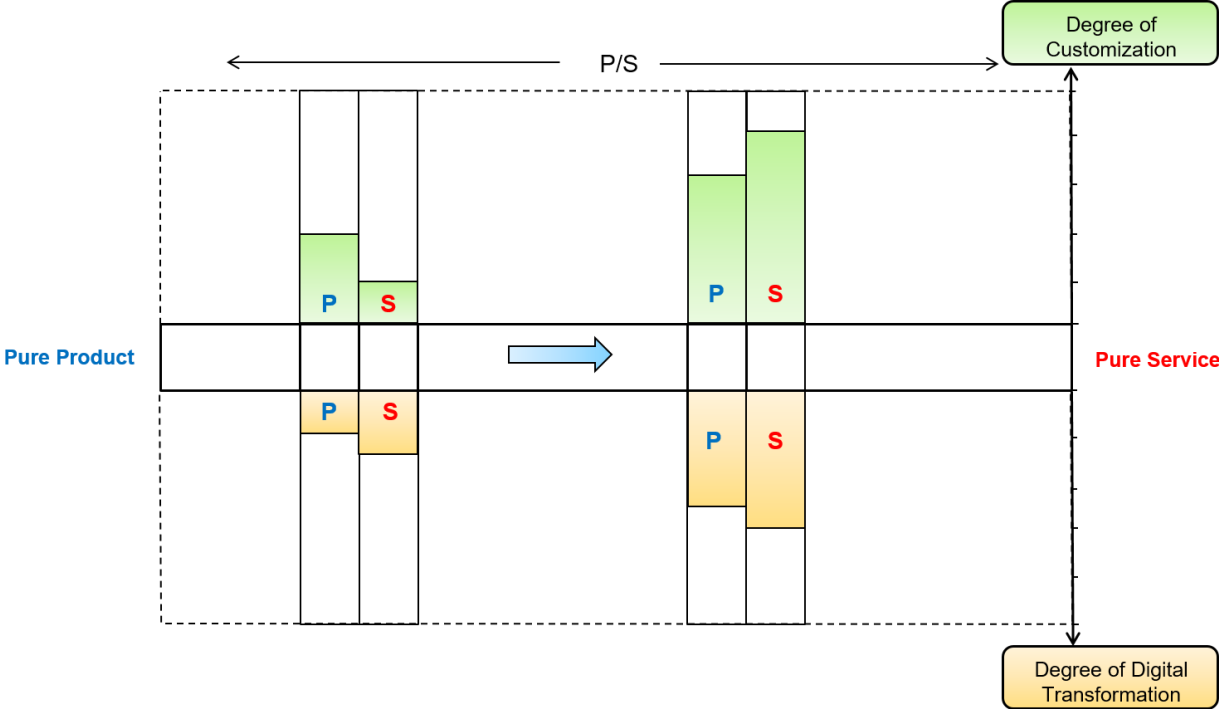


Figure 14. Customization and digital transformation model_Model_6.

The model in Figure 14 consists of three axes for the measurements of the degree of customization and digital transformation based on the process of servitization transformation. The horizontal axis represents the transformation process of servitization from pure product to pure service. The vertical axes describe the degree of customization that is supported by digital transformation. In other words, they visualize the strength of ICT systems that enables customization or customer involvement. When applying the model, the following questions would be helpful for obtaining in-depth insights:

- What are the previous and current strategic positions of digital transformation in supporting customization along the servitization transformation process?
- What are the achievements in digital transformation?
- What is the future target of digital transformation for enabling customization?
- Is the current digital transformation strategy in line with the company’s future strategy?
- How can the gap between the company’s current status and future strategy be overcome?

4.4. Detailed analysis

In the previous sections, an overview of the artifacts developed in this research project was provided. To develop and apply them, data analysis is critical. Therefore, this section introduces the detailed analysis included by the servitization framework. This analysis comprises a set of analysis tools that assist in completing the field study and revealing the data analysis results. Therefore, after the relevant data are collected from the industry partner, the set of analysis tools were used to investigate the business process and business activities at each stage of the PS value-adding process. The analysis results are presented through commonly applied means such as case write-ups, figures, and tables (Eisenhardt, 1989). They provide a solid foundation for applying the process-oriented and strategy-oriented model.

4.4.1. Analysis of the value-adding process

The overview of the artifacts clearly shows that the value-adding process plays an extremely important role. Therefore, the accuracy of the identification of the value-adding process is a prerequisite for applying the servitization framework. In the real business world, it is possible that companies either do not have a clearly defined value-adding process or the predefined value-adding process performs distinctively in various companies or departments. However, a certain degree of standardization on this process is required to serve as the baseline for any type of analysis. It is especially crucial for the analysis that is required for analyzing and assessing the transformation process.

In this research project, a five-stage standardized value-adding process was developed to identify the stages of the PS value-adding process or to adapt to various practical situations and provide the baseline for the analysis. It covers the value-adding process from idea generation to end-of-life treatment. Every stage has an output as a checkpoint to trigger the next stage. Figure 15 shows the iteration of the value-adding process, which could be applied for interpretation and identification of the value-adding process before applying the models. The five stages of the value-adding process are listed below:

- 1) Idea Generation
- 2) Development/Design/Test/Prototyping
- 3) Realization/Production/Provision
- 4) Application/Utilization/Implementation
- 5) End-of-Life Treatment.

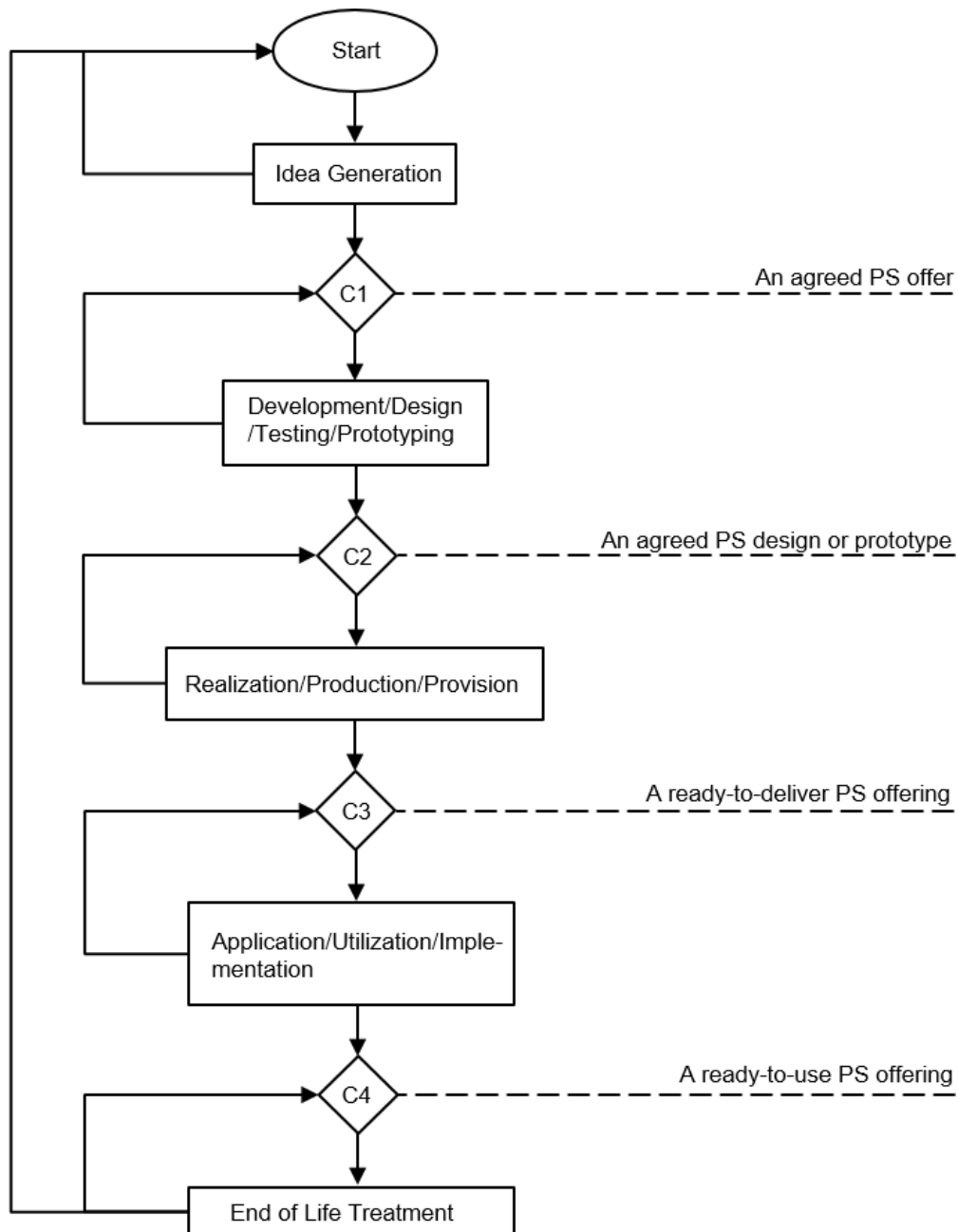


Figure 15. Value-adding process_Model_3.

As shown in the model, every stage of the value-adding process is iteratively performed and linearly connected to the next stage. Four checkpoints are appointed from C1 to C4. They are applied for indicating the completion of one stage and triggering the start of the next stage. For each of the value-adding stages, it will not be considered completed if the checkpoint is not delivered. Therefore, the checkpoints also act as the boundary to identify each stage. This will help companies that have not defined their value-adding process to identify and analyze each stage of the process. Details of each stage are introduced as follows.

1) Idea Generation

At this stage, the PS provider cooperates closely with the stakeholders to generate innovative P/S ideas. Analyses of the capabilities to develop, produce, and deliver are the main focuses; that is, an in-depth analysis on internal and external capabilities including the PS provider's R&D competence and the customer's capability as value co-creator is required.

In addition, customer feedback is a crucial source at this stage. It provides precious input that represents the perspective from the market. Other possible sources for the generation of an innovative idea on new P/S concepts originate from industry trend analyses, relevant seminars, or conferences. The checkpoint of the Idea Generation stage is an agreed P/S concept between the stakeholders.

2) Development/Design/Testing/Prototyping

Based on the P/S concept generated from the last stage, detailed design and development, testing, and prototyping are conducted. The customer as value co-creator can be provided with different options for participating in creating new products and services. Therefore, different degrees of customization can be achieved. At the end of this phase, a mutually agreed design plan or a tested prototype will be ready for realization or production, which is the checkpoint.

3) Realization/Production/Provision

At this stage, the PS provider focuses on realizing or producing the agreed design plan/tested prototype generated from last stage. The design plan or prototype can be adjusted during the production process based on the customer's requirements. The adjustment will be realized through the P/IS offered by the PS provider. The customer's role as value co-creator is possible at this stage of the value-adding process. A PS offering that is ready for delivery is the checkpoint of this stage.

4) Application/Utilization/Implementation

After the PS offering is ready for delivery comes the installation and application stage. The PS offering is finally delivered and ready for application. According to the servitization definition framework, the customer can participate in this stage through the AS offered by the PS provider.

5) End-of-Life Treatment

The last stage concerns the end-of-life treatment of the PS offering. An agreed plan should be generated between the customer/consumer and the PS provider. Throughout the end-of-life treatment, it is possible to obtain customer feedback on the P/IAS and iterate them back to the beginning of the value-adding process. The feedback from the customer brings valuable inputs for

the idea generation of new P/S concepts.

4.4.2. Typology analysis

Typology analysis aims to demonstrate the network of actors and infrastructure of the industry partner in a systematic and visualized manner. As mentioned in Chapter 2, the network of actors and infrastructure together with product and service comprise the four crucial elements of a PSS (Goedkoop et al., 1999; Mont, 2002). The network of actors and the infrastructure describe the relations and interactions of different parties, as well as the internal and external organizational structures (Baines, 2007; Gaiardelli et al., 2014). The purpose of the typology analysis is to draw attention to the transformation of network of actors and the infrastructure in the PSS before and after the servitization transformation. Therefore, the change generated by the servitization transformation to the industry partner's organizational structure and the relationship to the customer are analyzed.

4.4.3. Phase-level analysis

The phase-level analysis is the next step of the detailed analysis after identifying the value-adding process and typology. Five business process models are generated based on each stage of the value-adding process and eventually presented through ARIS Express Business Process Modeling Software provided by Software AG. The intention is to gain a comprehensive interpretation from data drawn from the field study and prepare for further business activity analysis.

With business process models, the related fundamental factors are identified, namely the start and the end status of each business process, the involved party, and the applied ICT-enabled system. In other words, people, processes, and technology are analyzed along the business process model's development, which have been identified as the most crucial elements of an organization (Prodan, Prodan and Purcarea, 2015).

4.4.4. Activity-level analysis

Activity-level analysis is conducted based on the completion of the phase-level analysis. After the five business process models are generated, the business activities included in each stage of the value-adding process can be listed. Detailed insights can be obtained through comprehensively examining all of the company's business activities.

Identifying all involved business activities from the status before and after servitization transformation is recommended. The results of the activity-level analysis serve as a critical input for the final analysis. After the activity-level analysis, a summarized write-up can be completed. Through the summarized analysis, the insights revealed by the detailed analysis are synthesized to elucidate the application of servitization transformation models.

5. A Field Study of a Carpentry Workshop

5.1. Introduction to the industry partner

In this section, the selected industry partner is introduced, including its applicability to this research project and its existing PSS. Complying with the predefined selection criteria in Chapter 3, the industry partner had to be an SME applicable to the research fields of this project and have a relatively simple PSS. According to the selection criteria, company H was selected to be the industry partner for this research project and worked closely with the researcher along the research process.

Company H not only satisfied the redefined selection criteria but also provided unique access to its servitization transformation phenomenon. With a mutual agreement between the researcher and founder, tight contact was guaranteed for gaining relevant information for this research project. Therefore, it was possible to observe the establishment of the new digitalized business model of company H, the construction of the digital platform, and the application of digital tools. More importantly, the motivation of company H's servitization transformation and challenges faced along the process could be discovered and observed.

5.1.1. Applicability of the selected industry partner

As discussed in the selection criteria in Chapter 3, the industry partner should be an SME that is adopting a servitization strategy and emphasizing customization and digital transformation. Company H is an online retail platform provider founded in 2014. It is a micro-sized company that includes fewer than 10 people. Company H was founded with the intention of providing service-intensive and customer-centered P/S provision through servitizing and digitally transforming a traditional carpenter workshop. The traditional carpenter workshop provides customers with solid wood furniture through company H's digital platform.

Company H provides an online platform for customers to design, configure, and purchase solid wood furniture, specifically eating/working tables and benches. Several digital tools are applied along the process. Web technology and 3D modeling contribute to the foundation of the online platform, upon which customization options are supported. Video recording is available to assist the customer in enjoying a close interaction with company H and the workshop. For example, the selection of solid wood trunks and process of production will all be filmed and shared with the customer. Other digital tools, such as sensors or augmented reality glasses are currently under consideration to enhance customers' experience.

In summary, company H is an SME that aims to servitize and digitalize a traditional carpenter workshop through the provision of an online platform. Its customization services are supported

by a digital platform and tools, which made it applicable for this research project in the fields of servitization with focuses on customization and digital transformation.

5.1.2. Suitability of the selected industry partner

As discussed in Chapter 2, the selection criteria required that the industry partner for the field study should have a relatively simple PSS to provide rich but focused information. Therefore, the existing PSS of company H is introduced and evaluated to demonstrate the company's suitability as an industry partner that meets the selection requirements.

- The P/S provided by company H

In terms of PS offerings, company H provides customers with solid wood table and benches as physical products. It also allows customers to apply 3D configuration tools on its website to design, configure, and customize the furniture. Specifically, they provide a collection of tables on the website, and the customer can customize and configure them through adjusting the parameters that satisfy their personal needs and taste. Furthermore, the customer is allowed to choose the wooden material based on their preference. In addition, company H provides consulting, support, and advice at every step of the value-adding process through the generation of design plans to the end-of-life treatment of the physical product.

- Network of actors and infrastructure

Company H's suppliers and partners form the network of actors and the infrastructure of its PSS. After an agreed P/S design concept is fixed between company H and a customer, the production process is triggered. The production process is achieved by the supplier of company H, the traditional carpenter workshop. It is responsible for the selection of the wooden material, the processing of the material, and the production of the product. There is no delivery partner involved after the production is completed.

5.2. Detailed analysis

A detailed analysis is crucial for applying servitization framework models. It includes the identification of the value-adding process, the analysis of the typology, as well as phase- and activity-level analyses. The results provide precious input for applying and evaluating other servitization models. It forms a solid foundation for the application of the models. Through a detailed analysis, the relevant data are collected from the industry partner, and then sorted and analyzed systematically. A comparative analysis can summarize and emphasize the results of the detailed analysis, thereby further processing the data for the next step. Furthermore, the status of

the traditional carpenter workshop before the advent of company H provided company H with a starting point for its servitization transformation journey. The detailed analysis was conducted based on data from the traditional carpenter workshop as the status quo. The creation of company H represents the status after the servitization transformation starts. Therefore, for observing and analyzing the long transformation process, the detailed analysis will follow a before-and-after method to compare the data from the traditional carpenter workshop and company H (Yin, 2018).

5.2.1. Value-adding process identification

In the servitization framework, the identification of the value-adding process is considered a prerequisite step. It serves as the most important basis for further analysis. Only when a clearly defined value-adding process is identified can further analysis on the servitization definition framework, typology, business process model, and business activity be possible.

As discussed in the previous chapter, the *iteration of value-adding process model* is the tool for assisting in the identification of the value-adding process of a target company. The phase outputs C1 to C4 are performed as the checkpoints that help to indicate the boundary of each stage of the value-adding process.

With the assistance of the model, the value-adding process of traditional carpenter workshop and company H is presented as follows:

Table 14. The value-adding process of traditional carpenter workshop and Company H.

Traditional carpenter workshop	Company H
1). Idea Generation	1). Idea Generation
2). Development/Design/Test/Prototyping	2)_a. Development/Design/Test/Prototyping_a (customization by configuration)
	2)_b. Development/Design/Test/Prototyping_b (customization by creation)
3). Realization/Production/Provision	3). Realization/Production/Provision
4). Application/Utilization/Implementation	4). Application/Utilization/Implementation
5). End-of-Life Treatment	5). End-of-Life Treatment

Table 14 clearly shows that the value-adding process of company H deviates from the standardized five-stage value-adding process. Specifically, two sub-stages are identified in Development/ Design/Test/Prototyping (DDTP) stage. The DDTP stage is defined as the process between two phase outputs: an agreed product offer and an agreed product design (see Figure 16). In company H’s case, the PS design can be generated by configuration or creation options that are offered to the customer through DDPT. In other words, company H provides the customer with

the configuration option on existing products as well as the creation opportunity where the customer has the freedom to design their own product from scratch. The founder of company H confirmed that the configuration and creation services of its digital platform are the most distinguishing factors compared with competitors. Figure 16 illustrates the iteration details of the five value-adding stages.

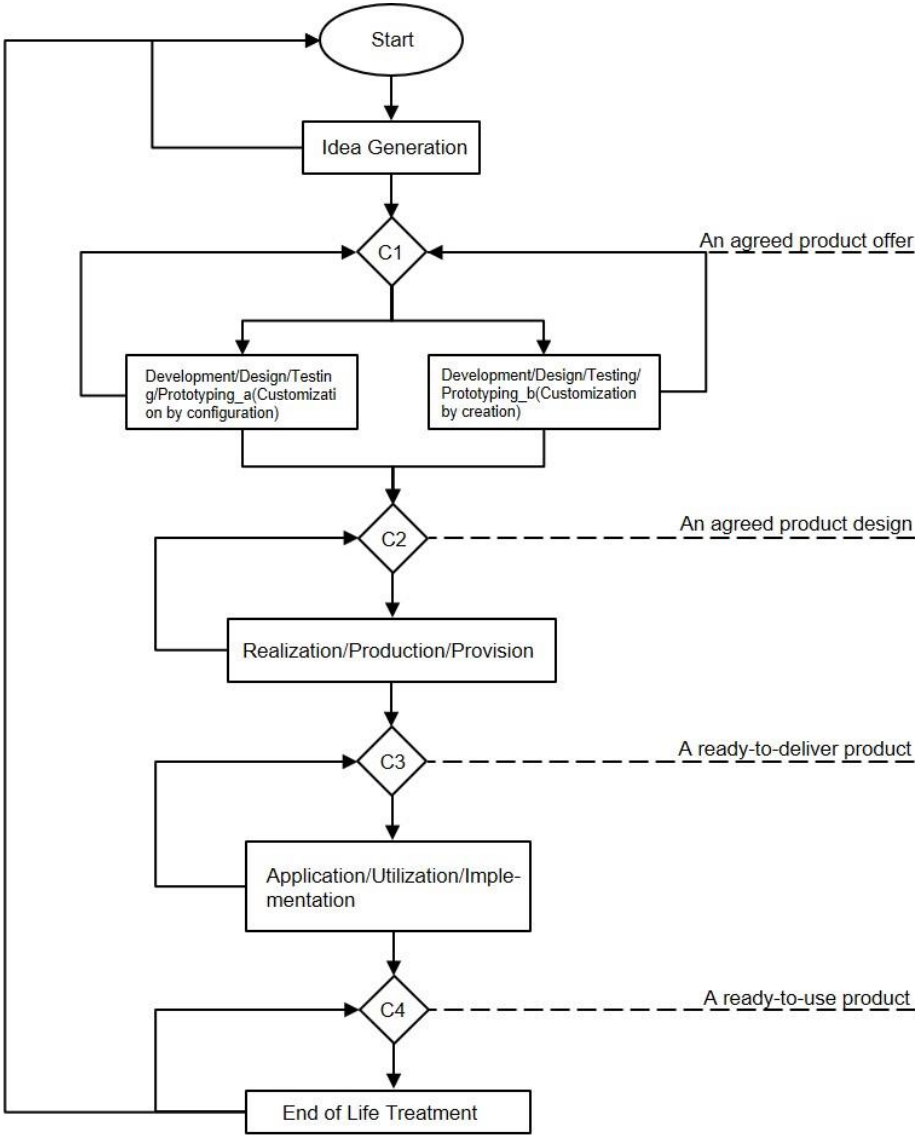


Figure 16. Model_3_Company H.

5.2.2. Applying the definition framework

In this section, the servitization definition framework is applied with company H’s P/S provision. The products, Integral Service, and AS are identified with company H’s five value-adding processes.

Product

The products provided by company H are tables and benches made of solid wood, which can be

used for either eating or working. Their unique character is that they feature a high degree of customization and emotional value. The products can be customized by the customer from a selection of tree trunks to product design and measurement adjustments through integral service. Every tree trunk, as the most basic and crucial material, is unique in terms of location, the weather of the year, the way it grows, and other factors. These features endow the product with a strong personal touch and emotional value. It also makes the price much higher for the customer, who has focused not only on the function that the furniture delivers but also the uniqueness of the tree trunk.

Integral service

An integral service by definition is a service that is inherently associated with the product and cannot be separated. Its engineering-oriented feature determines that the integral service will have an influence on the product before delivery. In company H, the integral service empowers the customer to influence the product concept development, design, and production process. Therefore, the integral services are involved in the 1) Idea Generation, 2) Development/Design/Testing/ Prototyping, and 3) Realization/Production stages of the value-adding process.

Additional service

An AS is defined as a sales promotion service, such as delivery, repair, maintenance, and consulting, which mainly occur after the production process. The feature of an AS compared with an integral service is that a tight attachment to the product is not a necessity. The AS provided by company H is delivery, information on maintenance, online surveys, customer feedback collection, and introductions to existing customer for potential product showcases in an agreed private environment.

Table 15. Servitization definition framework in the value-adding process.

Value-adding process	Product	Integral Service	Additional Service
1. Idea Generation	Customized Tables and Banks	1. Collect customer feedback and make necessary changes on the idea of new product design.	
2_a. Development/Design/Testing/Prototyping_a (Customization by configuration)	Customized Tables and Banks	1. Provide configuration options for the product design supported by company H’s website and 3D modeling tool. 2. Communicate with customer through company H’s website or other communication tools on the product design (Skype, WhatsApp, etc).	

2_b. Development/ Design/Testing/Pro totyping_b (Customization by creation)	Customized Tables and Banks	1. Provide creation options supported by company H's website and CAD tool, offering the customer the freedom to decide own product design. 2. Communicate with customer through company H's website or other communication tools on the product design (Skype, WhatsApp, etc).	
3. Realization/ Production/ Provision	Customized Tables and Banks	1. Send photos and videos of the tree trunk to the customer and wait for the decision. Empower the customer for the tree trunk selection. Send some production details. 2. Upload the photos and videos of the tree trunk or production process to company H's website for the customer to watch and wait for the decision when necessary, allowing the customer to make decisions on some details of the production. 3. Communicate with customer through company H's website or other communication tools on the production process (Skype, WhatsApp, etc).	
4. Application/ Utilization/ Implementation	Customized Tables and Banks		1. Product delivery at a time the customer chooses. 2. Advise the customer on the installation of the furniture. 3. Provide the customer with maintenance information.
5. Evaluation/ End- of-Life Treatment	Customized Tables and Banks		1. Online survey. 2. Ask for a short review of the product. 3. On agreement, introduce existing customers to new customers for showcasing the product.

5.2.3. Typology

Through applying the servitization definition framework, the product and service as two of the four basic elements of PSS were analysed. The analysis on the typology then aimed to analyze the other two basic elements of company H's PSS; specifically, the network of actors and the infrastructure. Company H enjoys a relatively simple PSS, the network of actors includes its supplier and customers. Therefore, the typology analysis demonstrates the internal and external organizational structure and the relationship between company H, its customers, and supplier.

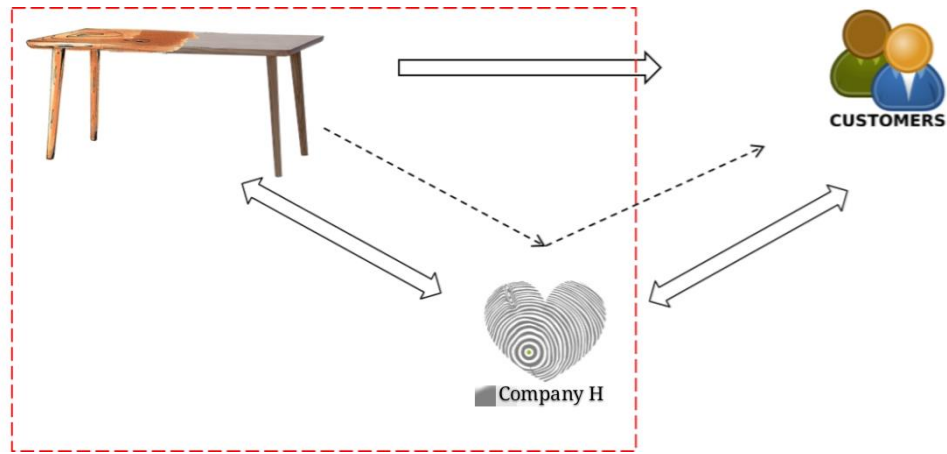


Figure 17. Typological structure of company H.

The supplier is a traditional carpenter workshop (on the left of the Figure 17), which is responsible for collecting and processing the material (tree trunk) and producing the final product for company H. Before the servitization transformation starts, the workshop has a direct interface with the customer. After the introduction of company H, the customer has no direct contact with the traditional carpenter workshop; the communication is managed by company H. The product and service are provided through company H's digital platform.

Therefore, it is clear that company H acts as the intermediary between the traditional carpenter workshop and customer. Externally, company H provides P/IAS together with the workshop to the customer. Internally, company H alone offers the customer services, including integral and additional service, whereas the workshop is responsible for the product. The typology analysis demonstrated that company H provides the opportunity for the traditional carpenter workshop to offer more customer-oriented services with its digital platform and tools, as well as the opportunity to improve the capability of traditional carpenters in respect to communicating with customers. Thus, by offering the customer integral and additional service, company H is able to empower the customer as value co-creator during the PS value-adding process.

5.2.4. Phase-level analysis

After applying the definition framework and analyzing the typology of company H, a holistic view of company H's PS portfolio and organizational boundary were obtained. Based on the results, the next step was to generate a phase-level analysis to demonstrate the business process models based on each stage of PS value-adding process. Generating business process models is considered in the servitization framework a necessary step to fully understand all aspects related to people, processes, and ICT systems.

Five business process models were generated using the ARIS Express Business Process Modeling Software based on the perception of the company’s value-adding process from Idea Generation to the Application/ Utilization/Implementation stage. The end-of-life treatment was omitted because there no standardized processes are included; activities are performed quite randomly.

The five business process models helped the researcher to gain a holistic view of company H. Questions such as who and what digital tools are involved in which business process are now answered through visualizations, which provide a foundation for the business activity analysis. An overview of the business process models is shown below in Figure 18 to give an impression on how is look like. Due to the size of each file, details can be seen in the Appendix.

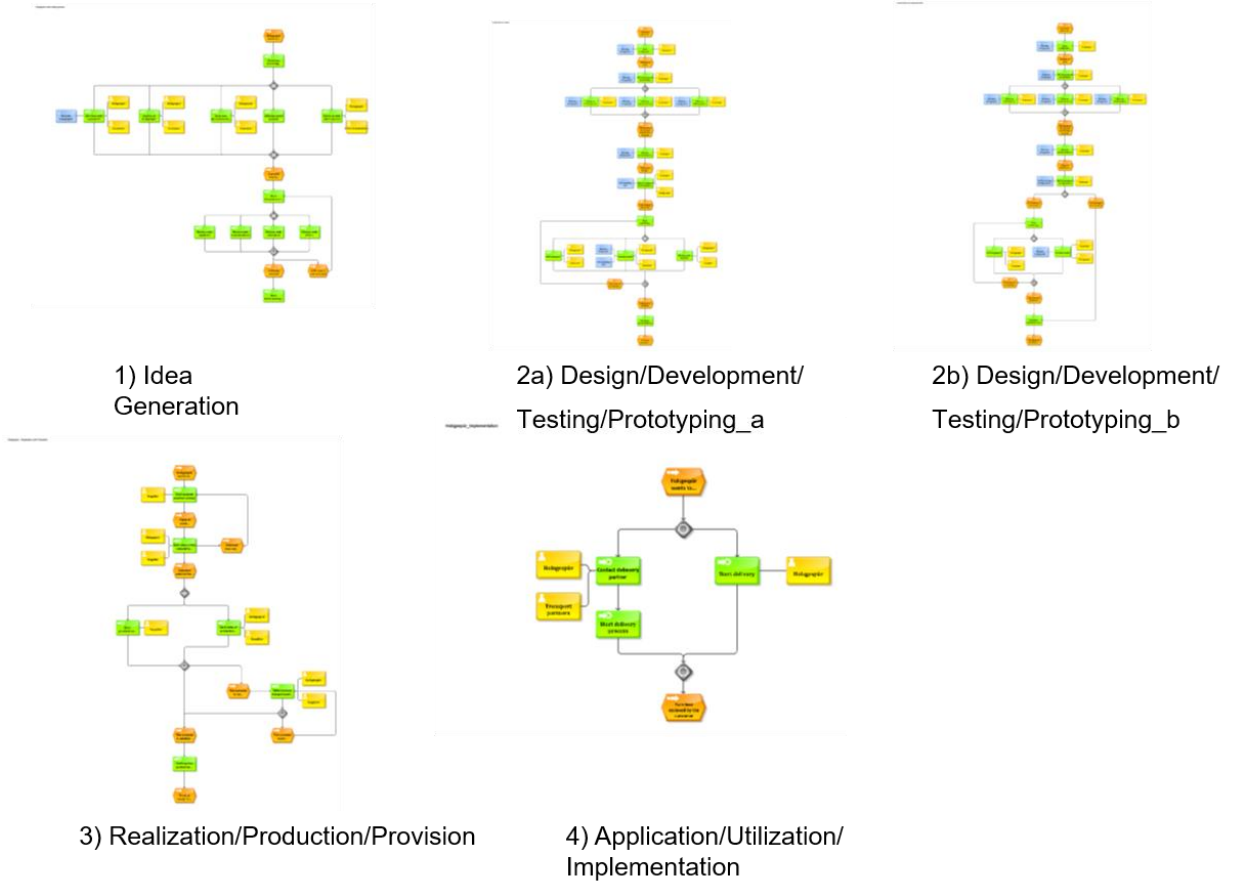


Figure 18. Overview of the business process model of company H.

The before-and-after method of analysis was not followed by phase-level analysis. In the traditional carpenter workshop, no standardized business processes were observed. Although the five stages of the value-adding process could be identified with the assistance of the *iteration of value-adding process model*, the business processes included in each stage are performed quite randomly, depending mainly on the carpenter personally. That is, the personal status of the carpenter is crucial for the business to be performed. For example, a high chance of delays in the production process and product delivery is possible if the carpenter is occupied with other

activities with or without business purposes. Therefore, it is not possible to draw a relatively standardized business process model because the processes are performed differently every time. This lack of a standardized business process faced by the workshop poses a great challenge to the daily business performance, which was identified as one of the difficulties for digital transformation (MIT Centre for Digital Business & Capgemini Consulting, 2011).

5.2.5. Activity-level analysis

After the business process models were generated based on the stages of value-adding process, insights in terms of people, processes, and technology were obtained. Next, the business activities based could be analyzed based on the perceptions obtained. To conduct a comparative analysis following the before-and-after method, the business activities of the workshop and company H were summarized and analyzed together. Although the traditional carpenter workshop follows a nonstandard business process within each value-adding process, the phase output of each stage is identifiable. It provided the foundation of a parallel activity-level analysis between the traditional workshop and company H. Details are found in the Table 16 below.

Table 16 clearly shows that more business activities were enabled by the introduction of company H. Within those business activities, instead of the carpenter, the customer provides precious input along the value-adding process, especially at the idea generation, development/design/testing/prototyping (DDTP), and realization/production/provision (RPP) stages. The most evident achievement is that the importance of the role of the carpenter is gradually replaced by the participation of the customer. The customer therefore starts to fulfill the role of value co-creator. Customer as value co-creator is a crucial feature for customization, which has been stressed in the literature (Vargo and Lusch, 2004; Ng, Nudurupati and Tasker, 2010). This is also the goal of servitization, because scholars have identified the definition of servitization as being the transition process that changes companies from a product-centric to a customer-centric view (Kinnunen and Turunen, 2012; Rabetino et al., 2017; Kowalkowski et al., 2017).

Table 16. Activity-level analysis.

Value-adding process		Business Activities		Digital Tools		Phase Output	
		Traditional Carpenter Workshop (TCW)	Company H	TCW	Company H	TCW	Company H
1	Idea Generation	<p>1. Industry trend analysis</p> <p>2. Seminar/Webinar/workshop/conference/business fairs</p>	<p>1. Analysis on customer feedback (problem solving)</p> <p>2. Internal discussion with team members, supplier (capability analysis-technology readiness, etc)</p> <p>3. Industry trend analysis</p> <p>4. Seminar/Webinar/workshop/conference/business fairs</p>	Website, Message tools (WhatsApp, etc)	Company H's website platform, Email, Communication tools (Skype, WhatsApp etc)	A new PS offering generated	A new PS offering generated
2a	Development/Design/Testing/Prototyping_a (Customization by configuration)	<p>1. Receive configuration options (from existing product samples) from the carpenter</p> <p>2. Receive the requirements of the product from the customer</p> <p>3. Receive the requirements of the product from the customer and communicate with the customer on the details</p> <p>4. Receive the product design from the carpenter</p>	<p>1. Receive contract requirements from the customer, send out the wood sample when required</p> <p>2. Receive the configured product design from customer</p> <p>3. Communicate with the customer with design and production details if necessary or required</p> <p>4. Receive the product design/order from the customer</p> <p>5. Process the order and proceed to production process</p>		Company H's website platform, Email, Communication tools (Skype, WhatsApp etc), 3D modeling tools	An agreed configured product design	An agreed configured product design
2b	Development/Design/Testing/Prototyping_b (Customization by creation)	<p>1. Receive the creation requirements of the product from the customer</p> <p>2. Communicate with the customer on the details of product design</p> <p>3. Receive the product design from carpenter</p>	<p>1. Receive contact requirement from the customer, send out the wood sample when required</p> <p>2. Receive the uploaded product design from customer</p> <p>3. Assess/communicate the design with supplier (carpenter, etc) and other relevant stakeholders</p> <p>4. Communicate/discuss with the customer on design and production details</p> <p>5. Receive the product design from the customer</p> <p>6. Process the order and go to production process</p>		Company H's website platform, Email, Communication tools (Skype, WhatsApp etc), CAD	An agreed created product design	An agreed created product design
4	Realization/Production/Provision	<p>1. Produce the product following the agreed design</p>	<p>1. Send the customer photos and videos of the material selection process and wait for the customer's decision</p> <p>2. Send the customer, the photos and videos of the production process</p>		Digital Camera, company H's website platform (Media platform on the website), Email, Communication tools (Skype, WhatsApp etc), 3D modeling tools	A customized piece of furniture ready for delivery	A customized piece of furniture ready for delivery
5	Application/Utilization/Implementation	<p>1. Deliver the furniture to the customer</p> <p>2. Advise the customer how to do maintenance</p>	<p>1. Deliver the furniture to the customer</p> <p>2. Advise customer where to locate</p> <p>3. Advise the customer how to do maintenance</p>		Company H's website, platform, Email, Communication tools (Skype, WhatsApp etc)	A customized piece of furniture delivered to customer and ready for use	A customized piece of furniture delivered to customer and read for use
6	Evaluation/End-of-Life Treatment		<p>1. Online survey</p> <p>2. Ask for a short review on the product</p> <p>3. Upon agreement, introduce existing customers to new customers to showcase the product</p>		Company H's website platform, Email, Communication tools (Skype, WhatsApp etc)		

5.3. Highlights

In previous sections, the value-adding process of company H was classified, followed by the application of the definition framework, and then the analysis of the typology. After five business process models of company H were developed and presented using the ARIS Express Business Process Modeling Tool, the details of activity-level analysis were listed and compared between the carpenter workshop and company H.

To apply the servitization framework to assess the transformation journey, it is necessary to analyze collected data in a before-and-after manner (Yin, 2018). The abovementioned analysis followed this logic. This section attempts to highlight the challenges faced by the traditional carpenter workshop before the advent of company H based on the abovementioned analysis. The achievements generated by company H are summarized for comparison. Such a summary on the highlights of the analysis is beneficial for the application of the models because it helps to focus on the most relevant factors that will have strong influence on the models.

5.3.1. Challenges faced by traditional carpenter workshop

In this section, the challenges faced by the workshop that are related to servitization transformation are summarized. Three main challenges were identified, which comprise most of the difficulties the business is faced before the servitization transformation began. The challenges can be summarized into three main topics: transparency, communication, and customer involvement.

Transparency

A significant lack of transparency was observed in the value-adding process of the workshop. The relevant information on new product design/development and production is neither shared within the workshop nor with the customer. The silo effect negatively influences the internal value-adding process and the customer experience, which results in a great deal of customer dissatisfaction.

1) Idea generation

In the idea generation stage of the value-adding process, no transparency is obtained for team members or coworkers within the workshop regarding the capability of design, development, and production. At this stage, a new PS idea should be generated as the phase output. Therefore, the capability of the PS provider should be transparently discussed by the team members or coworkers who are involved for P/S innovation and development. However, in the traditional carpenter

workshop, the capabilities of product design and production mainly depend on the carpenter personally; other coworkers are neither involved nor informed. This lack of transparency obstructs the internal methods of generating innovative ideas, such as conducting brainstorming, sending coworkers to relevant workshops, and further education on improving PS design capability.

2) Development/Design/Test/Prototyping

The lack of transparency in terms of the capabilities of design and development not only creates hurdles for internal capability improvements but also for external communication with the customer. At the DDTP stage, such communication on customer requirements and P/S design are crucial. For an agreed product design between the PS provider and customer, intensive communication is normally required for the details of the PS concept. However, extremely limited information is shared with customers. In a traditional carpenter workshop, communication on PS design and development relies mainly on oral explanations of the carpenter and the virtualization capability of the customer without any assistance from digital tools. Therefore, a lack of effectiveness and clearness are the greatest challenges faced by the carpenter in the DDTP stage, which makes a high level of misunderstanding possible.

3) Realization/Production/Provision

The lack of transparency has severe influence on the realization/production/provision process internally and externally. Internally, the lack of transparency slows the production process and generates challenges for the operation process. In the solid wood industry, tree trunks are the most basic material employed. The special feature of tree trunks as a material for producing solid wood furniture is that they must reach a certain degree of humidity to be applied in production. The readiness of the material entails years of waiting to reach the required level. In the case of the traditional carpenter workshop, such information is only held by the carpenter. The carpenter is responsible for all information on each tree trunk, specifically the humidity and the time and duration of storage. The decision on the readiness of the material relies only on the carpenter's personal experience.

Externally, the lack of transparency during this stage generates displeasure in the customer. No information is provided regarding the current production process, decision-making criteria, or even problems during the production process. From the customer's perspective, the whole production process is a black box until the final product is presented; that is, there is a great level of risk involved, which may result in PS offerings that are not expected by the customer, leading to dissatisfaction.

Communication

As discussed, the lack of transparency is a large hurdle faced by the workshop. The root cause is the lack of effective communication, which forms another pivotal challenge that has severe influences. Within the workshop, no certain communication strategy is applied for information regarding the competency of the team, readiness of the material, or the production process. Furthermore, the researcher observed during the field visits that keeping track of the workload and process is very difficult for the carpenter workshop because relevant training is lacking. Therefore, the silo effect is inevitable, which reduces the efficiency of the process and generates even more difficulties in communicating with customers about relevant matters.

In terms of the customer, the issues with communication lie in the whole value-adding process. Emphatically, in the DDTP and RPP stage, neither an effective communication strategy nor communication tool is applied to the generation of an agreed PS design or the product that is ready to deliver.

Customer involvement

The traditional carpentry industry provides a high degree of individualization based on individual requirements for a product (Kasper, 2014). However, the individualization is not based on the customer's empowerment or involvement as a value co-creator. For the decision-making process of each value-adding stage, the customer's requirements are mainly fulfilled by the carpenter's own understanding with limited opportunities for communicating with the customer. Therefore, the customer is not involved in the process of material selection, production, and end-of-life treatment. However, customer empowerment and role as value co-creator are the vital features of customization, as mentioned in Chapter 2. Therefore, even though individuality is high, the customization level is very low because the customer's role as value co-creator is not fulfilled.

5.3.2. Achievements generated by company H

In addition to the challenges faced by the traditional carpenter workshop, many achievements have been generated by company H, which are targeting those challenges. Based on the results of the detailed analysis, the achievements areas summarized and assessed in the fields of servitization, customization, and digital transformation are presented as follows.

Servitization and customization

In Chapter 2, it was argued that a close relation exists between servitization and customization. Customization presents servitization with a future direction (Armistead and Clark, 1993 ; Oliva and Kallenberg, 2003). Thus, the basic principle of customization is to fulfill the

customer's role as value co-producer. Therefore, fulfilling this role and being more customer-centric are tasks conducted in servitization transformation (Armistead and Clark, 1993; Vandermerwe and Rada, 1988; Kinnunen and Turunen, 2012; Rabetino et al., 2017; Kowalkowski et al., 2017).

Comparing the previous analyses and the challenges faced by the traditional carpenter workshop, it is evident that company H has transited further along the servitization and customization process by providing more customer-centric P/S offerings. With the advent of company H, the individuality provided by traditional carpenter workshop is transformed into customization.

The P/IS provided by company H before the *application/utilization/implementation* stage has enhanced the customization level through empowering the customer for P/S design and development as well as production. It is clear from Table 16 that the focus is transformed from the carpenter to customer in value-adding stages 1 to 4 where the P/Is are provided. Therefore, the customer fulfills the value co-creator's role through providing feedback to the new P/S concept development, customization by configuration, and creation services as well as through having an influence on the decision-making process during production.

The P/AS provided at stage five assists company H to place the customer at the center of consideration by obtaining his or her feedback after the project is delivered, which contributes to the improvement of new P/S idea generation.

Digital transformation

Company H applies diverse digital tools to offer the P/IAS to the customer. Based on the above-conducted analysis, Table 17 below summarizes the digital tools that have been applied during the value-adding process as well as the function they have delivered. As seen in the table, there are three main functions supported by digital tools, namely product design and development, production, and communication. The website of company H serves as a digital platform that enables the different functions through various digital technologies. The communication function is provided with different options throughout the value-adding process.

Table 17. Summarization of digital transformation in value-adding process.

Digital tools		Function	Value-adding process
Company H website	3D modeling tools	Product design and development	2_a
	Online chat box	Communication	1,2_a,2_b,3,4,5

	Media platform for sharing photos and videos	Production	3
	CAD	Product design and development	2_b
	Digital camera	Production	3
	Email	Communication	1,2_a,2_b,3,4,5
	Communication tools (Skype, WhatsApp, etc.)	Communication	1,2_a,2_b,3,4,5

Three main target areas of digital transformation were discussed in Chapter 2: the operation process, customer experience, and business model (MIT Centre for Digital Business & Capgemini Consulting, 2011). Company H has digitally transformed the traditional carpenter workshop in terms of the customer experience and business model, the details of which are as follows:

1) Customer experience

According to the MIT Centre for Digital Business and Capgemini Consulting (2011), the customer's experience can be digitally supported in the area of customer touchpoints, which include customer service, cross-channel coherence, and self-service. In the case of company H, the customer experience has been significantly improved by enhanced customer touchpoints through real-time customer service and self-service options.

First, the customer service is strongly supported by digital communication tools throughout the whole value-adding process. With digital tools (i.e., online chat boxes, Skype, and WhatsApp), company H is capable of providing customers with real-time communication to answer questions regarding the use of the website, 3D design tools, discussions on product design, and development details. It also assists the customer to make decisions on the details of production. This multichannel real-time communication has significantly transformed the lack of transparency and communication situation of the traditional carpenter workshop. The customer is no longer kept outside during the P/S design, development, and production processes.

Second, the self-service options improve the customer experience through digital transformation in the fields of product design/development and the production process. This has improved customer involvement during the value-adding process. To be more specific, the P/IS provided during 2_a, 2_b, and 3 are mainly realized through various digital tools such as 3D modeling, CAD, and digital cameras. With these tools, the customer becomes involved in processes from product design to production. They are provided with the option to influence tree trunk selection, the details of the design plan, and the production. That is, the lack of customer involvement

identified as a challenge faced by the workshop has been compensated for by digital transformation.

2) Business model

The business model is one of the three main areas that accommodate digital transformation. According to MIT Centre for Digital Business and Capgemini Consulting (2011), such digital transformation occurs in areas including the transition from physical to digital products and the reshaping of organizational boundaries.

With the advent of company H, the business model of the workshop was significantly transformed. The products and services were digitally transformed with P/IASs through the digital platform and tools. The digital integral services were therefore provided together with the physical products, which can be observed in stages 2_a, 2_b, 3, and 4 of the value-adding process in Table 17. The customization of configuration and creation services digitally transformed the product design and production processes of the traditional carpenter workshop. This led to improved empowerment of the customer and augmented customer satisfaction.

Furthermore, the organizational boundary of the workshop has been modified, as shown in the typology analysis, which also belongs to the business model area of digital transformation according to Table 3 (MIT Centre for Digital Business & Capgemini Consulting, 2011). As argued previously, the workshop transformed its role from directly communicating and selling to the customer to be the supplier of company H. This transformation has allowed company H to provide new Integral and Additional Services to the customer.

5.4. Applying the process- and strategy-oriented models

After the detailed analysis, the process- and strategy- oriented models can be conducted. The performance of the servitization transformation is visualized and assessed using these models. Thus, it is possible to understand how servitization, customization, and digital transformation are conducted by company H and what the impacts brought by the transformation are.

5.4.1. Process-oriented models

As discussed previously, the process-oriented model features in the aspects of customization along with the PS value-adding process. It analyzes the internal and external contributions of products and services separately at every stage of the value-adding process. Therefore, through the application of the process-oriented model, the degree of customer involvement is assessed and visualized in detail. Furthermore, the application of the process-oriented model is based on the

results of the detailed analysis, while its own results serve as a critical input for applying the strategic-oriented models.

The application of the process-oriented model for company H is shown below. Two process-oriented models were generated based on company H’s data analysis because two customization offers were found at the DDTP stage, namely customization by configuration and customization by creation. In the following sections, the performance of the traditional carpenter workshop is first introduced, followed by the demonstration of company H in comparison. Finally, the differences between the two process-oriented models are highlighted.

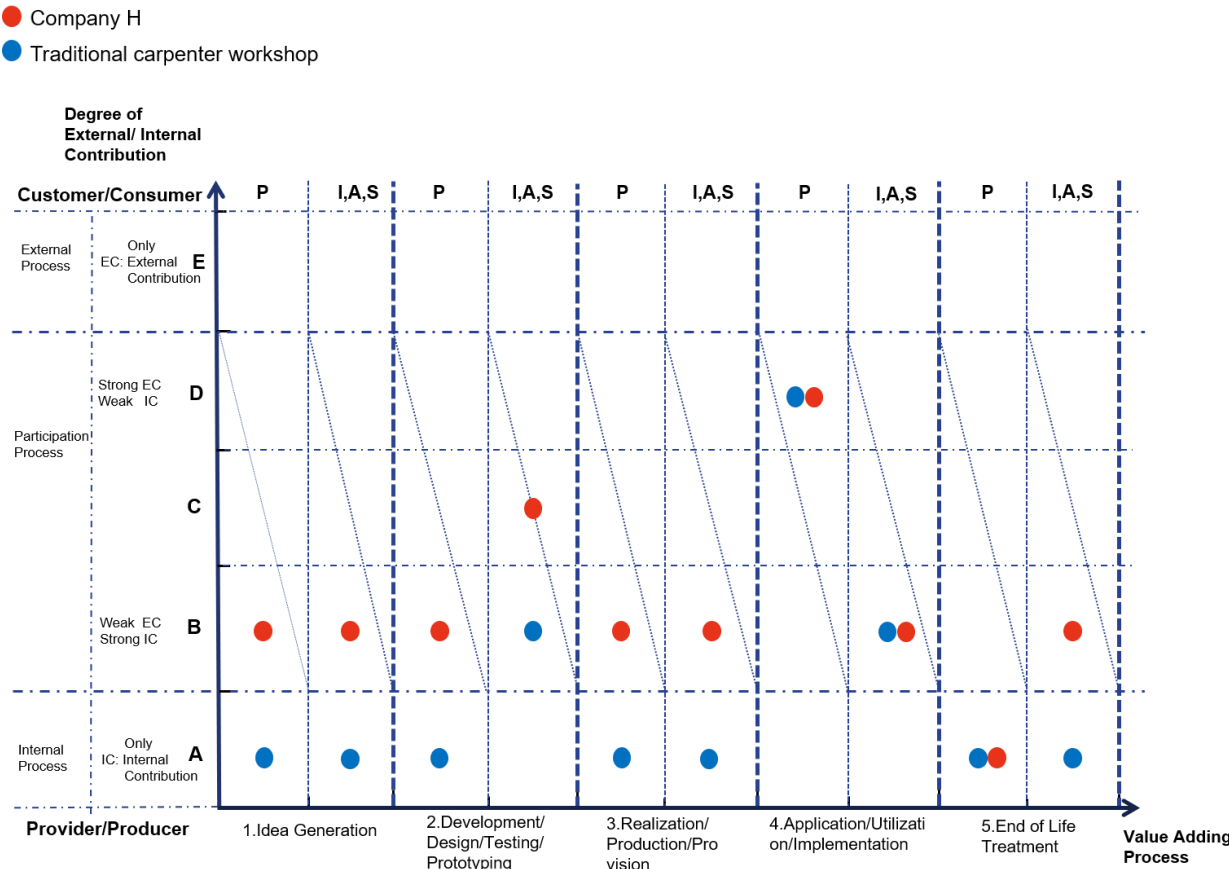


Figure 19. Model_4_Configuration_Company H.

Based on the previous analysis, it is evident that the traditional carpenter workshop suffered a lower degree of external contribution before the creation of company H in most stages of the value-adding process. Admittedly, the products provided by the workshop, for example, stairs, are individualized because they must fit the diverse requirements of different customers’ houses or apartments. However, except for the product requirements being laid out by the customer, the customer’s role as value co-creator in the process remains unseen, which is an important indicator

of external contribution, namely customization. That is, after the only communication on the product at the beginning of the value-adding process, the product design and production depend only on the understanding of the carpenter himself. The customer has basically no influence during the process. Therefore, the degree of external contribution on the product category in stages one, two, and three of the value-adding process fall into only the internal contribution area (see Figure 19). The individuality provided by the traditional carpenter workshop has contributed weak external contribution, which can be seen in the service category of value-adding stage two. Furthermore, in stage four, the customer's strong influence on delivery and implementation requirements have assisted the customization degree to reach a relatively higher position in the model.

By contrast, company H has accomplished a relatively higher degree of customization in most of the value-adding process stages than has the carpenter's workshop. In stage one, the customer feedback iterated back from the last stage contributes to the new PS development process, which has made the customization degree higher than that of the workshop where the concept of new P/S completely relies on the capability of the carpenter.

The main achievements that company H has generated are revealed in stage two in both process-oriented models. The Integral Services provided at stage two have fostered higher degrees of external contributions through empowering the customer with the two customization offers. The customer's role as value co-creator is fulfilled through company H's digital platform and the application of the other digital tools.

The difference discovered by comparing the *Process-oriented model _ configuration and creation* emphasizes the customer's role as value co-creator. Evidently, the customization through creation that is realized through the provision of the Integral Service has contributed a higher degree of external contribution than has customization by configuration. Customers have more freedom to generate the product design through creating their own design plans rather than configuring existing ones. However, this higher degree of external contribution is limited by the capability of the supplier of company H, namely the workshop. The product design from the customer can only be realized when the workshop confirms its capability to produce it. Therefore, the degree of external contribution is located in the strong external contribution area by the lower edge.

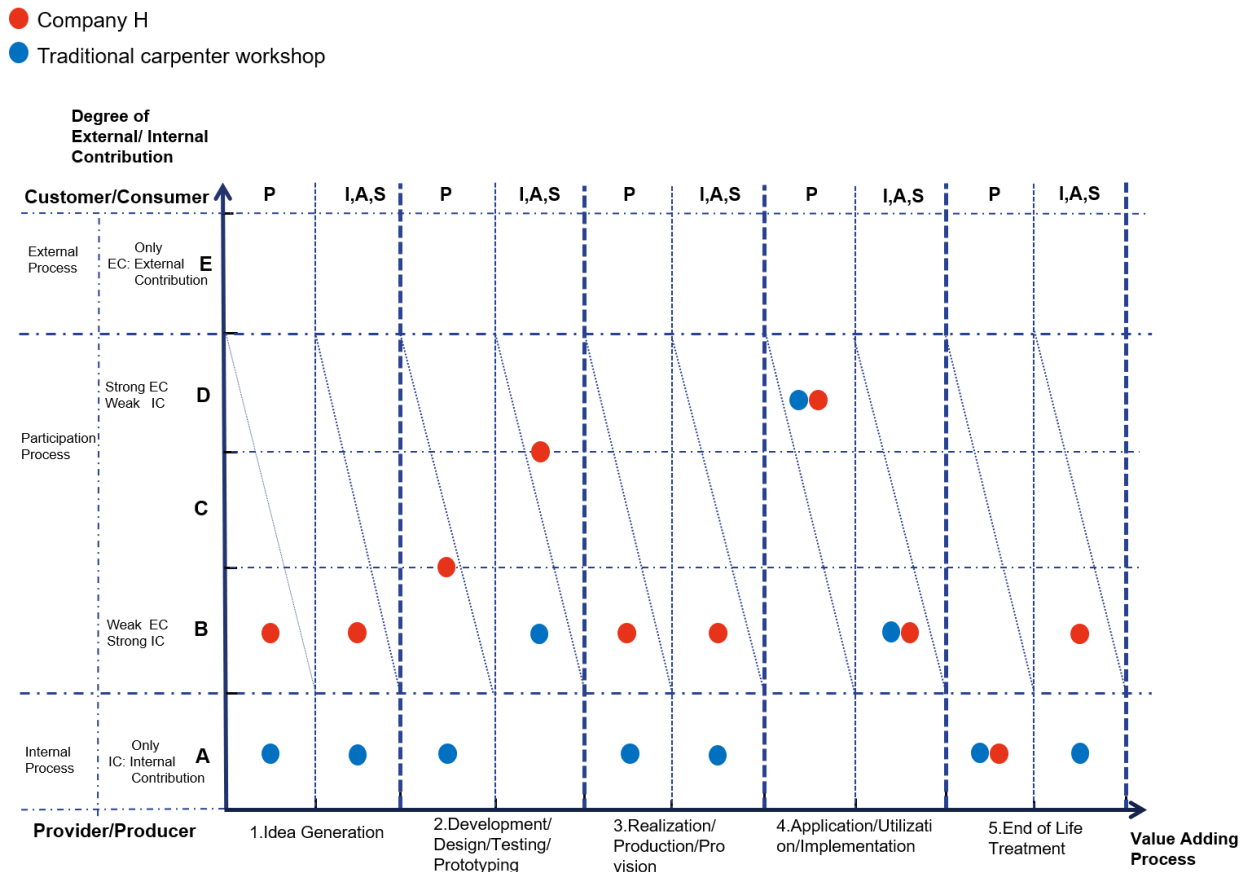


Figure 20. Model_4_Creation_Company H.

In addition, through the comparison of the two models, it is also notable that the Integral Services have also had positive impacts on the degree of external contribution on the product, which can be observed in Figure 20. In the two process models, from stage one to stage three when the degree of external contribution of services improves, the external contribution of product customization is accordingly enhanced. This is because the nature of Integral Services is closely related to the product and cannot be separated from it. Therefore, when the degree of external contribution of Integral Services has been enhanced, the external contribution of the product will also be improved. This indicates the crucial role of integral service in assisting the company to reach a higher level of customization and servitization transformation.

5.4.2. Strategy-oriented models

The two strategy-oriented models concern the degree of servitization, customization, and digital transformation. They assist the strategic decision-making process on relevant matters. The two models are: the degree of servitization and customization model and the degree of customization and digital transformation model.

Degree of servitization and customization model

- C** Traditional carpenter workshop
- H** Company H's current status
- F** Company H's future strategy

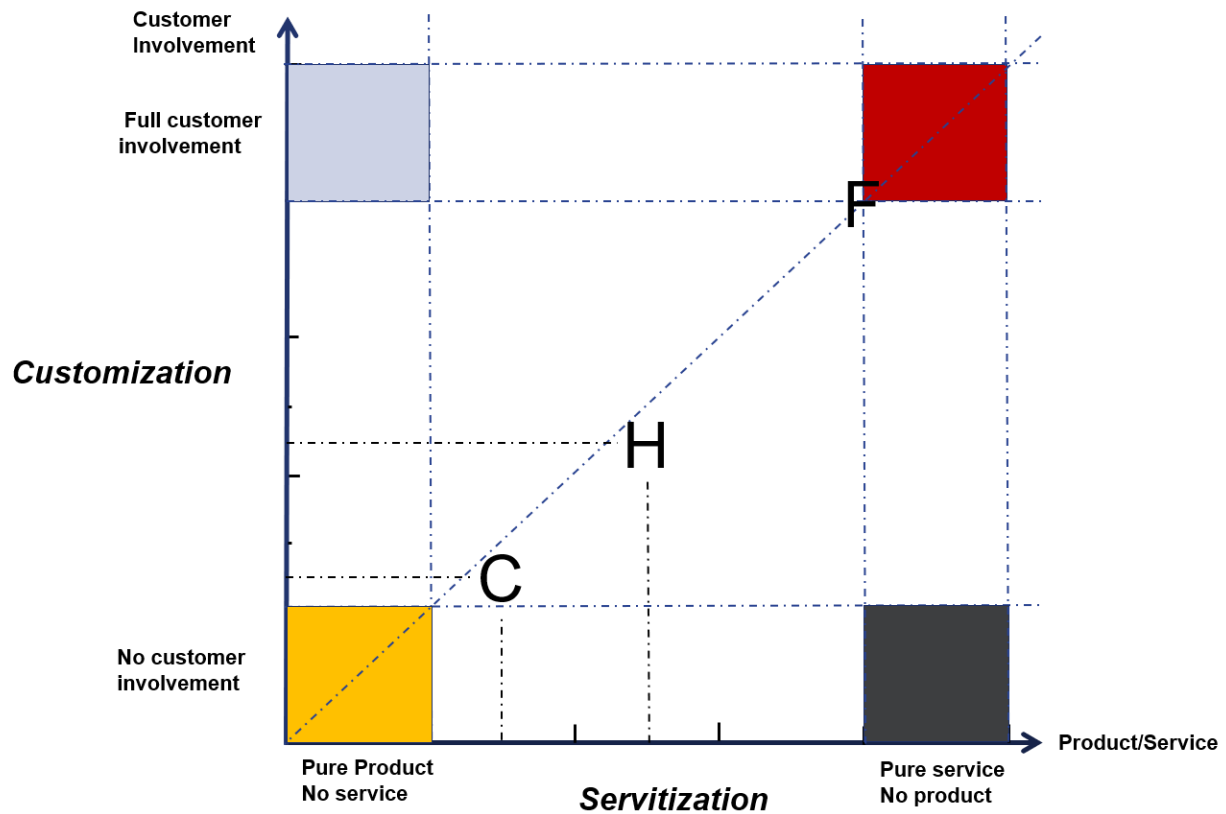


Figure 21. Model_5_Comapny H.

Based on the previous analysis, the *servitization and customization model* was applied. The capital letters C, H, and F in Figure 21 present the performance of the traditional carpenter workshop, company H's current status, and its future strategy in both the servitization and customization transformation areas.

Position C in the model indicates that the workshop has lower servitization and customization degrees compared with company H (Capital H). The detailed analysis makes clear that the traditional carpenter workshop was facing the challenges of a lack of transparency, communication, and customer involvement. These challenges motivated it to conduct servitization transformation and improve the degree of customization to create more value by attracting more customers. Position C reveals the driving force behind the workshop enhancing its performance in both servitization and customization transformation.

Furthermore, position C reveals that the customization degree of the workshop is lower than its servitization degree, because even though the individual services are provided based on individual customer requirements, it cannot be counted as customization as discussed in previous sections. Therefore, the individualized services cannot accordingly boost the degree of customization. That is, in this situation, the individualized services provided by the carpenter cannot fulfill the customer's role as value co-creator.

Position H in the model represents the servitization and customization degree of company H. It presents the higher degree of servitization as well as higher degree of customization transformation compared with the workshop. However, although the customization level is significantly boosted by the degree of servitization, the improvements of both are not proportional. The model shows that the customization degree is still lower than the degree of servitization. The fundamental reason is that the customer's role as value co-creator is limited by the carpenter workshop's production capability, which has restricted the degree of customization.

This inconsistency between the degrees of customization and servitization at positions C and H indicates that even though the customization presents the future direction of servitization, not all servitization has positive impacts on improving customization. From the model, it is meaningful for the decision-maker to realize that not all servitization initiatives result in a higher degree of customization. Therefore, it is worth raising awareness in practice during the P/S design and development process to ensure that the created P/S concepts are in the direction of enhancing customization or strengthening customer cooperation. Only then can a long-term relationship with the customer be formed through improved customization (Zine et al., 2014). Therefore, it is foreseeable that seizing the most relevant opportunities could be a challenge and requires cautious consideration for the decision-makers.

Position F represents the future strategy of company H. According to the model, the two extreme ends of the model in the directions of customization and servitization are full customer involvement and pure service provision. However, the extreme end of servitization is challenging to achieve, especially in manufacturing where the physical product plays the crucial role for a long time. As indicated by Kinnunen and Turunen (2012), it is unlikely that manufacturers will target providing pure services without product entities. The majority of companies in manufacturing are more interested in providing bundled or integrated PS offerings (Baines et al., 2009; Davies, 2004). Therefore, as confirmed by the founder of company H, the 5-year future strategy visualized by this model for the company is at position F where the physical products are still provided but with the highest possible customer involvement. Because position H reflects the current performance of company H and position F reflects the future goal, the next step could be to apply

the model to assess the gap between positions H and F. The future strategic decisions on adding services could be assisted by this model through filtering out those that contribute to closing the gap.

To summarize, the *degree of servitization and customization model* visualized the improvements to company H in terms of the degrees of customization and servitization transformation, compared with the traditional carpenter workshop. This can assist the decision-maker in building a goal-oriented strategy and enhancing the service portfolio with a focus on improving the customer's involvement, thereby boosting the degree of the customization. Future application of the model could follow the analysis demonstrated above and generate precious insights.

Degree of customization and digital transformation model

In the detailed analysis, Table 17 summarized the digital tools applied by company H and the functions they deliver. The digital tools have digitally transformed the traditional carpenter workshop in the areas of customer experience and business model (MIT Centre for Digital Business & Capgemini Consulting, 2011). Specifically, through real-time customer service and self-service options provided by company H, the lack of transparency and communication challenges faced by the workshop have been overcome, which has led to an improved customer experience. The digitally supported P/IAS has transformed the physical products of the workshop. Furthermore, the reshaped organizational boundary has contributed to the enhanced communication capability in and outside the carpenter's workshop. The business model of the workshop was accordingly transformed.

- C** Traditional carpenter workshop
- H** Company H's current status
- F** Company H's future strategy

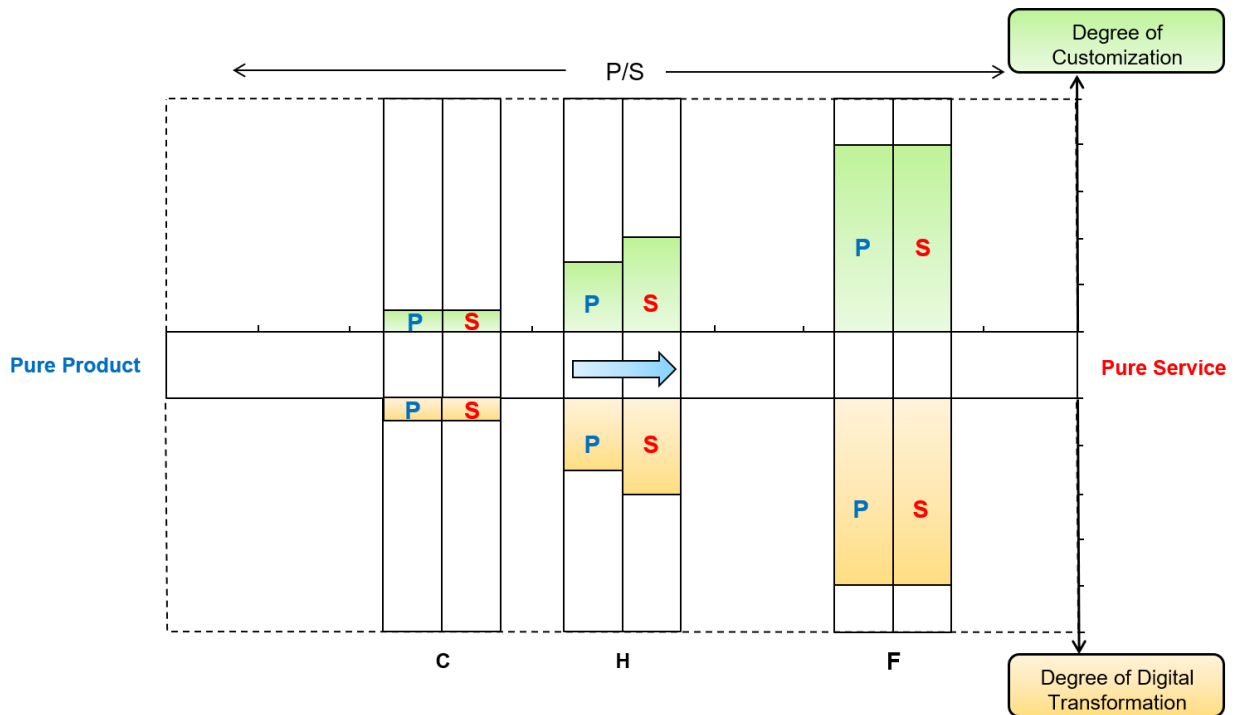


Figure 22. Model_6_Company H.

The process of digital transformation generated by company H is presented through the *customization and digital transformation model* in Figure 22. The model was applied with the abovementioned analysis results and insights from the two other models. Position C represents the traditional carpenter workshop, which suffered the lowest degree of digital transformation degree because no digital tools were applied during the value-adding process. Digital transformation has boosted the degrees of servitization and customization of company H, which can be seen from position H. However, the customization supported by digital transformation for products was lower than for services, resulting from the limited impacts brought by the provision of Integral Service, which is consistent with the result of the degree of servitization and customization model.

Position F illustrates the future goal of digital transformation of company H. Company H's future digital transformation strategy is to boost customization and servitization proportionally as well as digitally transform both products and services to the same degree. This indicates that the application of digital tools is one of the major tasks, because they can improve the customization degree of Integral Services, which impact the product. Based on the previous analysis, digital tools

that empower customers in the product design, development, and production processes would be favorable; for example, the virtual reality technology listed in the Gartner Report as one of the top 10 strategic technology trends for 2018 (Gartner, 2018). This technology can assist customers to visualize their home with virtual furniture, and thus it is worthy of the attention of company H's decision-maker. This would presumably assist customers in adjusting the design of the furniture to better fit their home and taste. Therefore, it would have effects on the product design and development processes, contributing to enhanced customization.

6. Discussion

This section concludes with step-by-step guidelines for implementing the servitization framework as well as discusses the main contributions and implications of this research project. The main tasks conducted for this research project are summarized, and furthermore, they are compared with streams of thought from the reviewed literature to demonstrate the contributions and implications. Thus, the achievements of this research project are presented as the contributions back to the knowledge base, as required by DSR. At the end of the chapter, the project's limitations are discussed, and recommendations presented.

6.1. Step-by-step guidelines

This research project developed a servitization framework, including analysis tools and models, that can help companies assess their servitization capability and implement a servitization transformation strategy. Based on the field study conducted by this research project, a six-step set of guidelines was developed. Their purpose is to guide companies through the application of the models and analysis.

1) Identify the value-adding process

This is the crucial foundation for all further analyses and applications. Therefore, the first step of applying the framework is to identify and classify the company's value-adding process into five predefined steps. The iteration of the value-adding process model should be completed to reach the goal.

2) Apply the definition framework

This step provides the opportunity to thoroughly analyze the company's PS portfolio and clear confusion caused by various definitions used by different communities. The P/IS and P/AS should be identified and analyzed based on the company's five value-adding processes.

3) Conduct a typology analysis

The typology analysis should be conducted with the application of the definition framework. A holistic perspective of the relation between the PS provider, supplier, and customer should be achieved. The four basic elements of the PSS of the target company are analyzed, namely product, service, network of actors, and infrastructure.

4) Performed a detailed analysis

The phase- and activity-level analyses constitute the detailed analysis. In the phase-level analysis, business models of each phase of the value-adding process are presented using ARIS Express Software. All business activities in each phase should be listed afterwards during the activity-level

analysis. At the end of this step, highlights of the analysis can be summarized in favor of the application of models. The current challenges and achievements can be compared and presented, providing a foundation for applying process- and strategy-oriented models.

5) Process-oriented model application

In this step, the customization degree in each value-adding process will be assessed and presented. The external contribution provided by customers can be analyzed in the product, integral, and additional services category. Details of the target company's performance in customer involvement are revealed, which provides an input for assessing the degree of customization also in the other models.

6) Strategy-oriented models

Based on the previous analysis, the two strategy-oriented models are applied to visualize the degrees of servitization, customization, and digital transformation at the strategic level. The current performance of the target company along its transformation journey and the gap between the current performance and future goal are assessed. Based on the application of the models, a strategy that targets this gap can be developed.

6.2. Main contribution

The servitization framework developed by this research project includes the definition framework, six models, a set of detailed analysis tools, and a six-step set of guidelines. They were created with the purpose of answering the research questions presented at the beginning of the research. The servitization framework will help academics and practitioners to understand what the roles of customization and digital transformation are during the servitization transformation. It will also assist them to measure the degrees of servitization, customization, and digital transformation together with the degrees of internal and external contributions along the transformation process.

First, the definition framework clarified the confusion caused by diverse definitions observed in the literature for describing the integration of products and services, such as bundling (Guiltinan, 1987), systems selling (Park et al., 2012), and solutions (Miller et al., 2002). The definition framework developed by this research project included different possible combinations of products and services to satisfy the various types of their integration along the PS value-adding process. Within the definition framework, practitioners can apply the correct P/S integration based on their own application contexts.

Second, the six models included in the servitization framework contribute to improving the design methodology of PSSs. The important contribution of the six models is that they were developed based on the interpretation that products and services are developed simultaneously and concurrently. Therefore, the products and services are considered together along the value-adding process from the idea generation stage to the end-of-life treatment stage. Comparing the previously reviewed PSS design approaches in the literature, the six models developed through this research project have not only simply combined service development with the existing product development process, as intended by the previous PSS design approaches of *the integrated Product and Service Design Processes* (Aurich et al., 2006a, 2006b) and *Integration Definition for Function Modelling* (Morelli, 2006), but concurrently developed the product and service development processes by integrating them throughout the PS value-adding process. The degree of customer contribution for P/S development can then be assessed along the value-adding process. As the literature review showed, plenty of PSS design methodologies have emphasized the PS value-adding process, but only parts of it. For example, some PSS design approaches have focused only on the idea generation stage of the value-adding process (Clayton et al., 2012; Mont, 2002), or on the customer involvement and customer requirements aspects (Maussang et al. 2009; Vasantha et al., 2011; Tran and Park, 2014). There are not sufficient focused approaches aimed at offering a framework that could assist companies to conduct servitization transformation from the beginning to the end of the PS value-adding process. This incompleteness causes inconvenience for servitization transformation, especially for SMEs, where the lack of a predefined transformation process is identified (Coreynen et al., 2015).

Another crucial contribution of the six models is that they provide a model-based approach based on the three dimensions of servitization, customization, and digital transformation, which provides companies with a strategic perspective of their transformation journey. It reveals the intrinsic link between the fields of servitization, customization, and digital transformation. Through the creation and application of the six models, it is evident that digital transformation enables servitization with more integral services that have positive impacts on the degree of customization of the product. Based on the interpretation, the decision-maker in practice could pay attention to filtering the digital tools that enhance the link for a successful servitization transformation journey.

Furthermore, the models of the servitization framework provide a method of measuring the degrees of servitization, customization, and digital transformation from a strategic aspect, which was identified as a demand in the literature (Coreynen et al., 2015). They have improved the scalability for servitization transformation. As mentioned previously, servitization is a complex transition process. It is not uncommon that a servitization strategy results in negative effects on

companies (Gebauer and Friedli, 2005; Baveja, Gilbert and Ledingham, 2004). Labor costs and a lack of scalability have been identified as two major challenges during the process and generated uncertain factors, which result in high risks in financial return (Gebauer et al., 2005). A lack of managerial tools and methods make the scalability difficult for servitization strategy implementation (Wise and Baumgartner, 1999; Slack, 2005; Baines et al., 2009). Companies have no means to assess their transformation progress to make efforts to fill the missing gap. However, measuring the progress is crucial for servitization strategy implementation. Only when companies understand their current progress can they make correct and individualized strategic decisions for their future strategic development. Therefore, the six models contribute to this aspect, allowing companies to assess their degrees of servitization, customization, and digital transformation from a strategic aspect. In turn, this assists them in improving the scalability and transparency of their servitization transformation.

Third, a set of analysis tools and step-by-step set of guidelines fills the gap in the form of a lack of practical tools and guidelines for the strategic implementation of servitization stressed in the literature (Welp et al., 2008; Aurich et al., 2010). The provided tools target different levels of business. They help to identify a company's value-adding process as well as analyze the business process and business activity at every stage of the value-adding process, with which the detailed analysis can be completed. Furthermore, these analysis tools can easily be adopted by practitioners. The six-step set of guidelines can help companies to adopt the models based on the results of the detailed analysis. Furthermore, they guide practitioners through the whole application process of applying the framework, which facilitates companies adopting a servitization strategy.

In summary, this research project developed a model-based approach with analysis tools and a six-step set of practical guidelines for conducting servitization transformation. It contributes to the research field of servitization and has a focus on customization and digital transformation. Moreover, it successfully combined customization and digital transformation as the two critical elements of servitization.

The contribution of this research project is that it fills the gap identified in the literature, which was a missing link between servitization and companies' capability. How to examine companies' capability and customer contribution over the stages of servitization transformation has been reported, as demand in the reviewed literature (Martinez and Bastl, 2010; European Commission, 2011). The servitization framework developed through this research project can assist researchers

and companies to fully understand customer involvement through the integrated P/S perspective, with an emphasis on covering the whole PS value-adding process. Only when such a holistic and coherent perspective is obtained can companies' capability in servitization be fully evaluated (Brax, 2005).

For industry practitioners, the model-based approach with the developed analysis tools and guidelines can help companies enhance their P/S design, their transformation in organization structure, and their servitization strategy, which have been identified as challenges faced by industries (Baines et al., 2009). It is critical for practitioners to have practical models, tools, and guidelines that can be directly implemented on a daily basis (Kinnune and Turunen, 2012; Welp et al., 2008; Aurich, Mannweiler and Schweitzer, 2010).

6.3. Limitations and recommendations for future research work

This research project had two major limitations, based on which the future research direction could be formulated. First, the servitization framework was developed based on a focus on the most relevant factors that influence servitization, customization, and digital transformation. The limitation here lay in the fact that there are indeed other influencing factors that were not targeted by this research project. A noncomplicated start is beneficial for investigating a complex servitization transformation; however, based on the contribution of this research project, future research projects are recommended to explore other influential factors that also have an impact on servitization transformation.

This limitation as caused by the selection criteria developed by this research project for the industry partner, which limited the size of the industry partner and complexity of its PSS. It will be beneficial for researchers to gain the most relevant information targeting servitization, customization, and digital transformation. Other factors such as changes in organizational structure and influence from legacy IT systems (which could be provided by larger companies with complicated PSSs) may also play a role during the transformation process, but they were not the focus of this research project. Based on the models created by this research project, researchers in this field could add the abovementioned factors to the models in future studies, observing and analyzing the impacts of the added factors to the existing models.

Second, this research cooperated with a single industry partner for the field study. This is necessary for observing the longitudinal phenomenon as servitization transformation with a single field study (Yin, 2018). However, the significance of the research was limited because the

practical requirements of one company are limited.

Based on the solid foundation provided this research project, future research projects can add more industry partners, thereby adding diverse application contexts with more requirements from the field. This could lead to advanced versions of the created artifacts. The challenge here is that observing and researching servitization transformation can be a highly time-consuming task; the transformation process could last for months or even years. Therefore, researchers must be mentally prepared to follow through with such a longitudinal process for the success of their research.

7. Conclusions

This research project was conducted in the field of servitization and focused on customization and digital transformation. It first identified the demands in both literature and practice, and then developed research questions to guide the research to fill the identified gap. A systematic literature review was conducted to obtain an in-depth understanding of the definitions of products and services, servitization transformation, its relationship with customization, and digital transformation. Subsequently, the concept of a PSS was reviewed together with its typology and design approaches. This formed the theoretical foundation for this research project to further contribute to the field. Based on the interpretation of the existing work, first versions of the models were developed and then further evaluated and adjusted through a field study with an industry partner. Therefore, the definitions and models were tested in the field and further developed based on feedback gained from the field. Once the designed definitions and models could reflect the real business work in the field and help to solve the practical problems faced by the industry partner, the requirements of the development of the servitization framework were satisfied.

In summary, the artefacts and guidance developed through this research project aimed to explore how to assess the degree of servitization by locating the given case within the models included in the servitization framework. In this manner, the company's capability for servitization was assessed in detail. With these models, companies will have a clear perspective on how efficient their servitization strategy is through analyzing their service-oriented offerings. Furthermore, they will assist companies to better leverage their related resources and implement new technology through transforming their business model.

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9. Appendix

9.1. The application of design science publication schema

(adapted from Gregor and Hevner, 2013, p. 350).

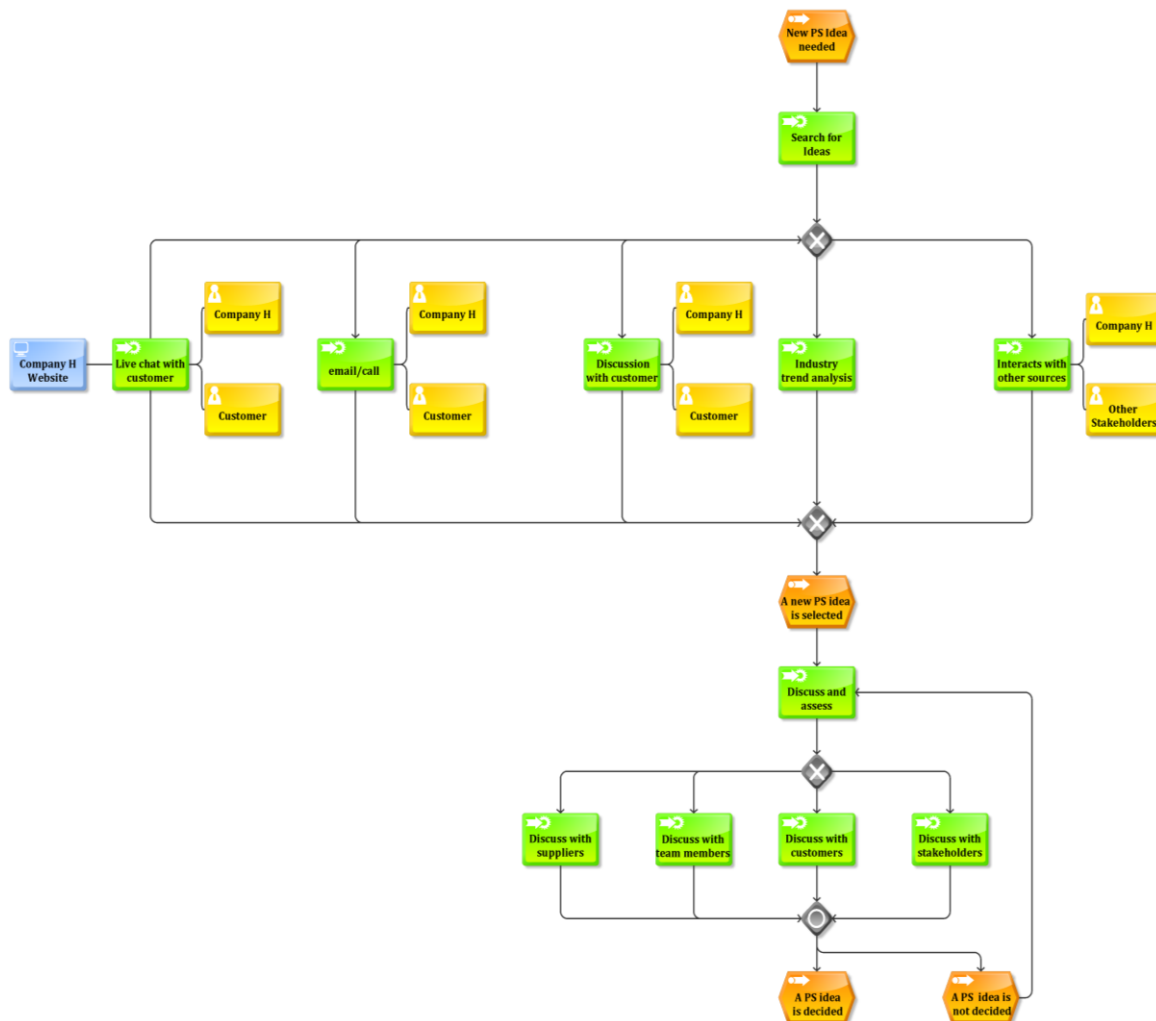
Section	Requirements	Application in this research project
1. Introduction	“Problem definition, /motivation, introduction to key concepts, research questions, scope of study, overview of methods and intended findings, theoretical and practical significance, structure of remainder of paper.”	The scope of this research project as the servitization transition process with focus on customization and digital transformation are introduced, followed by the overview of DSR and CSR methodology. The research questions are specified in detail to direct this research project. The intended artifacts and their significance for the researcher and practitioners are illustrated. The structure of the thesis is briefly introduced at the end of the chapter.
2. Literature	“Prior work that is relevant to the study, including theories, empirical research studies and findings from practice. For DSR work, the prior literature surveyed should include any prior design theory/knowledge relating to the class of problems to be addressed, including artifacts that have already been developed to solve similar problems.”	Relevant previous literature in the selected area: servitization, PSS, PS design approaches, digital transformation, customization are systematically reviewed. The existing concepts, definitions and classification are located within scope of servitization and logically reviewed. In regard to digital transformation, the role to servitization and customization that has been identified in literature are emphasized. The PSS design approaches that have already been developed and applied in real world will be chosen in corresponding to the requirements of experience and expertise in knowledge base domain. They provide the foundation for the innovative artifacts as well as the improvement on existing work.
3. Research methodology	“The research approach that was employed. For DSR work, the specific DSR approach adopted should be explained with reference to existing authorities.”	Principle of DSR in information systems research is selected and employed as basic research approach and CSR will be applied for the purpose of evaluating and testing the artifacts generated by DSR. The adoption of DSR in this research project is explained by demonstrating the application of the three-cycle view, the guidelines and the publication schema. The selection of CSR as evaluation method, including field study case selection criteria, data collection and analysis methods and so on are explained in detail.
4. Artifacts developed in the research project	“A concise description of the artifact at the appropriate level of abstraction to make a new contribution to the knowledge base. The format is likely to be variable but should include at least the description of the designed artifact and, perhaps, the design search process.”	This section begins with the introduction of servitization definition framework, which is considered to be he innovative way of considering PS offering based on the interpretation of PS continuum. It will then in detail present the three models regarding servitization, customization, and digital transformation, which consists of the major part of the artifacts from strategic and process level. Detailed analysis, including analysis tools at phase level and activity level, is briefly demonstrated. It intends to fulfill the requirements for an embedded case analysis with data analyzed at different levels.
5. A field study of a carpentry workshop	“Evidence that the artifact is useful. The artifact is evaluated to demonstrate its worth with evidence addressing criteria such as validity, utility, quality, and efficacy.”	This section provides the evaluation of desired artifacts with empirical data through case study. It starts with the introduction of the applicability and suitability of the sample case. Then the value-adding process model and the definition framework will be applied to the sample case to show how they match with the real business world. Afterwards, the data collected from business activity level

		and business process level will be emphasized and displayed, following the before-and-after manner. The highlights of the comparative analysis will be put in place. Based on the demonstrated data analysis, the models will be applied and evaluated. Therefore, the usefulness and impacts of developed models will be illustrated with empirical data as evidence.
6.Discussion	“Interpretation of the results: what the results mean and how they relate back to the objectives stated in the Introduction section. Can include: summary of what was learned, comparison with prior work, limitations, theoretical significance, practical significance, and areas requiring further work.”	This section intends to present the highlights of this research project. It illustrates how to interpret and apply the findings of this research through providing a guideline. A summary of how the generated artifacts answer the research questions will be stressed. Furthermore, the comparison with previous models, design approaches from PSS literature demonstrates the value of this research work and indicate the theoretical and practical significances. At this stage, the limitation and direction for further research in this area are at the end defined and articulated.
7.Conclusions	“Concluding paragraphs that restate the important findings of the work. Restates the main ideas in the contribution and why they are important.”	Summarizing and concluding the findings and the results of this research will reappear in this section. Final statement will highlight this crucial point of this research project.

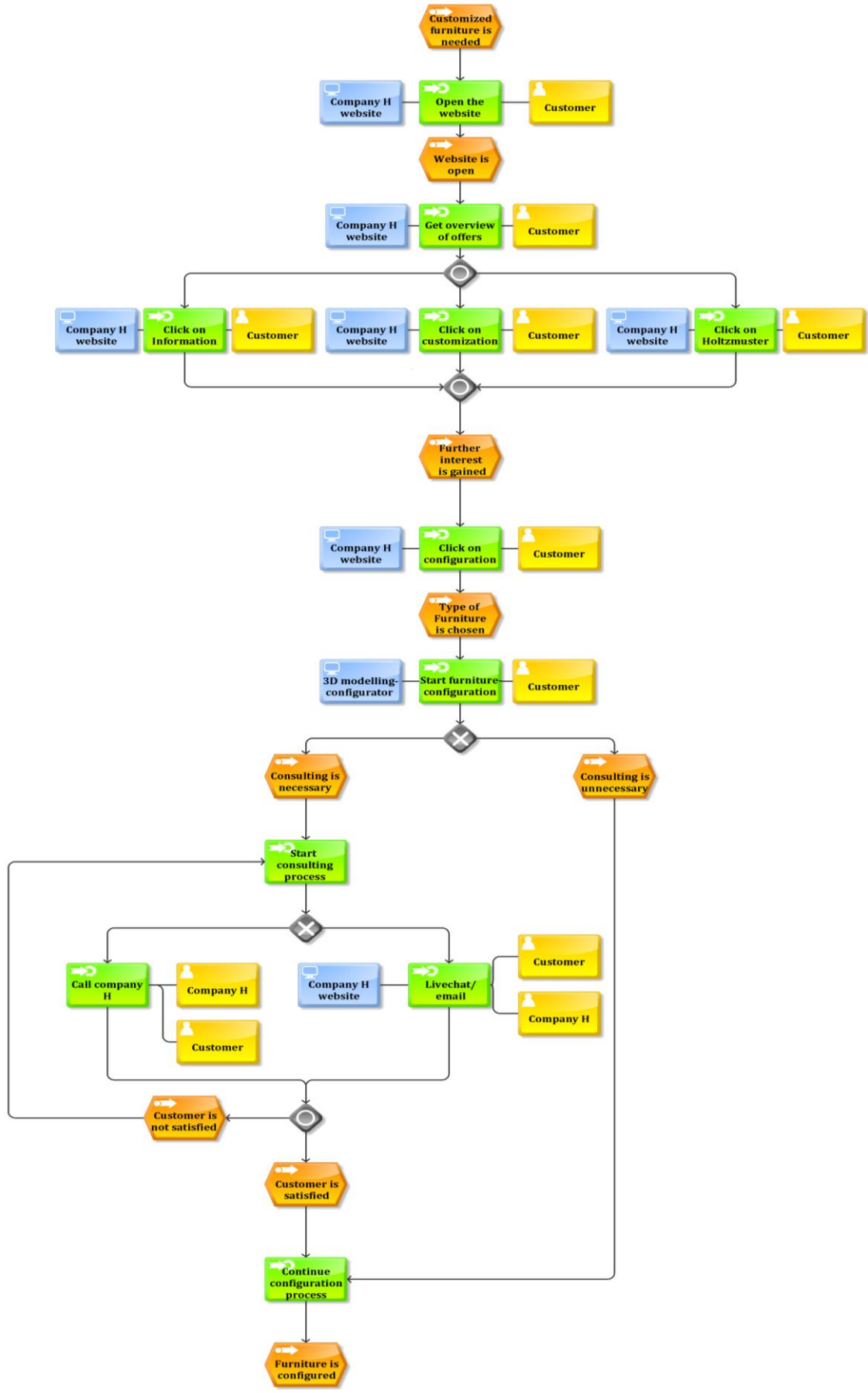
9.2. Results of phase level analysis presented by Aris Express Software

The five business process models are generated as follows:

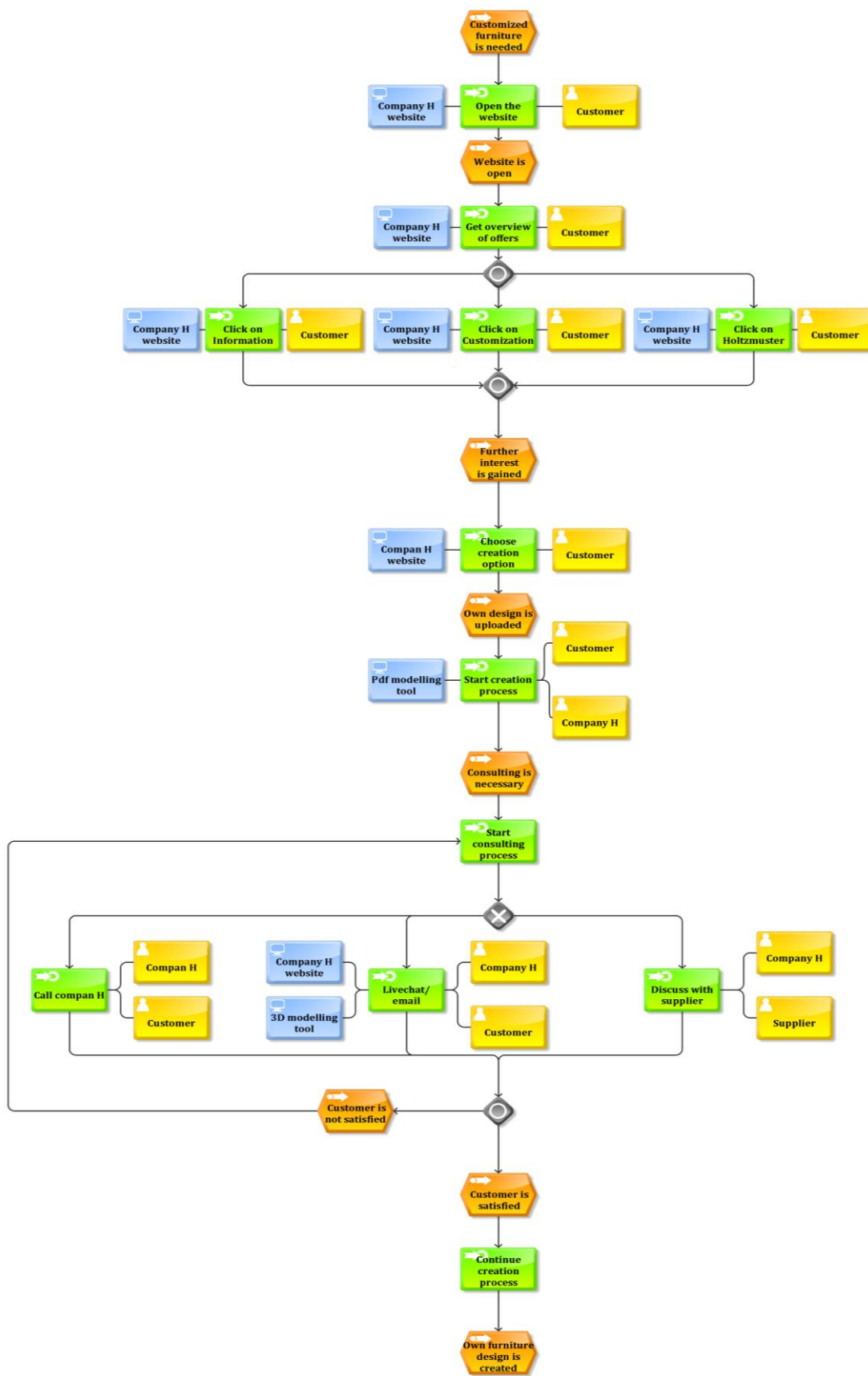
1) Idea generation



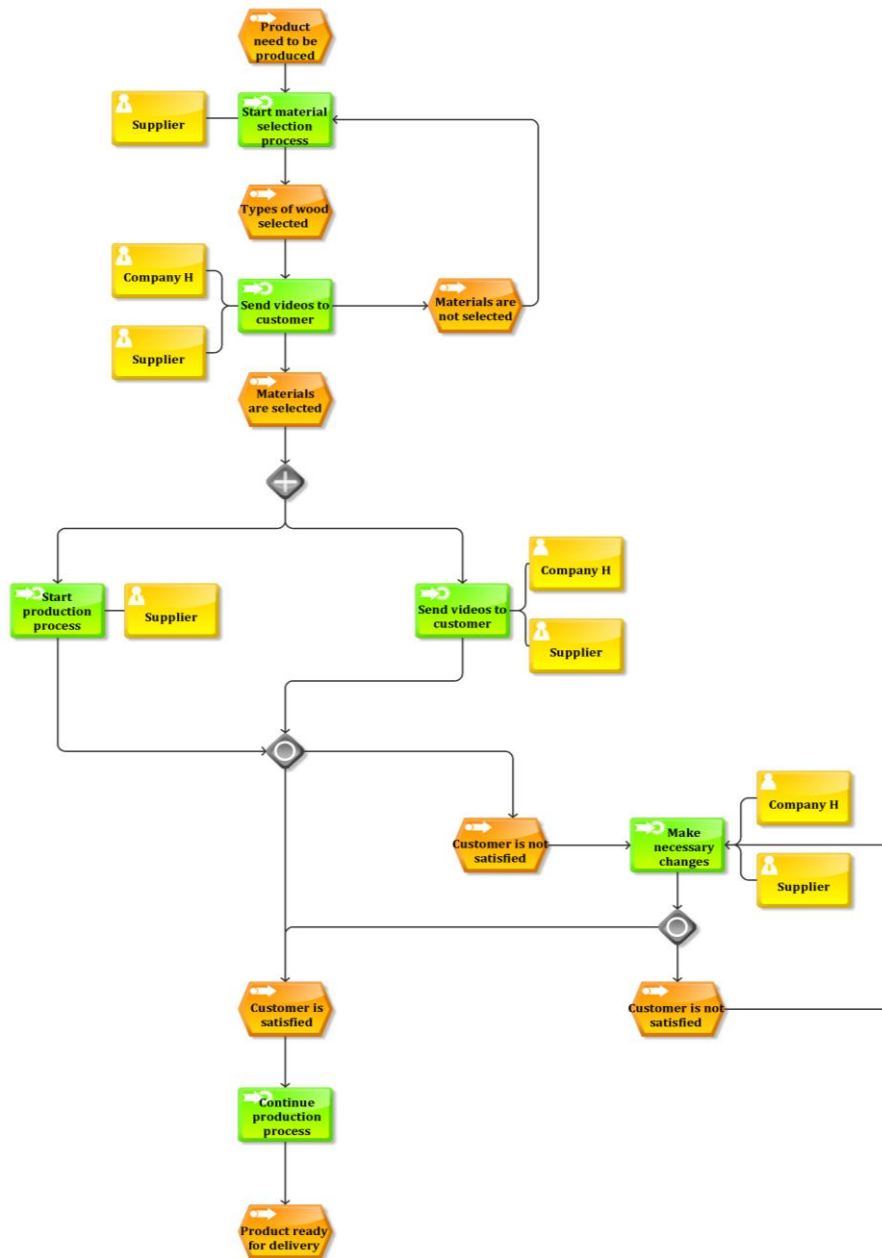
2a) Development/Design/Test/Prototyping_a (customization by configuration)



2b) Development/Design/Test/Prototyping_b (customization by creation)



3) Realization/Production/Provision



4) Application/Utilization/Implementation

