THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

ON THE USE OF PLATFORMS FOR PRODUCT–SERVICE SOLUTIONS

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Abstract

The purpose of this thesis is to identify and describe factors influencing the use of platforms for product–service solutions. Briefly put, product–service solutions are combinations of products and services integrated and customised to address customers' overall needs. However, because customisation can be costly and time-consuming, following a platform approach can enable companies to meet customers' individual needs while taking advantage of economies of scale and scope effects at the same time. Compiling five papers, this thesis proposes factors that are influencing the applicability and development of such a platform approach.

Drawing from research on product–service solutions and on platform and modular approaches, the thesis seeks to answer three research questions addressing: (1) arguments in favour of using platforms for product–service solutions, (2) how a platform approach influences key aspects of the solutions development, and (3) how a platform approach influences key aspects of the organisational structure. To answer those questions, the research for the thesis adopted a case-study approach. Following a pre-study on Alpha and Beta—an access solutions provider and a healthcare ICT solutions provider, respectively—the lion's share of data concerns the firm Gamma, operating in the transportation industry. Within the scope of that company, two solutions development projects—the ECOS and COBO projects—were also studied in-depth.

A platform for product–service solutions differs from product and service platforms. As revealed in the case studies, the use of platforms for product–service solutions is influenced by the objectives of the solution business, the solution and organisational architecture, as well as variation in customers' needs. Further, the thesis outlines three development-focused efforts undertaken in providing product–service solutions based on a platform approach: (1) developing and utilising standardised assets (i.e. a platform), (2) the customising efforts concerned with the configuration of solutions, and (3) personalising activities referring to adaption of the delivery of solutions. Leveraging knowledge about usage and technology as shared assets, the thesis identifies two approaches to developing a platform: establishing the platform first or taking a point of departure within an individual solution.

Despite arguments in favour of using a platform approach for product–service solutions, implementing such an approach presents obstacles. Challenges are likely to arise in an organisation if there is a misalignment of the solution architecture and the organisational architecture. After all, a solution architecture encompasses products and services that are inseparable from the development phase forward. However, if products and services are separated organisationally, then the organisational architecture direct product and service development into different structures, causing major challenges in managing the integration needed to provide a seamless solution.

Keywords: product–service solutions, servitization, solutions development, platforms, customisation, architecture

List of appended papers

***Paper 1*:** Jagstedt, S., & Persson, M. (2018). Describing different integrated solutions. *International Journal of Technology Management*, *78*(4), 343–361.

Authors' contributions: Jagstedt initiated the paper, collected and analysed the data, whereas Persson contributed support and guidance throughout the process, as well as improved the structure and readability of the paper.

***Paper 2*:** Jagstedt, S., Hedvall, K., & Persson, M. (2018). The virtue of customising solutions: A managerial framework. In M. Kohtamäki, T. Baines, R. Rabetino, & A. Bigdeli (2018), *Practices and tools for servitization* (pp. 291–308). Cham, Switzerland: Palgrave Macmillan.

Authors' contributions: Jagstedt and Hedvall initiated the book chapter and developed the first draft of the managerial framework, after which all authors jointly developed the framework and wrote the chapter. Jagstedt took a lead role in preparing the final version of the manuscript.

***Paper 3*:** Jagstedt, S., & Persson, M. (2019). Using platform strategies in the development of integrated product–service solutions. *International Journal of Innovation Management*, *23*(4), 1950034.

Authors' contributions: Jagstedt and Persson jointly designed and developed the concept for the paper, although Jagstedt collected and analysed the data as well as assumed a more prominent role in writing the paper.

***Paper 4*:** Jagstedt, S. (2019). Managerial attention alteration in product–service development. *International Journal of Technology Management*, *80*(1/2), 36–60.

Authors' contributions: Jagstedt is the single author of the paper.

Paper 5: Hedvall, K., Jagstedt, S., & Dubois, A. (2019), Solutions in business networks: Implications of an interorganizational perspective. *Journal of Business Research*, *104*, 411–421.

Authors' contributions: Written jointly by Hedvall, Jagstedt and Dubois, the paper is based on empirical data collected by Hedvall and Jagstedt in separate research projects. Jagstedt and Hedvall took the lead in developing the theoretical framework, and writing about the method and the analysis, whereas Dubois deepened the theoretical anchoring and significantly improved the logical argumentation throughout the paper. Hedvall played a more prominent role in preparing the final version of the manuscript for publication.

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1 Introduction

This thesis concerns the use of platforms for product–service solutions. As traditionally product-oriented companies increasingly engage in providing services, products and services already integrated in the development phase can ultimately be provided to customers as seamlessly integrated solutions (Park, Geum, & Lee, 2012; Wise & Baumgartner, 1999). Such solutions are highly customised (Johansson, Krishnamurthy, & Schlissberg, 2003; Park et al., 2012; Sawhney, 2006) as they need to be adapted to suit customers' operations. However, efforts involved in customisation can be costly for companies that provide solutions, and given both financial and practical constraints, there is a need to keep costs and complexity at reasonable levels.

To that end, platform and modular approaches have been proposed that allow the provision of a variety of differentiated, customised products at reasonable costs (Robertson & Ulrich, 1998; Sanchez & Mahoney, 1996; Sawhney, 1998), achieved via the standardisation of certain parts. Combining standardisation and customisation, however, is far from straightforward, and companies typically struggle in such efforts. To date, research on the topic has mostly provided guidance about development of products, albeit with limited attention to services, especially so when provided in product-dominated companies (Brax, Bask, Hsuan, & Voss, 2017). This thesis contributes to the existing body of knowledge by focusing on product–service solutions and the use of platforms to provide them.

This first chapter presents the background of the thesis, beginning with a brief introduction to the notion of product–service solutions. A problem discussion follows, focused on the challenging task of achieving flexibility to customers' needs at a limited cost. That discussion concludes with the formulation of the thesis's purpose. Lastly, a chapter-by-chapter outline of the thesis's contents is presented.

1.1 Background

Companies are 'increasingly offer fuller market packages or "bundles" of customer-focussed combinations of goods, services, support, self-service and knowledge' (Vandermerwe & Rada, 1988, p. 314), ultimately leading to the provision of product–service solutions. The rationales of this trend, referred to as *servitization*, have been explained by Wise and Baumgartner (1999) with reference to examples in for instance the automotive industry, in which only 20% of potential

revenues from each car come from its initial sale. Companies such as those in the automotive industry are therefore advised to move beyond mere product offerings by including or integrating services in their offerings, thereby capturing some of the remaining revenues over a product's life cycle (Wise & Baumgartner, 1999). Well-known, pioneering examples of such efforts include Rolls-Royce's 'Power-by-the-Hour' concept,[1] as well as Xerox's document management solutions.[2] As those companies have combined their products with services in order to provide more comprehensive solutions, they have had to shift the activities that they perform and, in turn, change how they provide value and how they operate (Vandermerwe & Rada, 1988).

Integrating services with offerings in product-dominated contexts—for example, in a manufacturing company—is a highly challenging task (Brax, 2005; Martinez, Bastl, Kingston, & Evans, 2010). Indeed, many companies fail to gain the advantages that they have sought and end up succumbing to service paradoxes, if not bankruptcy (Benedettini, Neely, & Swink, 2015; Brax, 2005; Gebauer, Fleisch, & Friedli, 2005; Martinez et al., 2010). A service paradox occurs when companies invest heavily in their service business but do not achieve the higher returns that they expected (Gebauer et al., 2005). As a consequence, the companies fail to exploit the financial potential of their offerings, because their costs exceed their revenues. Thus, although providing such offerings can be highly lucrative, the 'most significant challenge facing both researchers and practitioners of servitization is how to efficiently and effectively transform a manufacturing organization to exploit this opportunity' (Baines et al., 2017, p. 270). To create revenue spillover between products and services, adopting an integrated product–service business model has been advised (Visnjic Kastalli & Van Looy, 2013). Such an undertaking, however, comes with the need to keep the costs of customisation reasonable given the revenues from the solutions. Managing that dilemma is the point of departure in this thesis.

Matthyssens and Vandenbempt (2010) have stated that though companies follow different trajectories in servitization, they all converge in a general movement towards higher degrees of customisation. Research on solutions, with solutions being regarded as the ultimate stage in that trend, has stressed the need to provide solutions that are adapted to accommodate customers' unique processes and meet their unique needs. After all, because solutions, by definition, are

[1] For an example, see Baines and Lightfoot (2014), who provide a description of servitization in the aircraft industry.
[2] For an overview of Xerox and the photocopier industry, see Visintin (2014).

tailored and adapted to specific needs of customers, customisation ranks among the most central characteristics of solutions (Nordin & Kowalkowski, 2010). However, even while acknowledging that need, Kowalkowski, Windahl, Kindström, and Gebauer (2015) have added that companies should consider standardising their solutions in order to become able to serve a larger customer base and, in turn, achieve economies of scale. Likewise, Davies and Brady (2000) have emphasised the need to create opportunities for economies of repetition by creating repeatable solutions. That push towards standardisation, however, is not without challenges, a variety of which have been reported (Kowalkowski et al., 2015; Matthyssens & Vandenbempt, 2010; Shankar, Berry, & Dotzel, 2009).

1.2 Problem discussion and purpose

To increase profitability, companies should make investments in developing services that can benefit from economies of scale (Visnjic Kastalli & Van Looy, 2013). Even though solutions are described as being 'unusually tailored' (Miller, Hope, Eisenstat, Foote, & Galbraith, 2002) or as 'unique combinations' (Storbacka, 2011), achieving both effectiveness (i.e. developing the right solution for the individual customer) and efficiency (i.e. producing the solution fast at a reasonable cost) is necessary (Ulaga & Reinartz, 2011). Put differently, it is necessary to develop solutions that are customised to fit customers' requirements while enabling economies of scale.

To manage increased demand for the variety and customisation of products, modular and platform strategies have long been used (e.g. Baldwin & Clark, 1997; Meyer & Lehnerd, 1997). Although platform and modular approaches exhibit many similarities, they have also been shown to differ in certain aspects. Whereas modularity primarily focuses on economies of substitution as a means to enable variety, the emphasis of platforms is creating economies of scale and scope (Magnusson & Pasche, 2014). Following the notion that servitizing companies have to translate their service investments into economies of scale in order to be profitable in the long run (Visnjic Kastalli & Van Looy, 2013), the platform approach appears to be a promising avenue for reducing costs.

Despite extensive research on applying platforms for physical products, the 'majority of platform scholars study the commonality potential in its traditional setting, which is product management' (Hofman & Meijerink, 2015, p. 116).[3] Research on platforms and modularity has only recently

[3] *Commonality* refers to the clustering of components and/or functions based on similarities (Pirmoradi, Wang, & Simpson, 2014) to utilize a common foundation—that is, a platform.

begun to address the context of services, as demonstrated in Frandsen's (2017) overview, and most current studies continue to focus on products and services separated. As a result, scholars interested in the topic have largely overlooked cases in which products and services are integrated and provided as solutions. Except for a few recent publications on using modularity for solutions—for instance, Rajala, Brax, Virtanen, and Salonen's (2019) work on Kone, along with Gremyr, Valtakoski, and Witell's (2019) work on a manufacturer of mechanical components—research on using such strategies for services and solutions in product-dominated contexts has remained rare (Brax et al., 2017). On top of that, the use of platforms in relation to solutions has largely been disregarded.

To provide insights into capturing the potential benefits of product–service solutions, this thesis seeks to shed light on using platforms for solutions developed in product-dominated contexts. In so doing, it follows calls for research on the use of a platform approach in servitizing companies (Brax et al., 2017). In employing such an approach, products and services differ in several important aspects, especially related to the role of personnel and the processual nature of services (e.g. Bask, Lipponen, Rajahonka, & Tinnilä, 2010; Iman, 2016; Voss & Hsuan, 2009). However, it remains necessary to identify and understand aspects of platforms specific to product–service solutions in which products and services are integrated and not treated as separated offerings. Accordingly, the purpose of this thesis is to identify and describe factors influencing the use of platforms for product–service solutions.

In this thesis, the term *product–service solution* refers to an offering in which products and services are integrated to facilitate a surplus value in relation to the customers' operations (e.g. Brax & Jonsson, 2009; Davies, 2004). A solution is thus considered to be highly dependent upon products as well as concerned with value-in-use. Following that line of thinking, the thesis focuses on solutions in which products and services have been integrated since the design and development phases and, as such, assumes the inseparability of products from services (Park et al., 2012) such that customers perceive whole, seamless solutions (Wise & Baumgartner, 1999). Such solutions comprise products and services that are highly integrated and offer exceptional high degrees of customisability (Johansson et al., 2003; Park et al., 2012; Sawhney, 2006).

Platforms are considered to create opportunities to 'provide customized products or services through flexible processes in high volumes and at reasonably low costs' (da Silveira, Borenstein,

& Fogliatto, 2001, p. 1) and can be broadly defined as a ‘collection of assets that are shared by a set of products’ (Robertson & Ulrich, 1998, p. 20). In that light, platforms seek to exploit and capitalise upon commonalities among offerings, thereby enabling the development of a variety of products at a limited cost (Sawhney, 1998). Such commonalities may be used in different stages of a product’s life cycle (Halman, Hofer, & Van Vuuren, 2003; Sawhney, 1998) to utilise assets such as components, processes, knowledge, and people and relationships (Robertson & Ulrich, 1998).

The influential factors identified and described in this thesis refer to circumstances that, in one way or another, contribute to the applicability or use of platforms for product–service solutions. Such factors could thus be concerned with the arguments in favour of a platform approach and its development, but also aspects of the organisational structure, given its relationship with the structure of the corresponding offering (Leo, 2020; Sanchez & Mahoney, 1996).

1.3 Outline of the thesis

As a compilation, this thesis comprises five appended papers (i.e. four journal articles and one book chapter) and a cover. In this cover, Chapter 1 introduces the background of the thesis and presents the purpose of the thesis. In Chapter 2, literature on the various topics of thesis is reviewed, with a particular focus on product–service solutions as well as platform and modular approaches. The chapter concludes with development of the research questions. Chapter 3 presents the methodology adopted in the research, along with the research design and the empirical studies conducted for the thesis. The chapter also accounts for the collection and analysis of the data and presents reflections on the research quality. Chapter 4 provides brief summaries of the appended papers, after which Chapter 5 discusses the research questions based on insights gained from the studies. Last, Chapter 6 summarises the major conclusions of the research, outlines the contributions of the thesis, and advances some suggestions for future research.

2 Exposition of literature

This thesis addresses the use of platforms for product–service solutions—that is, offerings that integrate products and services to provide value beyond what the components can provide separately. Supported by the concept of modularity, platforms are often used to manage to provide offerings with high levels of variety while keeping costs at a reasonable level. As shown in Figure 1, this thesis is thus positioned in the intersection of literature on product–service solutions and platforms and modular approaches, particularly in the context of traditionally product-oriented companies that increasingly engage in providing services and solutions.

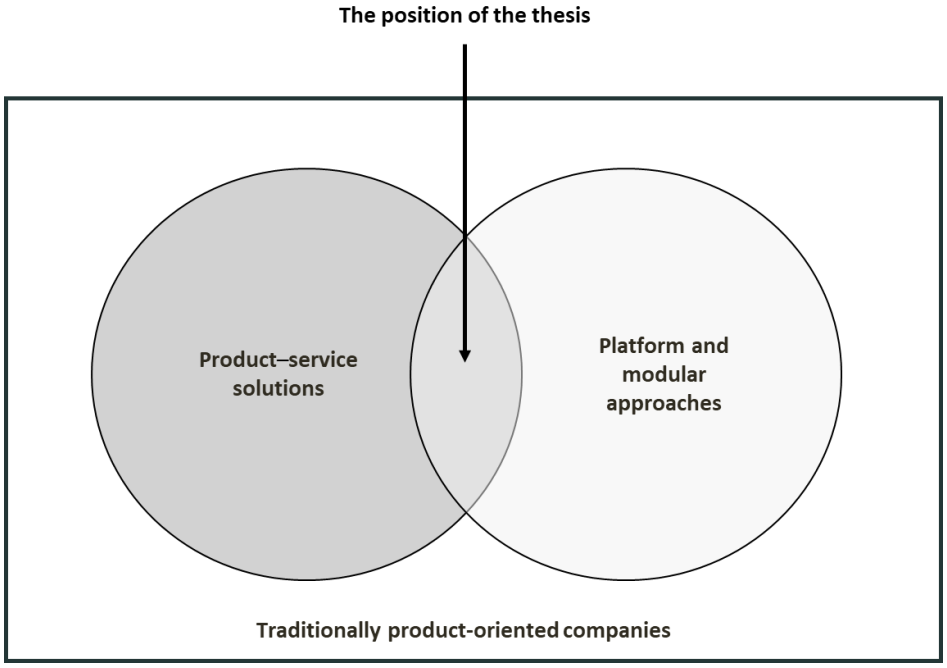

Figure 1: Position of the thesis

Reflecting that position, this chapter first considers the underpinnings of product–service solutions, especially the notions of products and services, and their relationships with each other. After that, three understandings of product–service solutions—as integrated product–services, as knowledge bundles, and as processes—are taken into account. Next, two sections of the chapter discuss platforms and modular approaches, starting with accounting for standardisation and customisation. Thereafter, two primary strategies for managing to combine standardisation and customisation are introduced—that is, using modularisation and using platforms. A comparison of platforms and modularisation, as well as their use for product and service offerings respectively, conclude the

section. Using modularisation and platform approaches, along with a solutions strategy, are linked to a corresponding organisational structure in which operational work is performed. To support that understanding, literature on organisational structures for services and solutions is also reviewed, especially with reference to the relationship between product design and organisational structure as proposed in the mirroring hypothesis (e.g. Colfer & Baldwin, 2016; MacCormack, Baldwin, & Rusnak, 2012; Sanchez & Mahoney, 1996). The chapter concludes by revisiting the research problem and, in light of the literature reviewed, developing three research questions.

2.1 Products and services

Product–service solutions encompass elements of both products and services, all of which can vary in nature. Over time have several attempts to describe services, often in relation to products, been made. These differing perspectives continue to influence also how product–service solutions are understood. For that reason, this section first reviews how the notion of a service has evolved. After that, the relationships between products and services in a product-oriented context—namely, a manufacturing company—are taken into account. In sum, the section shows that, eventually in servitization, companies will provide highly integrated, highly customised product–service solutions, which are the kind of offerings focused on in this thesis.

2.1.1 The notion of service

The term *service* has long been used to describe an offering that is intangible and whose consumption and production cannot be separated (e.g. Zeithaml, Parasuraman, & Berry, 1985). However, over time, service have been reinterpreted not as offerings but as a perspective. Although the concept of service was largely ignored by researchers and practitioners in the 1970s, Levitt (1972) observed that every organisation was providing service, nevertheless. More than 30 years later, that same understanding was echoed by Vargo and Lusch (2014), who posited that a service-dominant logic ‘of course, implies that all firms are service firms’ (p. 47). That perspective, as the most widely applied theoretical lens in research on servitization (Rabetino, Harmsen, Kohtamäki, & Sihvonen, 2018), has no doubt influenced literature on the topic (Martín-Peña, Pinillos, & Reyes, 2017). Figure 2 illustrates the evolution of perspectives on services in the literature taken into account in this chapter.

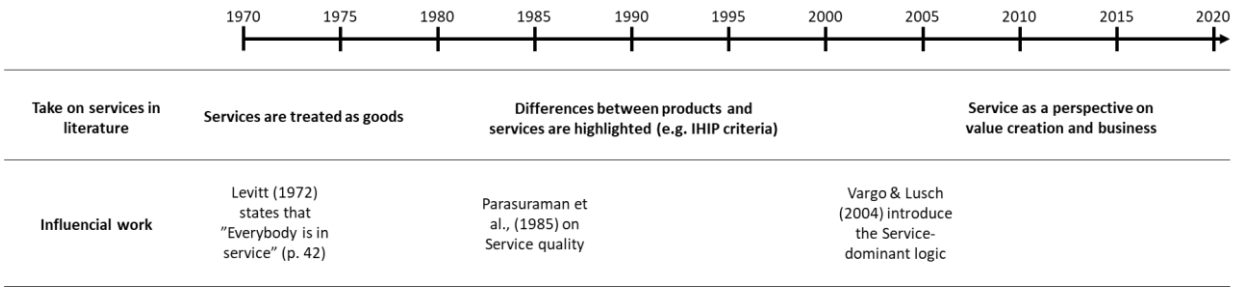

Figure 2: Evolution of perspectives on services

The term *service* has been described in terms of intangibility, heterogeneity, inseparability, and perishability, conveniently encapsulated as 'IHIP', as demonstrated in Zeithaml et al.'s (1985) compilation of literature on services. Following that, services have often been described as immaterial (i.e. intangible) and dependent on the customer–supplier relationships, which complicates their standardisation (i.e. heterogeneity). At the same time, because offering services typically requires the stages of production and consumption to occur simultaneously (i.e. inseparability), services are impossible to store (i.e. perishable). Although the four IHIP characteristics clearly impacted early work on services, they have since been called into question (Lovelock & Gummesson, 2004). Such criticism has often made reference to how the criterion are focused on distinguishing services from products, in which the product is perceived as the standard and the services are described as a deviation, which in turn has largely worked to polarise the two sorts of offerings. Beyond that, the IHIP characteristics might not accommodate all service encounters, because 'the infusion of technology is dramatically changing their nature' (Bitner, Brown, & Meuter, 2000, p. 138). Indeed, in some technology-based services, consumer–technology interface allows customers to serve themselves (Bitner et al., 2000; Dabholkar, 1996; Meuter, Ostrom, Roundtree, & Bitner, 2000), and in those increasingly personnel-free operations enabled by technology, the applicability of the IHIP characteristics can been contested. By extension, if customers can customise the services that they use, then possibilities for standardising such services increase. In that case, it may even become possible to separate the development of the preconditions of services and their consumption.

A more recent view on services, however, stresses their processual nature (Grönroos, 2006), following the longstanding idea that the service notion is best approached from the perspective of customers (Edvardsson & Olsson, 1996). In turn, the need to adopt a view on service that highlights

those aspects has been widely discussed, especially in marketing. Such a viewpoint would assign products a secondary role, with reference to the idea that 'service is the fundamental basis of exchange' (Vargo & Lusch, 2008, p. 7). The difference in perspectives also implies a shift in focus from goods to interactions and processes and is usually referred to as *service logic* or *service-dominant logic*.

By contrast, the traditional approach to service provision, considered to be goods-centric and focused on exchange, is understood to follow a goods logic (Grönroos, 2006; Vargo & Lusch, 2004). According to such goods logic, because of the focus on exchange, a company merely make its resources available to customers so that they may manage their processes themselves (Grönroos, 2006), i.e. providing them with a product. On the contrary, service logic emphasises that value is created within those very processes, the customers' processes, which amounts to a putatively new paradigm accompanied by a new perspective on value creation. Although the shift from focusing on services as invisible products to a perspective focusing on value poses major implications for marketers, it can also pose ramifications for how new offerings that focus on customers are developed. From that perspective on services, the notion of value-in-use plays an especially vital role, as the value creation is referring to the customers' creation of value-in-use (Grönroos & Voima, 2013). The notion of value-in-use thus positions the customer as the creator of value, while the company contributes only to facilitating its creation (Grönroos, 2006, 2008).

To facilitate this value creation through services, Vargo and Lusch (2004) have defined *services* as 'the application of specialized competences through deeds, processes, and performances for the benefit of another entity or the entity itself' (p. 2). Somewhat similarly, Grönroos (2006) has defined *services* as 'processes that consist of a set of activities which take place in interactions between a customer and people, goods, and other physical resources, systems and/or infrastructures representing the service provider and possibly involving other customers, which aim at solving customers' problems' (p. 323). In adopting a service-oriented perspective on value creation, this thesis conceptualises services as processes that involve applying knowledge and competences in order to promote value-in-use for customers. That understanding should not be interpreted to obscure the importance of products, however, because knowledge may indeed be associated with products. In that light, products and knowledge about them continue to constitute important resources for manufacturing companies.

2.1.2 The product–service relationship

Servitization, being the trend of adding and integrating services into product-based offerings, has commonly been conceived with reference to a theoretical polarisation of products and services (Luoto, Brax, & Kohtamäki, 2017). Therein, the value of services increases as a company matures in its service orientation. Such polarisation partly originates from the perspective that goods are 'tangible economic products that are capable of being seen and touched and may or may not be tasted, heard, or smelled. But "services" seem to be everything else' (Rathmell, 1966, p. 32). According to definitions of *product* and *service* developed by the International Organization of Standards (ISO, 2015), namely in ISO 9000:2015, products can indeed be distinguished from services in terms of production. That is, a product can be produced without any transaction between the provider and the customer. By contrast, a service requires activity between both parties. Moreover, as the standard maintains, the 'dominant element of a product is that it is generally tangible' (ISO, 2015, § 3.7.6), which further aligns products with the notion of goods. Taken altogether, even though products are not goods per se, goods are indeed a subset of products.

Companies engaging in servitization can provide an array of services that depend upon core products to widely varying degrees. To describe those services, a range of classification systems have been proposed, a few of which are presented in Table 1. Developed by Mathieu (2001), one of the most commonly used systems contrasts services supporting products (i.e. product-oriented services) with services supporting the customer (i.e. customer-oriented services). Beyond that, the type of services provided is contingent on the maturity of the industry (Cusumano, Kahl, & Suarez, 2015). On that topic, Visnjic, Ringov, and Arts (2019) have recently shown that companies operating under conditions of high technological uncertainty, on the one hand, tend to provide product-oriented services. On the other hand, under conditions of high value generation uncertainty (e.g. in highly cyclical industries in late stages of the industrial life cycle), companies tend to offer more customer-oriented services (Visnjic et al., 2019). However, even if that distinction might apply at a general level, companies are liable to provide a range of different services.

Table 1: Different kinds of services in relation to the commonly used classification of Mathieu (2001)

Mathieu (2001)	Services supporting products		Services supporting the customer	
Oliva and Kallenberg (2003)	Product-oriented services: basic installed base services and maintenance services		End user's process-oriented services: professional services and operational services	
Tukker (2004)	Product-oriented services		Use-oriented services	Result-oriented services
Ulaga and Reinartz (2011)	Services oriented towards supplier goods: product life-cycle services and asset efficiency services		Services oriented towards customers' processes: process support services and process delegation services	
Baines and Lightfoot (2013)	Base services (i.e. focused on provision of products)	Intermediate services (i.e. focused on maintenance of condition)	Advanced services (i.e. focused on performance)	
Saccani, Visintin, and Rapaccini (2014)	Product support services		Customer support services	Product-related services

Given the relationship between services and core products, the provision of services depends upon the complexity of products and their degree of customisation. According to Dachs et al. (2014), the best outcomes of servitization occur when products are complex, highly customised, and, in turn, produced in smaller batches or as single units (Lay, Copani, Jäger, & Biege, 2010). Accordingly, manufacturers making complex products (e.g. construction equipment) servitize partly due to economic motivations—for instance, to stabilise revenues and boost profitability (Raddats, Baines, Burton, Story, & Zolkiewski, 2016).

Even so, Neely (2008) has observed that, despite significant investment in the service business, manufacturers who transition into services generate less profit, in what has been characterised as a service paradox (Gebauer et al., 2005). Briefly put, the service paradox implies that for companies to be profitable, they need to limit costs associated with their new offerings, which can be done by for instance through increasing standardisation and thereby creating effects of economies of scale (Kowalkowski et al., 2015). On that topic, Sousa and da Silveira (2019) have posited that manufacturers with a product customisation strategy are aptly positioned to servitize. Hence, for companies in mature industries that provide complex products that aim to increase profitability by

providing services, a product customisation strategy in place is the first step. After that, in considering the adoption of an integrated product–service business model that can create revenue spillover between core products and services (Visnjic Kastelli & Van Looy, 2013), it is necessary to also consider how to deal with the customisation of the overall offerings in which products and services are integrated. This thesis, in reference to product–service solutions, addresses those kinds of integrated offerings, which will be accounted for in the following section.

2.2 Perspectives on product–service solutions

Solutions are most commonly understood as integrated combinations of products and services. However, when companies transition to providing solutions, they have to change how they operate and how they provide value to customers (Vandermerwe & Rada, 1988). Such transformations require companies to expand their knowledge base as they engage in activities altogether new to them in relation to providing products. To shed light on those different necessities in providing solutions, this section approaches product–service solutions from three perspectives: as integrated product–services, as knowledge bundles, and as processes.

2.2.1 Solutions as integrated product–services

Acknowledging the variety of terms used in different communities to describe integrated offerings (e.g. Lightfoot, Baines, & Smart, 2013; Raddats, Kowalkowski, Benedettini, Burton, & Gebauer, 2019), Park et al. (2012) have proposed the umbrella term *integrated product–service* to encompass all concepts referring to the integration of products and services. In this thesis, by some contrast, the term *product–service solutions* is used to describe offerings in which products and services are seamlessly integrated (e.g. Wise & Baumgartner, 1999). *Product–service solutions* also captures the meaning of similar terms, such as *hybrid solutions* (e.g. Shankar et al., 2009), *hybrid offerings* (e.g. Ulaga & Reinartz, 2011), *full services* (e.g. Stremersch, Wuyts, & Frambach, 2001), *customer solutions* (e.g. Tuli, Kohli, & Bharadwaj, 2007), *product–service systems* (e.g. Mont, 2002), and *solution offerings* (e.g. Nordin & Kowalkowski, 2010). In this thesis, product–service solutions are conceived as being not only mobilised to facilitate value-in-use but also thoroughly connected to the products.

Most commonly, a *solution* is defined as a combination, or a bundle, of products and services (Nordin & Kowalkowski, 2010). Wise and Baumgartner (1999) have described integrated solutions, by extension, as representing business models that ‘combine products and services into

a seamless offering that addresses a pressing customer need' (p. 138). Brax and Jonsson (2009), by comparison, have argued that such a solution is 'seamlessly combined to provide more value than the parts alone' (p. 541). That understanding is similar to Sawhney's (2006), which maintains that a *solution* is 'an integrated combination of products and services customized for a set of customers that allows customers to achieve better outcomes than the sum of the individual components of the solution' (p. 369). Such additional value achieved by integrating products and services can be referred to as a *surplus value*, which forms an important part of solutions. Briefly put, *surplus value* means that profitability should increase for both customers and providers above and beyond profitability that is possible when products and services remain separate. From the perspective of customers, such value also relates to *value-in-use* referring to the usefulness of the solution in the operations of customers as they create value for themselves (Grönroos, 2008, 2011). The value-in-use should thereby extend the value that can be obtained by purchasing a product and a service individually. From a company's perspective, on the other hand, surplus value ultimately boils down to the value gained from the offerings in terms of profit in the longer run, which should be higher for product–service solutions than for the products and services sold separately. In short, from that viewpoint, companies should either increase their profits directly through providing the solutions or it should provide the means to increase their insights into promoting their future profitability. Proceeding from a classical perspective on value emphasising the role of labour,[4] that viewpoint suggests that revenues from solutions need to exceed the effort and time put into their development. The revenues, in turn, depend on the customer's value-in-use, which determines his or her willingness to pay. Aside from purely monetary aspects, the revenues could also be concerned with, for instance, improved company–customer relationships that enable future revenue streams.

Miller et al. (2002) have proposed two major approaches to enabling surplus value that the most sophisticated solutions have reportedly adopted in one combination or another. The first approach is taking control over some parts of operations from customers—that is, value chain integration (Miller et al., 2002). Value chain integration is concerned with shifts in the activities performed by the different actors in a value chain. If manufacturers starting to provide solutions need to absorb and utilise capabilities that are new to them, which can be costly, then their investments in the

[4] See Adam Smith's *The Wealth of Nations* (first published in 1776) describing labour as the source of value, noting the two-sided nature of the term value, being about value-in-use on the one hand, and value-in-exchange on the other (Book 1, Chapter 4). Accordingly, the value gained from solutions needs to exceed the labour the customers otherwise would have needed to invest themselves, as well as the labour invested by the provider.

services provided by their business can lead to a decline in profits if the revenues do not increase at the same pace (Gebauer et al., 2005).

The second approach involves seamlessly integrating products and services in order to create especially valuable, customised offerings (Miller et al., 2002). Taking that approach typically requires achieving outcomes for customers that they cannot achieve on their own. At the same time, managing the integration of products and services in that approach involves bridging gaps between capabilities associated with either products or services. Therefore, its management requires extensive competence in integration (Shepherd & Ahmed, 2000) as various activities, previously performed in isolation, now need to be integrated. That requirement can elevate the costs of coordination above the costs of providing products only and indeed stands as a source of increased costs associated with providing solutions.

Products and services can also be integrated in different phases of the provision process, with or without the use of technology (Park et al., 2012). In the reasoning of service logic, service development is a task for the entire organisation, because an intensified customer-orientation is needed throughout the process of developing the offering. Accordingly, the research presented in this thesis is focused on solutions encompassing products and services that has been integrated already in the design and development phases. Such integration is referred to *engineering-oriented integration* (Park et al., 2012) or *technical integration* (Johansson et al., 2003), both of which denote the use of technology in the integration efforts. Such integration is based on the assumption that, from a customer's perspective, products and services are inseparable from each other (Park et al., 2012), which implies that their integration goes beyond the mere bundling of services and products (Nordin & Kowalkowski, 2010). In such integration, technology can be used as a facilitator, mediator, or enabler of the integration in one way or another (Geum, Lee, Kang, & Park, 2011; Park et al., 2012). This relates to the notion of technology-based services, because incorporating technology in service provision is thought to enable customised offerings, effective service recovery, and to enable to spontaneously delight customers (Bitner et al., 2000). Following such thinking, this thesis focuses on product–service solutions whose products and services are joined via engineering-oriented integration, relying on technology.

Of course, that opposes solutions developed based on products already existing, which is often the case (Visintin, 2012). In those kinds of offerings, the integration of products and services occurs

after product development and is often performed by personnel who operate closer to the markets and customers (Visintin, 2012). In Park et al.'s (2012) terminology, this type of integration can be called 'marketing-oriented integration', which is distinguished from integration made during the development phase. Likewise, Sawhney (2006) and Johansson et al. (2003) have distinguished marketing integration from technical and operational integration. Integration of the latter type, as the focus in this thesis, is arguably associated with higher degrees of integration that can increase the complexity of the operations for a company (Martinez et al., 2010) and involve higher degrees of customisation (Park et al., 2012). Overall, the costs of developing such offerings, at least initially, are likely to be higher than those of providing pure products or less sophisticated services. The reasons for that difference are indeed the costs of integration, albeit also the costs of accessing and developing the new knowledge needed. To understand what knowledge is needed, viewing solutions as consisting of knowledge-related components could provide additional insights.

2.2.2 Solutions as knowledge bundles

Although solutions are most commonly described as offerings that combine products and services, other interpretations do exist. Solutions can for instance be viewed as bundles of knowledge components (Valtakoski, 2017), drawing on the knowledge-based view. This positions knowledge as the fundamental element of solutions. That viewpoint also stresses the need for specific knowledge and competencies in order to enable solution providers to facilitate desirable outcomes for customers. To create a surplus value for customers, for example, the value-in-use of the solutions should be higher than that of services and products provided separately. Hence, customers benefit from, and rely on, the knowledge of solution provider, engaging in long-term relationships with them (Galbraith, 2002; Oliva & Kallenberg, 2003). To succeed, this requires the knowledge of solution providers to extend customers' own competences. To obtain and develop such knowledge requires investments, both in time and resources, which needs to be set in proportion to the additional value that can be afforded to customers.

Indicating a goods-dominant perspective, literature on innovation has mostly concentrated on products, especially their exchange and effects on the providing company, instead of acknowledging customers' value-in-use (Michel, Brown, & Gallan, 2008). In service logic (Grönroos, 2006; Vargo & Lusch, 2004), by comparison, service innovation is thought to involve the creation of value propositions and their evaluation with reference to the experiences of customers (Michel et al., 2008; Skålén, Gummerus, von Koskull, & Magnusson, 2015). In such

thinking, developing product–service solutions thus ultimately becomes a task of managing knowledge about customers and their operations, and thereafter applying knowledge about the products and their potential applications to address these. Starting in the problems experienced by the customers rather than in the own products can be described to be in line with a solution-oriented mindset (Sawhney, 2006).

Owing to its problem-solving motivation, the development of solutions benefits from two types of knowledge: knowledge about the needs of users—that is, problems—and knowledge of the means needed to address the problem—that is, solutions (Magnusson, 2009; von Hippel, 1994). Knowledge about problems is associated, at a general level, with tacit knowledge[5] held by service personnel, among others (Valtakoski, 2017). Physical products and software, by contrast, are often related to explicit knowledge[6] components (Valtakoski, 2017), that comprise the solution of the problem-solving process. Because knowledge creation benefits from interaction between explicit and tacit knowledge (Nonaka, 1991, 1994), developing solutions should involve knowledge about both problems and responses to them, and their interplay.

Given the need for knowledge about users, the development of solutions requires understanding customers better than when providing products only. Thus, gaining in-depth insights into customers' processes is stressed when providing product–service solutions (Raja, Bourne, Goffin, Çakkol, & Martinez, 2013). This follows that the provision of solutions needs to include the integration of the solution into customers' processes and businesses (Brax & Jonsson, 2009; Windahl & Lakemond, 2006), which alters the scope of knowledge needed about customers. Whereas providing products requires insights into the use of those products, providing solutions requires overall knowledge about the operations of customers. However, acquiring such in-depth knowledge is not a straightforward process and can require major investments to be made. Beyond that, if focusing on one industry in solution provision in order to create economies of repetition (Davies, 2004), the magnitude of costs associated with developing such knowledge becomes associated with the variety of use—that is, the variety of customers' operations.

Furthermore, responding to problems requires extensive knowledge about the technology and products in operation, representing the solution part of development efforts (Magnusson, 2009; von

[5] Tacit knowledge is learned by application and concerns how to do something (Grant, 1996).
[6] Explicit knowledge can be communicated verbally, being exchanged through expressing it in words (Grant, 1996).

Hippel, 1994). Although such knowledge derives from a more established part of manufacturers' organisations, the challenge nevertheless becomes generating competences about coordinating and integrating various technologies and products in order to create more comprehensive solutions to the identified problems. Therefore, whereas the costs of an increased customer orientation may require high initial investments, the costs associated to this part of the development efforts are liable to be more strongly associated with integration.

An additional complication is that these kinds of knowledge—that is, knowledge about problem and knowledge about the solution—are maintained by different actors within a company or even within a broader network. In discussing sticky information and technical problem-solving,[7] von Hippel (1994) has argued that when information is held in different places, problem-solving becomes an iterative process performed among the various sites, because such a process is less costly than transferring all required knowledge to a single site. Even so, when the time- and effort-related costs of such iteration are high, the activities of the problem-solving process can be divided into sub-problems, that is, to task partitioning problem-solving activities. Also, to reduce the costs of iteration, investments can be made to make the information less sticky (von Hippel, 1994), and to decrease the costs of iteration can users be assigned to perform parts the problem-solving themselves as part of user-based customisation (von Hippel, 1994, 1998).

Overall, developing product–service solution requires the acquisition and management of knowledge about the problem, as well as knowledge about the potential solution thereto, including how own products can be used. Developing product–service solutions accordingly implies a need for interactions among actors with the required knowledge, which includes managing the problem-solving activities involved, as they ultimately are about the process in which value is enabled. Thus, a third perspective on solutions—one that considers solutions as processes—could shed additional light on product–service solutions through focusing on the solution providing process.

2.2.3 Solutions as processes

In light of the processual nature of services, viewing solutions as processes may afford new insights into provision thereof. When manufacturers begin providing solutions, they also begin undertaking activities and processes that are new to them, the set-up of which may be costly and time-

[7] Von Hippel (1994) has defined the 'stickiness of a given unit of information in a given instance as the incremental expenditure required to transfer that unit of information to a specified locus in a form usable by a given information seeker. When this cost is low, information stickiness is low; when it is high, stickiness is high' (p. 430).

consuming, as well as require the development and acquisition of new competences and resources. If providing solutions is considered to involve using knowledge to first understand the problems and thereafter form solutions, then the process or project can be divided into sub-processes, or tasks, in what is known as task partitioning (von Hippel, 1990). Task partitioning arguably differs from partitioning outcomes—that is, the solutions—because it concerns the work (von Hippel, 1990). Even so, boundaries between outcomes and work processes may be blurrier when developing services than when developing products, because the processual nature of services and the circumstance that their value is created in use (Grönroos, 2006) imply simultaneous consumption and production, the outcomes of which are closely aligned to the processes of providing them. Taking a processual view on solutions may thus clarify which activities the various actors—providers, customers, and collaborators—participate in, what knowledge is needed throughout the process, and how the process's costs can be managed.

Taking the perspective of customers, Tuli et al. (2007) have argued that customers view solutions as relational processes encompassing four major steps: *requirements definition*, *customisation and integration*, *deployment*, and *post-deployment support*. Töllner, Blut, and Holzmüller (2011) have expanded Tuli et al.'s (2007) model to also include *signalling activities* as a stage prior to the step of 'requirement definition'. On top of that, taking a company perspective, Storbacka (2011) has proposed four stages of providing solutions—developing solutions, creating demand, selling solutions, and delivering solutions—to be performed in both the commercialisation and industrialisation of solutions.

In light of Tuli et al.'s (2007) and Storbacka's (2011) different findings, solutions as processes can be expected to differ depending on the perspective taken. The process described by Tuli et al. (2007), on the one hand, does not include any phase of solutions development, which suggests that developing solutions comprises the overall process. Storbacka's (2011) model, on the other hand, despite stating that solutions are relational processes, shows clear similarities to traditional stepwise approaches used in developing products, which positions the development of solutions as occurring before the creation of demand for those solutions. In this thesis, following the notion of engineering-oriented integration, *development* is defined as involving the product and service design and development, as well as their integration. Furthermore, following the arguments of Tuli

et al. (2007) and Töllner et al. (2011), the process is considered to entail defining the requirements—that is, identifying the problem—before starting to develop solutions.

Although solutions can be described as more or less linear processes (Storbacka, 2011; Tuli et al., 2007; Töllner et al., 2011), a cyclical model of solutions has also been suggested by Aarikka-Stenroos and Jaakkola (2012), one in which the various sub-processes are highly dependent. Whereas the steps proposed by Storbacka (2011), Tuli et al. (2007), and Töllner et al. (2011) are characterised as being 'interconnected and iterative' (Storbacka, 2011, p. 700), Aarikka-Stenroos and Jaakkola (2012) have described their model as encompassing 'collaborative activities in joint problem solving' (p. 22)—diagnosing needs, designing and producing the solution, implementing the solution, managing value conflicts and organising process and resources. The cyclical model thus illustrates the dynamics of providing solutions, especially considering the development of highly customised, unique ones. In the more linear models are however the interdependence of sub-processes also acknowledged. Töllner et al. (2011), for instance, have stressed the importance of inter-process management in four sub-processes: coordination, time management, incorporation, and proactive support. The need for coordination and collaboration is also supported by Storbacka (2011), who has referred to integrated solutions as 'longitudinal relational processes' (p. 699). Likewise, Windahl and Lakemond (2006) have highlighted the role of dependencies among actors in the network in the provision of solutions, pointing to the importance of relational aspects.

When solutions development rests upon relational processes, knowledge about users and problems (following Magnusson, 2009 and von Hippel, 1994) is developed somewhat simultaneously. In turn, despite the decomposition of the process into sub-processes, demands for solving problems together are high, both internally and externally, and tend to require considerable coordination. As a consequence, identifying problems and developing solutions to these are processes liable to evolve in tangled, highly iterative ways. Intensified interdependence among tasks in regard to processing information to solve problems lowers efficiency (Simon, 1973; von Hippel, 1990), because such interdependence means high costs of changes, as decisions made regarding one task affect other tasks.

To boost the efficiency of the process, two approaches have been suggested: reducing the need for problem-solving between various tasks by specifying the boundaries between them and minimising the costs associated with problem-solving across those tasks (von Hippel, 1990). To apply these

approaches in a suitable way, there is a need of distinguishing highly dependent processes from processes that are nearly independent of each other. One possible way of reducing the costs associated with the iteration of problem-solving is to distinguish standardised aspects of offerings from customised ones. It has been suggested, for instance, that at least some customisation efforts can be undertaken by users (von Hippel, 1998). To understand how that dynamic might be realised, however, first requires understanding the link between standardisation and customisation both for products and services, as well as how the combination thereof can be managed. As Davies, Brady, and Hobday (2006) have stated, 'Success in integrated solutions depends on how quickly and easily a company can move from unique to repeatable solutions delivery. It is about balancing customization and standardization' (p. 45).

2.3 Standardisation and customisation

In their operations strategies, companies have traditionally focused either on volume, namely by providing standardised, mass-produced products that take advantage of economies of scale, or on variety, namely by using craft skills to produce customised products (e.g. Hayes & Wheelwright, 1979). Given their focus on manufacturing capabilities, companies long perceived a trade-off between volume and variety. There are however opportunities to achieve both—that is, strategies that allow for a 'low-cost production of high variety, even individually customized goods and services' (Pine, 1993, p. 7). In such arrangements, companies can offer differentiated products to customers while maintaining efficient product development and manufacturing operations (Robertson & Ulrich, 1998). Strategies to do so appeared more compelling as the market has become more unpredictable and fragmented, while the production systems were built upon the premises of stability and control (Hart, 1995). Such strategies have since been widely used to manage increased demands for product variety and thereby overcome the traditional view of having standardised products on one side and customised products on the other. Because the trade-off between volume and variety seems to have faded, the following sections account for the standardisation–customisation continuum commonly described in the literature, thereafter turning to how these could be combined.

2.3.1 The standardisation–customisation continuum

Products have traditionally been positioned along a standardisation–customisation continuum, ranging from pure standardisation, segmented standardisation, and customised standardisation to tailored customisation and, beyond that, pure customisation (Lampel & Mintzberg, 1996). Along

that continuum, the type of customisation relates to the point at which standardised processes are separated from processes focused on producing offerings that target individual customers' needs (Rudberg & Wikner, 2004), referred to as the customer order decoupling point. Likewise, various types of strategies exist in which customisation spreads upstream in the value chain as the degree of customisation increases (Lampel & Mintzberg, 1996). Indicating a product-oriented perspective, adding services to products has been pinpointed as an initial way of increasing the degree of customisation in offerings—that is, providing customised services for existing standardised products (Pine, 1993). That approach aligns with the notion that companies servitize in order to differentiate themselves on the market (Vandermerwe & Rada, 1988). In that case, services represent a way of extending the commoditisation of products and, in turn, gaining additional sources of revenue.

At the same time, viewing standardisation and customisation along such a continuum can seem oversimplified, especially in the case of solutions, in which customisation can be associated with not only the process of product development but also processes that are associated with services. Similarly, Gilmore and Pine (1997) proposed a matrix based on two dimensions: changes to products and changes in representation. From that matrix, one of several approaches to customisation described by Gilmore and Pine (1997) is the adaptive approach, which does not involve changes to either the product or its representation but entail creating a standard product that customers may alter themselves (Gilmore & Pine, 1997) as a sort of self-service.

By contrast, the transparent approach is concerned with changes to products and thus involves developing a different product for each customer, without the customer being aware of such customisation (Gilmore & Pine, 1997). Although possibly costly, the approach can pay off when customers are prepared to pay premium prices to receive exactly what they need. As a case in point, Gilmore and Pine (1997) describe a company that provides the right individual soap mixture to industrial customers as well as attends to the product's availability at the customers' sites. Interestingly, the transparent approach thus shows similarities to descriptions of services for which the company is compensated based on availability, despite referred to only as a change to the product by Gilmore and Pine (1997).

A third approach—the cosmetic approach—involves offering a single standardised product in various ways to various customers. In presenting and displaying the product differently, the

approach is only concerned with changes in representation. In a service setting, the cosmetic approach is often concerned with personalisation, not customisation, at least according to the definitions proposed by Voss and Hsuan (2009): 'At the customer interface, we define personalization as where the personnel interacting with the customer *adapt* the delivery of a given service in response to the customer's expressed or implied needs. Customization occurs when the personnel interacting with the customer *configure* the service delivery system to deliver a service that responds to the customer's expressed or implied needs' (p. 556). The costs of such efforts thus arise in the customer-facing parts of the organisation, mostly in association with personnel.

Last, the collaborative approach is concerned with changes in both products and their representation, including in dialogues between customers and the company that are held to identify the customers' needs as a means to guide the creation of offerings (Gilmore & Pine, 1997). The collaborative approach describes the strategy of many product–service solutions and relates to the notion of problem-solving in which companies leverage both knowledge of users, which is focused on problems, and knowledge of technology, which is focused on solutions (e.g. von Hippel, 1994). Such a strategy can be costly, however, because the activities involved in identifying and meeting the specific need of an individual customer is time-consuming and resource-demanding.

2.3.2 Combining standardisation and customisation

To be able to offer customers offerings that are adapted to their specific needs while limiting costs and complexity, companies adopt modular and platform strategies. Using either type of strategy represents a way of managing the increased demand for customisation and refer to the standardisation of assets or interfaces—that is, platforms (Robertson & Ulrich, 1998) or modules (Mikkola, 2006; Sanchez & Mahoney, 1996), respectively. Services can also be developed and delivered in more cost-efficient, flexible ways by utilising a platform or modular approach, if not both (Hofman & Meijerink, 2015; Pekkarinen & Ulkuniemi, 2008). Both strategies thus offer a way of providing offerings addressing customers' specific needs more efficiently.

The fundamental principle of the strategies in relation to the customisation and standardisation of solutions can be observed in the framework of Bask, Lipponen, Rajahonka, and Tinnilä, (2011) for service settings, as shown in Figure 3. That framework establishes two dimensions—the degree of customisation and the degree of modularity—referring to both the service offerings (i.e. from the

perspective of customers) as well as processes undertaken by suppliers (i.e. from a service production perspective).

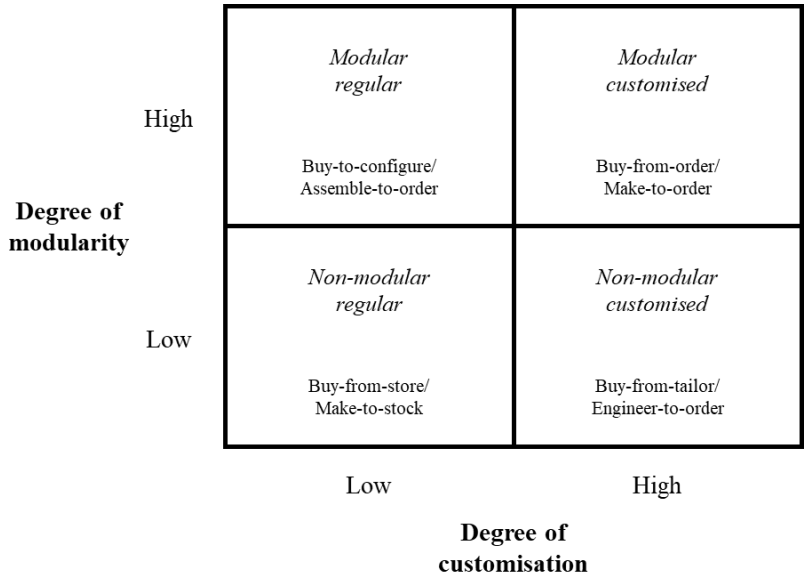

Figure 3: Customisation and modularity framework (adapted from Bask et al., 2011)

In that framework, a solution can typically be categorised as non-modular customised—that is, tailored for a specific customer in an engineer-to-order process (e.g. a Formula One car; Bask et al., 2011). In that case, the solution is traditionally developed entirely from scratch, with a focus on solving the customer's specific problems, in what is called 'pure customisation' or 'tailored customisation', as presented by Lampel and Mintzberg (1996). However, to reduce costs, address a larger customer base, and enable growth (Kowalkowski et al., 2015), some companies aim to move into the 'modular customized' quadrant, in which the solution is made to order (e.g. a Volvo car; Bask et al., 2011). That approach follows the suggestion that companies should develop modular solutions as a next stage in servitization (Rajala et al., 2019). At the same time, though modularity refers to a mixing-and-matching approach as a means to enable variety, the same idea as presented in Figure 3 can be used for platforms, which are concerned with forming a foundation based on a collection of assets (Robertson & Ulrich, 1998) from which customised solutions can be derived, enabling economies of both scale and scope. In sum, although modular and platform approaches are commonly used together, they differ in their chief focus, and understanding their similarities and differences is important to understanding how their benefits in terms of

standardisation and customisation can be combined. The next section addresses platform and modular approaches as ways of meeting demand for customised solutions while keeping costs at a reasonable level, considering these similarities and differences.

2.4 Platform and modular approaches

Along the traditional continuum of servitization, solutions have been described as the ultimate stage. The solutions need to not only fulfil individual customers' needs but also turn a profit and accommodate a larger customer base, and companies should thus typically aim for economies of scale (e.g. Brax et al., 2017; Kowalkowski et al., 2015; Rajala et al., 2019). Accordingly, in providing solutions, companies should aim to promote both efficiency—fast at a reasonable cost—and effectiveness—suitability to the specific customer's context (Ulaga & Reinartz, 2011). In settings focused on product offerings, modular and platform approaches have been widely used to efficiently manage the product architecture, and according to Voss and Hsuan (2009), designing services can also benefit by being approached from an architectural perspective. Thus, in this section, the notions of product and service architectures are first accounted for, followed by a description of modular and platform strategies. After that, concepts associated with those approaches are contrasted.

2.4.1 Product and service architectures

Product architecture is the 'scheme by which the function of a product is allocated to physical components' (Ulrich, 1995, p. 419). In recent years, interest in product architectures has expanded from settings focused on manufacturing to settings that focus on services (Bask et al., 2010; Brax et al., 2017). Although Ulrich's (1995) definition of *product architecture* is concerned with physical products, as is most research on the topic, it also highlights three aspects of product architectures that apply to service-focused contexts as well (e.g. Voss & Hsuan, 2009): functional elements, mapping from functional elements to components, and the specification of interfaces among those components (Ulrich, 1995). By extension, *service architecture* has been defined as 'the way that the functionalities of the service system are decomposed into individual functional elements to provide the overall services delivered by the system' (Voss & Hsuan, 2009, p. 546). On the topic of service architecture, researchers have highlighted the importance of considering the differences between products and services (e.g. Bask et al., 2010; Iman, 2016; Voss & Hsuan, 2009). As a result, a dilemma identified regarding the development of services concerns what is being designed: a process or a product (Voss & Hsuan, 2009). That discrepancy means that the

architecture and, in turn, the application of platform and modular strategies depends upon the perspective on services taken.

To clarify service architecture, Voss and Hsuan (2009) have stressed the importance of considering the levels of decomposition. While the highest level of decomposition of a product architecture is the product, a service architecture instead positions industry at the top. By extension, to further explore service architecture, Voss and Hsuan (2009) have proposed four levels of decomposition—from greatest to smallest, the industry, the service company or supply chain, the service bundle, and the service package or component—yet admitted that several other levels are possible. In any case, the differences between those levels raise questions about what elements to treat as independent and which as interdependent in the process of determining on which level to standardise.

2.4.2 Modularisation of products and services

The idea of modularity follows the notion of nearly decomposable systems, in which 'intra-component linkages are generally stronger than intercomponent linkages' (Simon, 1962, p. 469). Product architecture can range from integral to modular,[8] with a modular one being concerned with making the components of products independent so that they can be mixed and matched using standardised interfaces (i.e. linkages) that allow for flexibility (Sanchez & Mahoney, 1996). That arrangement is referred to as loose coupling (Orton & Weick, 1990), which means that independence exists between modules but there is interdependency within them. Whereas complete independence is difficult to accomplish, a nearly decomposable system tends to contain weak, yet not insignificant, interactions among the sub-systems (Simon, 1962). Decomposing such a system can make its complexity more manageable. In modular architectures, sub-systems are dubbed 'modules', while the architecture itself refers to the structure of the system, including which modules will be a part thereof and their roles (Baldwin & Clark, 2000). With *modularisation* defined as 'building a complex product or process from smaller subsystems that can be designed independently yet function together as a whole' (Baldwin & Clark, 1997, p. 84), such modules can be described as 'units in a larger system that are structurally independent of one another, but work together' (Baldwin & Clark, 2000, p. 63). Accordingly, the term *modularity* refers to a strategy 'in which the interfaces shared among the components of a given product architecture become

[8] For an overview of the characteristics of modular and integral product architectures, see Mikkola (2006).

standardized and specified to allow for greater substitutability of components across product families' (Mikkola, 2006, p. 130). Thus, a modular architecture allows for variety and flexibility, such that customers can put together products from a predefined set of components.

Bask et al. (2010) have posited that an essential difference between product and service modularity is the processual nature of services. Accordingly, they have argued that service modularity is more closely related to process modularity than product modularity. Such thinking corroborates the supposed importance of considering the processual aspects of services (Grönroos, 2006) instead of focusing on the point of exchange as in the case of applying a goods logic. Accordingly, service modularity is concerned with the decoupling of sub-processes, not components. Gremyr et al. (2019) have even gone so far as to aver that 'tight couplings between the service modules are beneficial' (p. 83). Distinguishing processes from outputs, they have maintained that processes can be decoupled, whereas outputs should not (Gremyr et al., 2019). As a consequence, the value of mixing and matching from a customer's perspective becomes limited.

Drawing from the idea that the value of solutions is created within a network (Jaakkola & Hakanen, 2013) and that solutions can be developed based on both internal and external resources (Salonen & Jaakkola, 2015; Story, Raddats, Burton, Zolkiewski, & Baines, 2017), researchers have suggested that modular solutions offer a way of orchestrating actors in a business network so that they may access both internal and external resources (Salonen, Rajala, & Virtanen, 2018). Such thinking follows the idea that any modular architecture, with nearly independent modules, makes the components loosely coupled with reduced costs of coordination (Sanchez & Mahoney, 1996). Although such thinking may ring true once a modular architecture is established, Hsuan (1999) has underscored that collaborating in the initial phases of development increases the likelihood of success of the modular products. As a result, the initial cost of coordination may be higher, albeit with a reduced need for managerial authority to manage the coordination later on.

2.4.3 Platform approaches for products and services

Another approach to managing product and service architectures is adopting a platform strategy. Platforms are connected to the concept of a *product family*, defined as 'products that share a common platform but have specific features and functionality required by different sets of customers' (Meyer & Utterback, 1993, p. 30). Such a family shares assets and addresses a certain market, for example, or a customer segment (Meyer & Utterback, 1993; Sawhney, 1998).

Accordingly, a *product platform* can be described as a 'collection of assets that are shared by a set of products' (Robertson and Ulrich, 1998, p. 20), with the set of products also being the product family. The platform approach is thus concerned with achieving efficiency by standardising assets among products, instead of standardising interfaces between modules, as is the case in modular approaches. Likewise, the chief objectives of platform versus modular approaches differ as well, with platforms being focused on economies of scale and scope, whereas modularity facilitates economies of substitution (e.g. Magnusson & Pasche, 2014).

The standardised aspects of any platform approach can be referred to as *commonalities*, in which components or functions are clustered based on their similarities (Pirmoradi et al., 2014). The basic principle of a platform approach, both for products and services, is to balance the potential for commonalities among offerings—that is, what can be standardised or reused—with the need for differentiation and variety within the product family (Halman et al., 2003; Hofman & Meijerink, 2015). Commonality can allow lower costs via the effects of economies of scale as well as increased quality (Meyer & Lehnerd, 1997; Robertson & Ulrich, 1998; Sawhney, 1998; Sköld & Karlsson, 2007). At the same time, variety, albeit costly, is valuable when customers' demands differ. Designing a platform thus becomes the task of determining what common elements will comprise the platform and which will be differentiated elements among the products (Halman et al., 2003).

Although product platforms are the most commonly described type of platforms (Zhang, 2015), a range of types of platforms involving various assets exist. One example is process platforms, which can be used for production as well as for supply chains and product development (Sawhney, 1998). In addition to these, Robertson and Ulrich (1998) have described two other platform categories: knowledge platforms and platforms based on people and their relationships. Customer platforms have also been described; therein, a company chooses a beachhead as a basis for expansion into related markets and segments (Sawhney, 1998). Although most research on platforms to date concerns products, some attention has been paid to processes as well (Fixson, 2007), and depending on the offering, assets other than product components might be of commonality potential. Beyond that, platform strategies can also be applied to capitalise on commonalities at different stages of an offering's life cycle (Halman et al., 2003; Sawhney, 1998; Zhang, 2015), because various assets may hold different value in different phases. As a consequence, an overly strong focus on

components as a basis for commonality can cause other opportunities for platforms to be overlooked.

As touched upon earlier, platforms have been associated with lower costs by enabling economies of scale, because sharing designs and components reduces the overall costs associated with their development and manufacture (Robertson & Ulrich, 1998; Sawhney, 1998). The potential cost savings afforded by platforms are especially expected in manufacturing operations, as less investment in equipment are needed compared to manufacturing the same variety of products without a platform. Referring to the automotive industry, for example, Muffatto (1999) has reported that, by using platforms, manufacturers can reduce their investments in welding equipment by up to 50%. Because services are generally more personnel-intense and do not involve standardised manufacturing processes with expensive equipment, their potential cost reductions would arguably be less significant. However, Hofman and Meijerink (2015) nevertheless found that the value of services benefits from the use of a platform approach. After all, platforms can reuse knowledge, and when used for solutions, efforts geared towards standardisation enable the use of existing knowledge and resources (Kowalkowski et al., 2015), which requires less investment in new knowledge and, in turn, lowers costs.

Further still, product platforms can also allow companies to significantly reduce the lead times for the development and delivery of new products (Meyer & Utterback, 1993; Robertson & Ulrich, 1998). In the automotive industry, that dynamic is clear when platform development is separate from vehicle development, which shortens the cycle of vehicle development because the underlying basis is already in place (Muffatto, 1999). For services, that division could also allow shorter development times, precisely because processes are decoupled. Consequently, as responsiveness to customers may increase (Robertson & Ulrich, 1998), so too may the degree of flexibility. In that sense, a platform approach can also improve the design quality (Meyer & Utterback, 1993; Sawhney, 1998), because the platform itself can be thoroughly tested and debugged as necessary. In the process, the resources assigned for testing can be reduced overall, which boosts productivity in development (Muffatto, 1999) and lowers costs for each product or service derived.

Although service platforms can occur at different levels of decomposition and also span across them, the most common levels are those of service bundles and service packages or components

(Brax et al., 2017; Voss & Hsuan, 2009). Pekkarinen and Ulkuniemi (2008) have identified four dimensions of modularity in modular service platforms: the service, the process, the organisational, and customer interface. A shortcoming of that conceptualisation, however, is its failure to distinguish modular from platform architectures, which complicates deriving benefits from each of the two approaches. On a similar note, Yakob and Tell (2007) have interpreted product platforms as being nearly decomposable systems that hence combine a modular with a platform approach. Although such combined approaches with interlinked concepts are common, such combinations do not take the contingencies of their applications into consideration (Magnusson & Pasche, 2014), which can obscure clear paths to organising the development and making decisions. That potential drawback can be especially damaging in the case of product–service solutions, given the heightened complexity of what to share and what to differentiate among solutions. Contrasting those concepts can shed additional light on their use for product–service solutions. Therefore, the next section accounts for differences between platform and modular approaches as well as their application for products and services as described in previous literature.

2.4.4 Modularisation and platforms: Contrasting key concepts

As discussed in the previous sections, concepts associated with managing the architecture of products and services are multifaceted and commonly overlap. Although scholars commonly have described strategies that combine platform and modular approaches, important distinctions between these two have been identified, which affect their applicability (Magnusson & Pasche, 2014). Contingencies to consider include both internal and external aspects, including organisational structure and the demands of customers (Magnusson & Pasche, 2014). Furthermore, although the concepts originated in product-dominant settings, they have recently been extended to service-dominant settings as well, in which they have proven considerably useful (Hofman & Meijerink, 2015; Pekkarinen & Ulkuniemi, 2008).

Differences between product platforms and modularisation, largely based on the characteristics and contingencies considered by Magnusson and Pasche (2014), are listed in Table 2. Despite their differences, the approaches often appear, sometimes even explicitly, in combined forms, both in service-dominant settings (e.g. Pekkarinen & Ulkuniemi, 2008) and product-dominant settings (e.g. Yakob & Tell, 2007). Nevertheless, because several of their distinguishing characteristics are quite different, before adopting either strategy it is important to consider the degree of fit with both firm-specific characteristics and industry-specific ones. The same aspects should also be taken into

account when executing a service-based strategy. Therein, questions to consider include the impact of technology and value generation uncertainty in the industry, wherein companies operating in industries with value generation uncertainty being more likely to offer customer-oriented services (Visnjic et al., 2019). Thus, considering the characteristics of platforms and modularisation, providing product–service solutions can likely benefit from following a platform approach, given that approach's focus on reducing costs in industries with high value uncertainty and the possibilities for exploiting existing assets to activate the effects of economies of scale and of scope.[9] Even so, research on using platforms for product–service solutions has been scarce.

Table 2: Product platforms versus modularisation, largely based on Magnusson and Pasche (2014)

	Product platforms	**Modularisation**
Key principle	Balance potential for commonalities (forming the platform) and needs for differentiation	Decoupling of modules by reducing the dependence between them
Unit of standardisation	Assets	Interfaces
Rationale: Primary emphasis	Economies of scale and scope	Economies of substitution
Focus	Reducing costs via reuse	Creating large variety
Responsiveness to changes	Lower responsiveness, with high costs of upgrading the platform	Higher responsiveness, with easier, less costly upgrades
Corresponding organisational structure	Centralised	Decentralised

An overview of terms associated with efficiently managing either product or service architectures appears in Table 3, which presents definitions or conceptualisations of the terms as applied in product-oriented settings versus service-oriented settings. As shown in this chapter, whereas concepts associated with managing the architecture of products are well-established, their applicability in service-oriented settings continues to evolve. The differences between those settings double as important aspects to consider in gauging the applicability of the concepts.

[9] The term *economies of scale* refers to the decrease in the average cost per unit costs following an increase in volume (Law, 2016a). The term *economies of scope*, by contrast, refers to when 'it is less costly to combine two or more product lines in one firm than to produce them separately' (Panzar & Willig, 1981, p. 268).

However, after all, the contexts in which the modular and platform approaches are applied are heterogeneous even within service-oriented settings. Two out of three core scholarly articles on service modularity, as identified by Frandsen (2017), concern the logistics service industry (Bask et al., 2010; Pekkarinen & Ulkuniemi, 2008), while healthcare has provided an important context for other research on the topic (Brax et al., 2017). In regard to service platforms have internal human resources management services been used as a case of application (Hofman and Meijerink, 2015). All these contexts however represent 'pure' service context, in which the offerings do not directly include any products.

Table 3: Concepts associated with modular and platform approaches

Term	**Definition in product-oriented settings**	**Definition in service-oriented settings**
Customisation	Along the continuum of customisation, pure customisation occurs when 'all stages—design, fabrication, assembly, and distribution—are largely customized' (Lampel & Mintzberg, 1996, p. 26).	*Customisation* 'occurs when the personnel interacting with the customer configure the service delivery system to deliver a service that responds to the customer's expressed or implied needs' (Voss & Hsuan, 2009, p. 556)
Mass customisation	*Mass customisation* is 'the low-cost production of high variety, even individually customized goods and services' (Pine, 1993, p. 7).	
Product or service architecture	*A product architecture is* 'the scheme by which the function of a product is allocated to physical components' (Ulrich, 1995, p. 419).	*Service architecture* is 'the way that the functionalities of the service system are decomposed into individual functional elements to provide the overall services delivered by the system' (Voss & Hsuan, 2009, p. 546).
Commonality and component sharing	*Component sharing* is 'using the same version of a component across multiple products' (Fisher, Ramdas, & Ulrich, 1999, p. 297).	'A service module is common, variant or unique, the core modules providing communality and standardization, and the variants and unique modules variety and diversity to meet users' different service needs' (Tuunanen, Bask, & Merisalo-Rantanen, 2012, p. 103).
Modularity	*Modularity* means 'building a complex product or process from smaller subsystems that can be designed independently yet function together as a whole' (Baldwin & Clark, 1997, p. 84).	*Service process modularity* refers to 'the usage of reusable process steps that can be combined ("mixed and matched") to accomplish flexibility and customization for different customers or situations in

	Modularity is 'a special form of design which intentionally creates a high degree of independence or "loose coupling" between component designs by standardizing component interface specifications' (Sanchez & Mahoney, 1996, p. 65).	service implementation' (Bask et al., 2010, p. 368).
Modules	*Modules* are 'units in a larger system that are structurally independent of one another, but work together' (Baldwin & Clark, 2000, p. 63).	A *service module* 'can be seen as one or more service elements offering one service characteristic' (Bask et al., 2010, p. 365). A *service module* is 'a system of components that offers a well-defined functionality via a precisely described interface and with which a modular service is composed, tailored, customized, and personalized' (Tuunanen et al., 2012, p. 101).
Product family	A *product family* represents 'products that share a common platform but have specific features and functionality required by different sets of customers' (Meyer & Utterback, 1993, p. 30).	
Platform	A *platform* is a 'collection of assets that are shared by a set of products' (Robertson & Ulrich, 1998, p. 20).	*Platforms* are 'comprised of subsystems and interfaces between subsystems, which in services are distinct processes that typically will have both a human and technological component' (Meyer & DeTore, 2001, p. 200). A conceptual model of a modular service platform can be found in Pekkarinen and Ulkuniemi (2008).

As shown in Table 3, the definitions of concepts associated with platform and modular approaches overlap in product- versus service-oriented settings, even while key distinctions can be found in the fact that services are considered to be processes and goods to be manufactured. The distinction of services and goods influence the potential of applying platform versus modular approaches, because the basis of costs and revenues differ, not least in terms of the proportion of variable and fixed costs. For manufacturers, fixed costs associated with equipment, for instance, comprise a large part of the overall costs. For service companies, by contrast, variable costs are more prominent. That source of contrast also poses an important difference in the actual application of

one approach versus the other, because platforms tend to promote economies of scale and of scope, whereas modularisation tends to promote economies of substitution and variety (Magnusson & Pasche, 2014).

Moreover, because the production of products is separated from their use by customers, whereas the production and use stages of services are entangled, if not simultaneous, it can be more difficult to synchronise demand and supply in the case of services (Zeithaml et al., 1985), which are impossible to 'produce to stock' at least in personnel-intense services. Beyond that, because services are time- and location-specific, it is difficult to achieve the sufficient utilisation of personnel. Accordingly, as shown in Table 3, the use of the concepts in service-oriented settings is more focused on decomposing service-related processes, in which humans play important roles. It could thus be argued that applying those concepts in service-oriented settings is not as focused on reducing costs of development, as on reducing the complexity associated with service delivery.

Nevertheless, when considering the applicability of the platform versus modular approach, it is pivotal to consider the extent of cost reduction, because developing either approach can be costly in itself. To break even, it is therefore necessary to consider opportunities for lowering costs in relation to the value gained from variety. For companies in the process of servitizing, it is also important to be able to translate service investments into economies of scale (Visnjic Kastalli & Van Looy, 2013), often associated to standardisation efforts. Although some companies aim for increased standardisation, many fail in taking important aspects into consideration, including both costs and potential revenues. Kowalkowski et al. (2015) have identified some major barriers for companies seeking to standardise their solution offerings, including lack of resources, managerial attention, and limited capabilities in standardising and upscaling. A platform approach utilises the standardisation of assets to be able to create economies of scale and scope and, in that way, generate higher volumes at a given cost. Therefore, the approach could be a useful strategy to enable both efficiency and effectiveness in providing solutions. To apply such an approach, however, platform-related concepts need to be translated for use in solution-oriented settings, in which products and services are not treated individually but are instead integrated.

At the same time, applying a platform architecture for solutions poses implications for the design of the organisational structure, because the product architecture exists in relation to the organisational architecture in which the products are developed (Leo, 2020; Sanchez & Mahoney,

1996). In the case of servitization, there is also debate about how to organise for services and solutions, and several propositions on that topic warrant additional consideration.

2.5 Organisational structure for services and solutions

As previously acknowledged, the provision of services and solutions instead of products only changes how value is provided as well as how companies operate (Vandermerwe & Rada, 1988). In turn, companies have to alter their organisational structures to align them with the chosen service strategy in order to succeed (e.g. Bustinza, Ziaee Bigdeli, Baines, & Elliot, 2015; Galbraith, 2002; Raddats & Burton, 2011). Which structure corresponds to which strategy remains debatable, however. This section sheds light on that debate by drawing from the mirroring hypothesis, after which different views on structural aspects of product and customer orientation, as well as product–service integration, are accounted for.

2.5.1 Mirroring hypothesis

In general, although especially in research on modularity, the relationship between the product or service architecture and the organisational structure is discussed in terms of the mirroring hypothesis (Sanchez & Mahoney, 1996), which addresses how product and organisational architectures mirror one another. Sanchez and Mahoney (1996) have posited that 'although organizations ostensibly design products, it can also be argued that *products design organizations*, because the coordination tasks implicit in specific product designs largely determine the feasible organizational designs for developing and producing these products' (p. 64). The mirroring hypothesis accordingly 'posits that, in a complex system, the technical architecture and the division of labor will "mirror" one another in the sense that the network structure of one will correspond to the structure of the other' (Colfer & Baldwin, 2016).

The causal direction of the relationship between the two structures can be understood from two perspectives: that the organisation should mirror the architecture of the offering and that the offerings will mirror the organisation (Leo, 2020; MacCormack et al., 2012). The first perspective focuses on matching the communication patterns of development with the interdependencies of the components in the offering. Thus, modular product architectures can provide the means for loosely coupled organisations, in which autonomous development efforts can occur with less need for authority to coordinate them (Sanchez & Mahoney, 1996). The second perspective, by contrast, assumes that the structure is fixed, at least in the short term, and thereby focuses on the implications

of that set-up on the design of offerings (Leo, 2020; MacCormack et al., 2012). Such reasoning supports the argument that the development of new designs is constrained by the contexts in which the search for those designs is made (MacCormack et al., 2012). After all, because a firm's attention capacity is limited, it is allocated to specific decisions based on the context, which sets boundaries for what solutions will be considered (Ocasio, 1997; Simon, 1973). That process of decision-making leading up to offerings, as the final outcome, is thus influenced by the organisational structure in which it occurs, because that context doubles as the arena for communication among teams and individuals in the organisation.

Departing from those perspectives, the remainder of this section outlines different aspects of organisational structure in relation to services and solutions. For one, Ocasio (1997) has argued that organisational action—herein, the development of solutions—depends upon what the decision-makers focus their attention on. In seeking solutions to problems, organisational actors lean partly on past experience (Simon, 1962) and the mindsets of employees, and such will affect the selection of answers that they attend to. Moreover, in providing solutions in product-oriented companies, the need for increased customer orientation represents a first aspect to consider in determining the organisational structure for services and solutions.

Another aspect concerns the need for a joint search for solutions, which represents a process that depends upon the setting and influence by the procedures and channels used, along with the governance structures and frameworks that they provide for decision-makers (Ocasio, 1997). Overall, that dynamic underscores the relationship between organisational structure, communication among individuals and teams therein, and the final outcomes of the process—herein, the solutions—and thus concerns the management of product–service integration.

2.5.2 Product orientation and customer orientation

Contrasting product-centric and customer-centric companies, Galbraith (2002) has highlighted the organisational transformation that occurs when companies shift to providing solutions instead of products. In that process, the need to refocus from a product-oriented to a service-oriented mindset has also been commonly stressed (Gebauer, 2009; Gebauer, Edvardsson, & Bjurko, 2010), and it has even been argued that manufacturers engaging in servitization need to resist continuing to view themselves as product providers (Kindström & Kowalkowski, 2014). By the same token, the establishment of a service-oriented culture has been thought to heavily impact the success of

servitization (Fliess & Lexutt, 2019). On top of that, being able to foster such an organisational environment has been reported to benefit from the separation of product- and service-oriented functions within organisations and the establishment of service business units with their own profit-and-loss responsibilities (Gebauer et al., 2005, 2010; Oliva, Gebauer, & Brann, 2012; Oliva & Kallenberg, 2003). Thus, certain aspects of a company's organisational culture are affected by its organisational structure. Separating functions such that they operate independently reflects a modular organisational architecture that affords all of the benefits of an efficiently operating, loosely coupled organisation: reduced costs, more efficient coordination, and the flexibility to adapt to environmental changes, among others (Sanchez & Mahoney, 1996).

If independence of products in relation to services is achievable, then the approach also poses implications for relationships with other actors in the network. At the component level, if the product architecture remains stable, then suppliers and buyers can act independently, because modularity is acting as a 'substitute' for information sharing among actors, and other interorganisational integration mechanisms (Cabigiosu & Camuffo, 2012). However, it has also been found at the level of the firm that modularity can boost information sharing between suppliers and buyers, in what is referred to as the complementary hypothesis (Cabigiosu & Camuffo, 2012). That hypothesis derives from the idea that the development of a successful modular architecture in the network is influenced by the degree of collaboration between suppliers and buyers (Hsuan, 1999).

Despite arguments that companies should develop distinct product and service cultures (Story et al., 2017), it is also crucial to enable synergies between those cultures by managing the interplay of product and service innovation (Burton, Story, Raddats, & Zolkiewski, 2017; Story et al., 2017; Visnjic, Wiengarten, & Neely, 2016). There is thus a need for balance, and in that balance, manufacturers should be careful before abandoning their heritage (Burton et al., 2017). The need for balance also means that companies need to manage coexisting logics in their organisations and leverage capabilities related to both product and service provision. Jointly managing those capabilities means both upholding existing knowledge and coordinating functions if they are separated. Given those needs, creating an embedded product–service culture is a major challenge (Martinez et al., 2010), one which requires a cultural reorientation from products to solutions (Salonen, 2011), not from products to services (Johnstone, Dainty, & Wilkinson, 2009; Peillon,

Pellegrin, & Burlat, 2015). It thus remains questionable whether the reorientation is a shift to be made actively or whether it is about combining different perspectives within the organisation in order to adapt an organisational structure that can facilitate a solution orientation. Perhaps needless to say, the development of product–service solutions requires a greater degree of joint problem-solving between product and service-oriented functions compared to providing products.

2.5.3 Managing product–service integration

Somewhat contrasting the suggestion to separate the service-oriented and product-oriented aspects of a business, in their case studies Neu and Brown (2005) detected a shift towards integrating business unit responsibilities instead of establishing autonomous divisions. Such a shift would result in lower costs of coordination between functions, provided that they cannot act independently. In a more tightly coupled organisation, namely one in which problems are solved via direct communication, having access to knowledge and solutions of different modules can allow the emergence of more integral designs (MacCormack et al., 2012). On the contrary, if products and services are separated within an organisation, meaning that problem-solving activities are performed in isolation, then such separation can result in the emergence of offerings in which products and services are separable. Thus, to be able to provide solutions in which products and services are integrated in their development, there is a need to facilitate product–service integration in the organisational structure.

Fliess and Lexutt (2019) have put forward the proposition that the 'appropriate organizational structure depends on the maturity of the servitization process; the more advanced, the more appropriate a separate service organization' (p. 66). However, such thinking is somewhat contradictory, because a higher degree of maturity indicates a higher degree of product–service integration, which in turn points to a greater need for integration throughout the development process. In a similar vein, Oliva et al. (2012) have discussed whether Neu and Brown's (2005) contradictory findings might be due to the degree of product–service integration, in which integrated solutions may be more suitably provided by a unit with integral responsibility. Accordingly, the need for integration in the development process should be treated as a contingency in the choice of a suitable organisational structure.

Raddats and Burton (2011) have reported challenges that companies might face in separating the service-oriented part of their businesses from the product-oriented part. Among them are intra-

organisational conflicts and the development of an overly self-serving unit. Likewise, it has been argued that organisational silos in product and service development prevent communication (Shelton, 2009), the importance of which in creating synergies has been highlighted (Burton et al., 2017). That dynamic points to a frequently occurring problem in innovation in general, as individual parties, in making sense of their work, establish their own logic, even though such 'impeccable micro-logic often creates macro nonsense' (Van de Ven, 1986, p. 598), because it ignores the big picture. In that light, whereas a separate service business unit might benefit the establishment of a culture that makes sense for the service-oriented part of offerings, it can also inhibit the development of solutions in which the value of the sum is greater than the individual parts (i.e. surplus value). Thus, Neu and Brown's (2005) notion of integrated responsibilities partly contrasts the findings of Oliva and Kallenberg (2003) due to their emphasis on the management of the part-whole relationships[10] which is requiring taking the product–service integration into account, rather than the establishment of a service culture.

2.6 Revisiting the research problem: Developing the research questions

Considering that this thesis sets out to provide insights into the use of platforms for product–service solutions, this section revisits the research problem underlying the purpose as a means to develop three research questions. The questions have been formulated by drawing from the two primary fields of reference accounted for in this chapter: product–service solutions and modular and platform approaches.

2.6.1 Revisiting the research problem

The purpose of this thesis—to identify and describe factors influencing the use of platforms for product–service solutions—stems from challenges with profitability facing product-oriented companies when providing product–service solutions. Although customisation constitutes a characteristic feature of solutions (Nordin & Kowalkowski, 2010), the development of unique solutions can be too costly and too complex to manage (e.g. Brax & Jonsson, 2009). To overcome the service paradox (Gebauer et al., 2005) on the way to becoming profitable, servitizing companies should strategise to achieve economies of scale by capitalising on their existing assets (Kowalkowski et al., 2015; Visnjic Kastalli & Van Looy, 2013). Platforms offer a way of doing so while accommodating adaptions to meet the needs of customers. However, in using a platform

[10] Following the notion by Van de Ven (1986) about the structural problem of the collective efforts in innovations.

approach, companies also have to consider impact of the integration of products and services, not only managing products and services separately.

To be clear, in product–service solutions, products and services are integrated as a means to create a surplus value (e.g. Brax & Jonsson, 2009). In the description of complex systems, Simon (1962) has stated that, in 'such systems, the whole is more than the sum of the parts', adding that 'it is not a trivial matter to infer the properties of the whole' (p. 458). Likewise, the architecture of a complex system can be managed by considering its composition, and modular and platform strategies are indeed built upon that idea. Although such strategies originate from a product-oriented perspective, they have recently been extended into and proven useful in service-oriented settings (Hofman & Meijerink, 2015; Pekkarinen & Ulkuniemi, 2008). However, the application of such strategies to date has mainly concerned either products or services, as shown in Frandsen's (2017) overview, thereby neglecting specific cases in which they are integrated, despite the major impact that this specific characteristic can have on the application of these strategies. Accordingly, when devising strategies to exploit existing assets in a bid to activate the effects of economies of scale and economies of scope, it is crucial to consider the solution architecture, involving aspects of both products and services, the interactions of which facilitate surplus value for both customers and providers.

Although research on the modularisation of services provided in product-dominant contexts has been rare, researchers have shown that such modularisation can be useful (Gremyr et al., 2019; Rajala et al., 2019). The notion and benefits of platforms have not been explicitly treated, however, but mentioned only in passing, if not described as a nearly decomposable system, as in Yakob and Tell's work (2007), wherein the modular and platform architectures were observed to be tightly interlinked.[11] A study by Brax and Jonsson (2009) stands as an exception, as a result of which they proposed a layered view of solutions with similarities to a platform approach. Nevertheless, additional insights are needed, especially into the use of platforms for product–service solutions in ways that take the integration of products and services into account. In fact, scholars have also

[11] See for instance Gremyr et al. (2019) describing how a 'modular service platform has been argued to be a key to take advantage of the benefits of service modularity. Service platforms enable leveraging commonalities in services; combining the benefits of service standardization and customization in service provision.' (p. 84), or Rajala et al. (2019) describing the Kone solution platform as 'a modular offering architecture to connect the components and reduce on-site integration work' (p. 642).

called for research on the use of platforms for services in product-dominant contexts (Brax et al., 2017), comprising specific types of offerings. In this thesis, following Robertson and Ulrich (1998), a *platform* is broadly defined as a collection of assets, comprising the unit of standardisation, shared by a certain family of solutions.

2.6.2 Developing Research Question 1

The need for customisation in solutions is commonly highlighted with reference to solutions as comprising 'unique combinations' (Storbacka, 2011, p. 699) of products and services being 'unusually tailored' (Miller et al., 2002, p. 3). However, companies also need to consider ways of making their efforts geared towards standardisation to be more efficient. In response, a platform approach has been applied to efficiently manage the increased demand for customised physical products (Labro, 2004; Meyer & Lehnerd, 1997), although less is known about their use for product–service solutions. Such solutions differ from both products and services that are provided separately, and it remains necessary to understand how those differences impact the use of platforms.

Owing to mounting interest in service operations, service modularity has also been investigated (cf. Bask et al., 2010; Ulkuniemi et al., 2011; Voss & Hsuan, 2009), often to the conclusion that services can be provided via modular and platform strategies in more flexible, cost-efficient ways (Pekkarinen & Ulkuniemi, 2008). However, two aspects of the use of such strategies for service provision merit attention. First, literature on service modularity focuses on services in service-dominant contexts such as healthcare, financial, and logistics services, in which it is acknowledged that the heterogeneity of contexts calls for a need of paying attention to context-specific characteristics (Brax et al., 2017; Voss & Hsuan, 2009). Thus, findings about other types of services might not be directly transferrable to solution-oriented settings. Second, literature on managing service architecture seems to be mostly concerned with modularisation or else treats modularisation and platforms in an indiscriminate manner. Therefore, it remains necessary to clarify the applicability of platforms for product–service solutions, because such solutions constitute a specific arena for investigation—namely, a context other than service-dominant settings that focus on providing pure services. To elaborate on the usability of platforms in relation to the solution architecture, there is a need to know *why* companies should consider devising a platform approach for their solutions. Accordingly, Research Question 1 is formulated as:

What are arguments in favour of using platforms for product–service solutions?

It has been argued that service design can be beneficially considered from an architectural perspective (Voss & Hsuan, 2009). Accordingly, to understand the use of platforms in the context of product–service solutions, the solutions architecture needs to be understood. Although product architecture and service architecture have been discussed by researchers, less attention has been focused on solutions architecture, which includes both products and services in seamless integration. In that sense, *seamless* is associated to integration that occurs during the design and development phases of the solutions (Park et al., 2012); it contrasts integration that occurs later in the process, which builds on the assumption that products and services can be separated and thus provided individually (Park et al., 2012). Such integration, carried out by sales personnel, for instance, is thus based on products already in existence (Visintin, 2012) and associated with lesser degrees of customisation (Park et al., 2012). By extension, the engineering-oriented integration of products and services means that neither the product architecture nor the service architecture can provide a full picture of how a solution is composed.

As highlighted by Voss and Hsuan (2009), it is also important to consider the level of decomposition, especially because some important aspects of services are immaterial (Brax et al., 2017). Solutions can be understood from different perspectives, including as product–service bundles (e.g. Galbraith, 2002; Wise & Baumgartner, 1999), as bundles of knowledge components (e.g. Valtakoski, 2017), and as relational processes (e.g. Tuli et al., 2007). In this thesis, by assuming different perspectives on solutions, characteristics of a solution architecture are identified and described, all by taking the level of decomposition into consideration.

2.6.3 Developing Research Question 2

Development of product–service solutions based on engineering-oriented integration (Park et al., 2012) encompasses both product and service development. Such innovations, containing both products and services, outperform pure service innovations as well as pure product innovations (Eggert, Thiesbrummel, & Deutscher, 2015). Nevertheless, how to develop such product–service solutions while considering the need to create revenue spillover between products and services, as well as to activate the effects of economies of scale (Visnjic Kastalli & Van Looy, 2013), remains unclear.

Identified as a research priority, the gap in knowledge about how manufacturers should manage the development of services and products in order to optimise them needs to be filled (Raddats et al., 2019). In a similar vein, Park et al. (2012) have called for researchers to probe the processes required for the development of different types of product–service solutions, with various degrees of integration and customisation. They have also argued that processes existing for the development of new products and new services, respectively, are not applicable in product–service development (Park et al., 2012). On top of that, product–service development differs from cases in which product development and service development are separated, in which the platform approach is likely to affect these development efforts. Thus, the assumption of inseparability of the product and the service from a development phase forward becomes prominent when it comes to the use of a platform approach in developing solutions. Research Question 2 is thus formulated as:

> *How does a platform approach for product–service solutions influence key aspects of the solutions development?*

As discussed in this thesis, developing solutions involves integrating products and services to create prerequisites for value-in-use in relation to customers' operations. That aspect of solutions development stems from the idea that solutions, in attempting to facilitate value-in-use for customers, position customers as the creators of value (Grönroos, 2006, 2008). In a similar vein, service innovation is argued to involve creating value propositions, focused on the value-in-use for customers (Michel et al., 2008; Skålén et al., 2015), whereas product development, broadly speaking, involves generating and processing ideas into either new or modified products.[12] Solutions development is thus a matter of integrating activities of both product and service development.

Research has suggested that increasing customisation often implies increased integration of the components of the solution (e.g. Raddats et al., 2019) and thus a relationship between the degree of customisation and the degree of the integration of offerings (Johansson et al., 2003; Sawhney, 2006). The focus in this thesis is the integration of products and services appearing in the design and development phases, which assumes the inseparability of products and services from the customer's point of view (Park et al., 2012). That type of integration, though termed *engineering-*

[12] Compare 'product development' and 'new product development' in *A Dictionary of Business and Management* (Law, 2016b).

oriented integration (Park et al., 2012), also relates to the notion of technical and operational integration as distinguished from marketing integration (Johansson et al., 2003; Sawhney, 2006). Such solutions are often highly integrated as well as customised (Johansson et al., 2003; Park et al., 2012; Sawhney, 2006), and accordingly, their development constitutes a task of effectively managing both integration and customisation. In that light, to answer Research Question 2, both the specific form of integration and the foundation for a platform approach need to be taken into consideration, particularly concerning what assets to standardise and how to establish the platform.

2.6.4 Developing Research Question 3

In the context of servitization, adopting a suitable organisational structure has been a major challenge (Zhang & Banerji, 2017), owing to the urged need for a service-oriented culture to succeed (Fliess & Lexutt, 2019; Gebauer et al., 2010). Such a service orientation is arguably facilitated by establishing a separate service business organisation to protect the emerging service-friendly culture from the otherwise product-dominant environment (Gebauer et al., 2010, 2005; Oliva et al., 2012). However, the beneficiaries of such a separated organisation for the service-related part of the business continues to be debated (Neu & Brown, 2005; Oliva et al., 2012; Oliva & Kallenberg, 2003), with the impact of the degree of product–service integration acknowledged as being potentially influential (Oliva et al., 2012).

The mirroring hypothesis suggests a relationship between the product architecture and the organisational architecture (Colfer & Baldwin, 2016; Sanchez & Mahoney, 1996), in which a loosely coupled organisation is more likely to develop a modular product than a tightly coupled one. Accordingly, the architecture is associated with ties among the components of the offering and the organisational functions. In a servitization setting, that statement stands in contrast to the proposition that a separate unit might be more beneficial as the company matures and offers more advanced services (as proposed by Fliess & Lexutt, 2019), providing more integrated offerings (Matthyssens & Vandenbempt, 2010; Park et al., 2012). More integrated offerings would indicate the beneficiary of a more tightly coupled organisation in which product and service development involves joint problem-solving efforts. Thus, starting in the solution architecture, in which engineering-oriented integration renders the product and service inseparable, a more tightly coupled organisation would be needed. At the same time, using a platform approach therein would require centralising decision-making concerned with the platform, because decisions are cross-functional and of high strategic importance (Magnusson & Pasche, 2014; Robertson & Ulrich,

1998). However, most research on the organisational structure in servitization has not considered the architectural perspective but instead provided only generic suggestions.

Research Question 3 thus addresses the literature's contradictory recommendations about separating the service business as the company matures in servitization, and a need for a centralised structure when using platforms:

> *How does a platform approach for product–service solutions influence key aspects of the organisational structure?*

The aspects of the organisational structure elaborated upon concern the internal organisational architecture regarding the separation of service development from product development and the tightly coupled or loosely coupled organisation. Aspects of the organisational structure, however, also concern the company's relationships with other actors in its network, to which the mirroring hypothesis also applies.

Scholars have suggested that either the organisational structure or the product architecture can be seen as fixed in the short term, such that their mirroring can occur in two directions (Leo, 2020; MacCormack et al., 2012). As a consequence, it can be difficult to determine what represents the hen and what represents the egg, although, in any case, it is likely that they work in parallel. In that light, to illustrate the relationship between the organisational and solution architecture, their alignment is needed. The appropriateness of the organisational structure thereby becomes concerned with the challenges and obstacles that might confront a product-oriented company when increasingly engaging in solution provision using a platform approach for product–service solutions. As a result, the adopted organisational structure might either benefit or hinder the emergence of a platform approach for solutions.

Along with internal structures, relationships with other actors in a business network also affect solutions, with facilitation of linkages between actors required (Windahl & Lakemond, 2006). Establishing partnerships with external actors has thus been stressed for servitization to succeed (Fliess & Lexutt, 2019), because cooperating with partners and leveraging the network can be important ways of accessing resources and capabilities (Bustinza, Gomes, Vendrell-Herrero, & Baines, 2019; Matthyssens & Vandenbempt, 2008; Salonen & Jaakkola, 2015). Such partnerships are 'purposive strategic relationships between independent firms who share compatible goals,

strive for mutual benefit, and acknowledge a high level of mutual interdependence. They join efforts to achieve goals that each firm, acting alone, could not attain easily' (Mohr & Spekman, 1994, p. 135). Such partnerships highlight a need to consider the structure beyond the company's boundaries, for solutions can be developed based on internal or external resources, if not both (Salonen & Jaakkola, 2015; Story et al., 2017). In that sense, the mirroring hypothesis can also apply between actors, because the degree of coupling between components varies in relation to the degree to which actors couple (Cabigiosu & Camuffo, 2012). Modular solutions have also been found to enable the integration of resources from various sources in the network by acting as a key integration mechanism (Salonen et al., 2018) that reduces the costs of integration. Ways of leveraging external resources could thus also be an important aspect to consider when devising the structure for a platform approach for product–service development.

3 Research methodology

This chapter describes the methodology adopted for the research conducted for the thesis. After explaining the research design, the chapter introduces and justifies the empirical studies performed in the research, followed by a description of the case companies involved therein. Next, the collection of data from various sources is detailed, after which the data analysis is explained, and the quality of the research reflected upon.

3.1 Research design

Following the argument that the methodology should relate to the purpose and the research questions (Edmondson & McManus, 2007), the methodology chosen for the research was a qualitative case-study approach. The purpose of this thesis is to identify and describe factors influencing the use of platforms for product–service solutions; thus, a case study approach was perceived useful to study the emerging phenomenon in question. This section first explains this starting point in the emerging phenomenon of using platforms for product–service solutions, after which it describes the case-study design involving an abductive and collaborative approach. Last, the section addresses the basic assumptions and overviews the research's overall trajectory.

3.1.1 Studying an emerging phenomenon

Although servitization has recently received increased scholarly attention (Baines et al., 2017; Victorino et al., 2018), it nevertheless remains in its development as a field of study, as indicated by the proportion of literature on the topic published in the last few years (Field et al., 2018). As those published works reveal, research on servitization has been dominated by conceptual as well as qualitative studies (Rabetino et al., 2018). Also, though a great deal is known about platforms for products, their use for product–service solutions remains poorly understood. The intersection of product–service solutions and platforms thus constitutes an emerging field in which the constructs applied by scholars are under development. Given those trends, rich empirical insights are needed to properly advance knowledge about the phenomenon. According to von Krogh, Rossi-Lamastra, and Haefliger (2012), phenomenon-based research is to 'capture, describe and document, as well as conceptualise, a phenomenon so that appropriate theorising and the development of research designs can proceed' (p. 278). That characterisation indeed describes the research approach taken in this thesis, which aims to contribute knowledge about the use of platforms for product–service solutions, i.e. aiming to contribute to knowledge with the motivation

of understanding an organizational phenomenon (Schwarz & Stensaker, 2014). Although taking a starting point in the phenomenon of interest, the scope of the research has somewhat shifted over time. Nevertheless, throughout the research, the case-study design continued to facilitate closeness to the phenomenon and its context, which ultimately afforded in-depth insights.

3.1.2 A case-study design

This thesis is based on a pre-study with two case companies and a main study with one case company, which also included two embedded cases, each representing a development project. As the unit of analysis, a *case* can be described as 'a phenomenon of some sort occurring in a bounded context' (Miles & Huberman, 1994, p. 25). A case's boundaries can be determined by, for instance, the setting and the concepts used (Miles & Huberman, 1994), the case also being bounded by time and activities (Stake, 1995). To interpret data embedded in a case, a thorough contextual understanding is needed. By extension, to study a case in a complex context, a qualitative case-study approach can be especially suitable (Eisenhardt & Graebner, 2007), because the context needs to be understood in sufficient depth together with the case. For studies on servitization in general and service architecture in particular, paying close attention to context-dependent factors—for example, the industry and type of offering—has been strongly encouraged (Brax et al., 2017).

In the research conducted for this thesis, it was thought to be beneficial to study the phenomenon as it evolved over time. This was perceived to generate additional insights, preferred over a more retrospective approach common in servitization-oriented research. Retrospective case studies have been widely used to investigate servitization in terms of offerings and outcomes, while a longitudinal research design is less commonly applied (Brax & Visintin, 2017), even if encouraged as a means to provide further insights (Rabetino et al., 2018). Beyond that, collecting data continuously during a period of time was expected to benefit the accumulation of knowledge about the phenomenon as it emerged. Spending longer periods of time with people, talking to them about what they do, and coming to terms with what they say and think all provided opportunities to understand how they perceive their worlds (see Delamont, 2004). As a result, the distance between the case and the researcher diminished, which allowed a more profound understanding of the case and the context needed to access the required data.

3.1.3 An abductive, collaborative approach

To be able to develop such a profound understanding of the case in its context, the research questions for the research called for proximity to the cases studied. Also heeding the call for research that can be used to help practitioners (Baines, Lightfoot, Benedettini, & Kay, 2009), the research for the thesis was conducted according to a collaborative approach, which further allowed the required closeness. Considering that 'collaborative management research respects the contextual character of management knowledge' (Shani, Mohrman, Pasmore, Stymne, & Adler, 2007, p. 18), conducting a case study that followed a collaborative approach was perceived as a way of making the emerging knowledge relevant to practitioners. The approach described in this thesis is thus based on an emerging research focus, as the cooperation with the participating companies was expected to influence the direction of the research. Thus, the research followed an abductive approach, which prescribes researchers to move back and forth between the empirical phenomenon and theory as the case unfolds and evolves over time (Dubois & Gadde, 2002). Because the research's scope evolved amid interactions with participants and in iterations between empirical findings and theory, the process was interactive as well as iterative. Such abduction helped to steer the focus of the research towards relevant issues, being a phenomenon-driven research that aims at contributing to a body of knowledge, to thereby understand the phenomenon under study better (Schwarz & Stensaker, 2014).

The collaborative approach taken hence proved to be helpful in matching emerging empirical insights and theoretical constructs while ensuring focus on aspects that the practitioners considered to be relevant. The approach thus comprised a form of *engaged scholarship*, defined as 'a participative form of research for obtaining the different perspectives of key stakeholders (researchers, users, clients, sponsors, and practitioners) in studying complex problems' (Van de Ven, 2007, p. 9). Put differently, knowledge was created in interaction with its beneficiaries involved in the phenomenon in practice. In moving back and forth between the phenomenon and theory, the research for the thesis involved engagement and collaboration with practitioners as part of an iterative research process. Altogether, the abductive, collaborative approach taken in the research aimed to provide opportunities for joint reflection throughout the research process as a way that allowed the insights gained to influence the direction of the study.

Unlike some approaches to action research, the approach followed in the research for thesis did not seek a solution to a specific, predefined problem but instead took a more explorative approach

towards the phenomenon (e.g. Börjesson, 2011). Following the purpose to identify and describe factors influencing the use of platforms for product–service solutions, the research adopted a perspective aiming to develop knowledge in collaboration. That approach somewhat differed from any approach suitable to a purpose of designing or controlling, as opposed to identifying and describing factors, for which an action research approach would be a more appropriate choice (Van de Ven, 2007). In this thesis, the partly active role of the researcher aimed principally to promote and provide opportunities for the participants to reflect on decisions, actions, and problems. Such engagement by the researcher included being close to the cases and designing the studies in collaboration with the case companies in order to facilitate a fruitful collaboration for both parties (Shani, David, & Willson, 2004).

3.1.4 A note on basic assumptions and the research trajectory

The approach taken meant that the trajectory of the research was far from a straightforward route to a predefined objective. On the contrary, it involved an ongoing process of searching, redirecting, and scoping, and as a result, the focus of the research emerged and sharpened over time. Accordingly, the process was informed by numerous closely related assumptions corresponding to three major questions about the nature of reality (i.e. ontology), the relationship between the reality and the researcher–observer (i.e. epistemology), and the methodology, which generally concerns the nature of explaining and reasoning to study so-called 'reality' (Corbetta, 2003; Guba & Lincoln, 1994). This thesis builds upon an assumption that the nature of reality is not entirely possible to capture objectively, and although some aspects of reality do exist externally to people, despite our inability to completely capture or understand those aspects, other parts of reality are made real only by way of subjective interpretation and understanding. Added to that, it was assumed that the reality and the observer were indeed interrelated, for a researcher cannot disconnect herself from the phenomenon being studied. The methodology applied accordingly became a matter of relating to these assumptions, which aligned with the abductive approach taken by going back and forth between the empirical world and theoretical insights. The research takes it point of departure in focusing on a phenomenon of interest in organisations—the use of platforms for product–service solutions—which made it a phenomenon-driven research (e.g. Schwarz & Stensaker, 2016; von Krogh et al., 2012). Throughout the research process, insights gained from interactions with people concerned with the phenomenon in practice shaped the way forward. In short, the research's trajectory was highly influenced by both an iterative and interactive research methodology.

Setting out to define the problem, the research underlying this thesis entailed both reviewing literature and talking to people experiencing that problem, or the symptoms thereof, in practice. That framework followed the suggestion that researchers should 'become coarchitects not of the evidential content (to be translated) but of the process in which practitioners obtain evidence. The scholar's task is to ensure genuine understanding of the processes through which evidence is gathered and interpreted' (Mantere & Ketokivi, 2013, p. 84). In the process, as knowledge of the research problem accumulated over time, the scope and focus of the research evolved. The research problem was thus revisited many times throughout the research process, during the iteration between theoretical insights gained along the way and empirical findings from the studies.

Because the purpose and the research questions originated in the research problem, they were not formulated in advance but instead emerged during the research process. In that way, and as formulated in the thesis, they were formed retrospectively and adopted to guide the writing of the thesis, not the execution of the studies conducted. The very first idea for the research was to study the relationship between services and modularisation; however, as time passed, the research focus has broadened, then narrowed, and, at any rate, changed. Accordingly, in reflection of insights gained from the studies, the scope of this thesis ultimately came to encompass the intersection of product–service solutions and platforms.

Overall, the research constituted a continuous iteration between the phenomenon and the literature, with a focus that evolved out of collaboration, especially with Beta and Gamma, two of the case companies. To provide an overview of how the research process evolved, the next section accounts for the empirical studies conducted, presented in chronological order.

3.2 Empirical studies

The research informing this thesis consisted of a pre-study and a main study, the latter of which also formed the context for two sub-studies on product–service development projects: the ECOS project and the COBO project. The following sections first provide an overview of the studies conducted, after which each individual study is accounted for, with a description of their respective cases and contexts.

3.2.1 Overview of the studies

The research began with a pre-study of two companies—Alpha and Beta—followed by a main study with Gamma, another company. Within the scope of the main study were two sub-studies

conducted on two projects about developing solutions: the ECOS and COBO projects. Figure 4 depicts the timeline of the studies conducted.

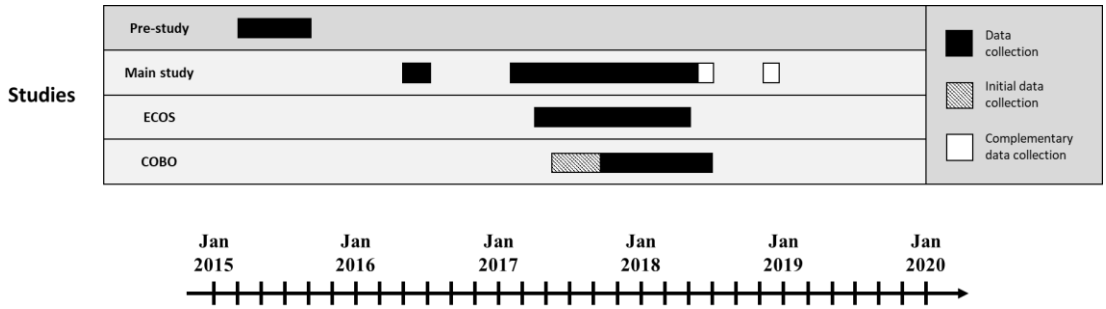

Figure 4: Research process

Within the scope of those studies, the companies involved in the research were threefold: Alpha, Beta, and Gamma. As cases in the pre-study, Alpha and Beta represented companies that provided a smaller part of the data collected for the thesis, whereas Gamma, studied in greater depth in the main study, represented a context that provided the majority of the data. Beyond that, the case of Gamma had sub-cases embedded in it (see Yin, 2014)—namely, the projects ECOS and COBO—and thus encompassed the context for them.

All of the case companies are traditionally product-oriented companies that offer product–service solutions to their customers. They all also operate in mature markets, which may not be surprising given that companies at markets with higher value generation uncertainty have been identified as more likely to offer customer-oriented services (Visnjic et al., 2019). Although the case companies exhibited some overall similarities, case selection was chiefly guided by another criterion: willingness to participate. To succeed in the described collaborative approach, in which the practitioners and the researcher were expected to work closely together, the need for in-depth access and trust among the participants was considered crucial. The final case sampling was therefore based on convenience, by utilising existing contacts within the companies to gain access to people and functions of interest within the organisation, thereby allowing the phenomenon to be studied in particular depth.

3.2.2 Pre-study: Alpha and Beta

The pre-study, designed to gain initial insights into how servitization has been managed in previously product-oriented organisations, comprised two companies: Alpha and Beta. The pre-study helped to frame the scope of the overall research in particular in terms of the offerings in focus. The insights gained hence also provided guidance for designing the research for the main study. Thus, the exploratory pre-study was initiated during spring 2015 at Beta by conducting 10 interviews with representatives at the company. Afterwards, during early autumn 2015, four additional interviews were performed at Alpha. All of those interviews were complemented with information, furnished by the companies, about solutions being provided.

The four respondents at Alpha were chief technology officers or directors of R & D or Innovation. Providing security and door opening solutions, Alpha employs approximately 48,000 individuals across all of its divisions. It operates mainly as a business-to-business firm, although also addresses the consumer market, which represents 25% of its total sales. The products and services provided by Alpha are affected by a sharpened focus on connectivity, the digital society, and the demand for electromechanical components. Services are accounted for separately only in the company's global units, in which services, on average, contribute approximately 20% of sales.

By comparison, Beta, with only approximately 1200 employees, is a smaller company than Alpha but also operates primarily as a business-to-business firm. The 10 respondents at Beta included product managers, managers of portfolio management and project office, service and solutions development managers and directors, and the chief executive officer. Albeit once a developer of telecommunications equipment, Beta is now positioned as a provider of information and communication technology solutions for the healthcare industry. Although healthcare is the company's primary target segment, Beta also provides products as well as some solutions to other industries, including retail and security (e.g. prisons). At the time of data collection, the company was launching an initiative to transition from products to solutions, which entailed sharpening its focus on the healthcare sector and becoming more software-centric. In 2017, more than 60% of Beta's revenues were associated with the healthcare industry, with more than 46% of the revenues originating from services and software (all sectors), an 8% increase in absolute terms from the year before.

3.2.3 Main study: Gamma

Once the pre-study was completed, the main study with Gamma commenced. Part of a larger company group, Gamma operates in the business-to-business transportation industry and employs nearly 60,000 employees worldwide. Due to saturation on the market, servitization has offered companies a way to differentiate themselves from competitors (Vandermerwe & Rada, 1988). In the transportation industry, solutions are increasingly used as a way of offering mobility instead of providing products to customers (Mahut, Daaboul, Bricogne, & Eynard, 2017). That trend can be illustrated by the share of Gamma's service-oriented business, which grew by approximately 8% from 2017 to 2018 and, as a result, constituted 23% of net sales in 2018.

Companies operating in industries with value generation uncertainty, given the lower potential of existing technologies (e.g. late stages of the industry life cycle), tend to offer customer-oriented services such as solutions (Visnjic et al., 2019). That tendency partly dictated the choice to investigate Gamma's case in an extended study. From previously focusing on basic services such as spare parts provision, maintenance, and financial services, the company increasingly engages in providing transportation solutions, and during the last couple of years, it has launched several solutions that have gained considerable attention from customers, the transportation industry, and the public. Such solutions, which integrate products and services during the development phase, thus became the focus of the research, following insights from the pre-study about the difficulties of involving product development in the provision of services.

Aside from that, because modularisation and platforms were of interest to the research, Gamma's longstanding experience with using such strategies was perceived important. As Sousa and da Silveira (2019) have suggested, companies pursuing a product customisation strategy are well suited to offer services as well. In the case of more advanced offerings, the link between service provision and customisation might be due to improved customer interaction (Sousa & da Silveira, 2019). Gamma has long worked to provide customised products by applying strategies to efficiently manage the customisation of those products. Gamma's extensive experience with deploying modular and platform strategies for their products, which is common in the industry (Mahut et al., 2017), was considered to making them especially beneficial for the studies, as it began shifting focus towards doing the same with services and solutions. On top of that, because closeness was considered to be essential in the research, that Gamma afforded access for research and suitable projects to examine should not be underestimated in its selection as a case company.

The continuation of the study was facilitated by closeness between the researcher and the company, particularly important for this matter were the so-called 'key informants' or 'principal informants', who in case studies need to be identified as sources of support (Bryman & Bell, 2011; Voss, Tsikriktsis, & Frohlich, 2002). Although the first interviews at Gamma were conducted before summer 2016 with representatives of the company's service and commercial development function, who provided initial insights into Gamma's work with services and solutions as well as its portfolio of offerings and how they managed them, two key informants at Gamma, both commercial project managers, served as primary contacts and informants thereafter. As suggested by Voss et al. (2002), however, because the key informants were not completely initially identifiable, finding a suitable prime contact—for example, a senior manager with a more comprehensive view of the organisation—was a necessary step before establishing closeness with the key informants. At Gamma, one of the key informant's role indeed involved granting the researcher access to the organisation. However, an even more senior manager granted further access, including physical and digital access, access to the work area and a desk, and even access to team meetings and social activities (e.g. Christmas dinners). Thus, the prime contact, who helped to identify relevant cases and was involved in ongoing discussions, collaborated with an even more senior manager who provided formal access to the organisation. More in-depth discussions about the cases studied, not to mention operational access (e.g. access to informal meetings), were granted by the key informants. Such individuals were not only knowledgeable about the topic being studied but also provided access to the organisation and support throughout the study. Those key informants also reviewed the final papers as part of the research's validation. In the ECOS and COBO projects, one of the key informants, who provided initial insights into both projects, also played an especially important role in identifying and providing access to meetings, both formal and informal, about the projects.

With such access provided by the key informants, the researcher had the opportunity to spend two days a week within Gamma's service and commercial development function. The opportunity not only afforded proximity to the case and the data collected but also facilitated informal conversations and meetings between the researcher and employees of Gamma. During the time spent on-site, reflection meetings were also held that provided opportunities for joint reflection by the researcher and company representatives as well as established a way forward for the research. Moreover, those meetings influenced the scope of the research as challenges and concerns on the

managers' minds directed the research's focus into relevant activities and trends occurring within the context of the organisation. While working on-site at Gamma, the researcher was given her own desk, complete with a nameplate, which facilitated ongoing conversations about topics of interest as well as more general discussions about what was happening in the company. On top of that, access to lunches and coffee breaks provided rich information about perceived obstacles, reasons for frustration, and managerial responses. At times, getting caught up in those conversations and daily operations complicated distinguishing what was officially within the boundaries of the case and what was extraneous material. On top of that, the researcher additionally participated in meetings with the team associated with the service and commercial development function, including ones about developing a partnership strategy and ones with potential external partners. During those meetings, the researcher also actively participated by providing input and reflections about, for instance, a proposed framework for partnership.

Although provided extensive access to the organisation, which was enhanced by participation in the mentioned meetings, the researcher struggled to avoid 'going native'—that is, adopting the perspectives of the people being studied at the expense of the researcher's perspective (Delamont, 2004). As time progressed, that struggle even became reflected in the actions of the managers. On several occasions, personnel at meetings would address 'You in the commercial department', including the researcher along with the department's staff. In another example, during one of the projects, when all project managers in the weekly meetings reported on the current status of their work, the researcher also participated in reporting status updates. Although the researcher greatly appreciated such inclusion, for it indicated a certain closeness with the research participants, it also sometimes obscured the other reality that research was being conducted. Thus, in an effort to guard against going native, several complementary strategies were used. To highlight that the researcher's primary role was indeed that of a researcher, her university-affiliated email address was used to send and receive all emails to and from employees at the company, even at the risk of limiting the information that could be sent due to confidentiality, as some content was prohibited from being included in such correspondence. Furthermore, the researcher and the key informants clearly communicated to the organisation that her role was that of a researcher—more specifically, a doctoral student studying the company—both before and at the beginning of interviews, as well as while in contact with other personnel in the organisation (e.g. in meetings). Another helpful tactic was discussing emerging findings of the study with other researchers investigating Gamma, albeit

in different functions of the company. Because such individuals were knowledgeable about the organisation and encompassed by the confidentiality agreement, those discussions often provided exceptionally fruitful insights into other perspectives on provision of services and solutions were given.

Following the initial interviews as well as extended time spent in the Gamma's service and commercial development function, two projects were identified for further case studies. In both of those studies, the aim was to trace the evolution of efforts in developing solutions within the organisation. Yin (2014) has described holistic and embedded cases, which can be subject to both multiple- and single-case studies. Once solutions at Gamma and their development had been studied holistically in a broad sense, insights gained in initial interviews and during extensive collaboration with key informants at the organisation helped to identify the ECOS and COBO projects as suitable embedded cases. Such a design facilitated studying the cases from different perspectives, all while continuing to allow a sufficient depth of the case and sensitivity to the context.

3.2.4 The ECOS and COBO projects

To be suitable sub-cases for study, projects chosen were ongoing to be representative of longitudinal cases. Voss et al. (2002) acknowledge that for case selection, a choice has to be made to choose retrospective or longitudinal cases. Being embedded within the main case study, ongoing, longitudinal cases as ECOS and COBO were expected to furnish ample opportunities to study the use of platforms in product–service solutions not as a static but as a continually developing phenomenon. Studying such projects as they happened was also anticipated to reduce the risk of interviewees' forgetting about previous but relevant developments within the cases, as well as to prevent interpretations of situations or decisions based on information not available at the time of decision (Voss et al., 2002). Two downsides of the approach, however, were the difficulty of evaluating the projects' outcomes and the time-consuming nature of studying longitudinal developments. Nevertheless, the approach did provide first-hand access to the projects, which allowed observations of events as they unfolded and enabled proximity and, in turn, sensitivity to the temporal and spatial aspects of the context being studied.

Both the ECOS and COBO projects concern connected products and integration of data from different sources in order to deliver services and solutions. More relevant to the research conducted

for the thesis, both projects also involve the engineering-oriented integration of products and services (Park et al., 2012). In addition, the ECOS and COBO projects both necessitate partnering with external actors in bringing solutions to the market. Indeed, work performed in association with Gamma and its partners was undertaken in part for the projects.

On the one hand, the sub-case study of the ECOS project started in spring 2017 and lasted approximately a year, during which time the development process was examined by observing project management meetings and through interviews with project managers. Throughout the study period, the researcher's on-site presence facilitated her participation in project-associated work meetings and planning meetings as well. On the other hand, the sub-case study of the COBO project began before summer 2017, before the project had been formally given a go by the organisation. The primary period of data collection for the COBO study commenced in autumn 2017 with the observation of project management meetings and interviews. The period ended nine months later, more than a year after the first project meeting, when the launch of the solution was imminent.

Although the ECOS and COBO projects are interlinked, because they involve using connected products, integrating data from various sources to deliver solutions, they also differ in size, duration, and governance. In particular, ECOS is a large, long-running project, whereas COBO is a smaller one without as much history. In fact, COBO in part aimed to provide insights into ECOS. The projects also differ in that ECOS is designed to facilitate the wide-scale provision of services and solutions, whereas COBO seeks to support the development of a certain type of solutions. The COBO project represents a case of working with other firms to provide solutions to end customers. Altogether, the projects were considered to complement one another in terms of using platforms for product–service solutions.

3.2.5 Connections between the studies and appended papers

The papers appended to this thesis have applied data to varying degrees from the pre-study of Alpha and Beta, the case study examining Gamma, and from the sub-case studies examining the ECOS and COBO projects. Figure 5 illustrates the connections between the studies and the appended papers.

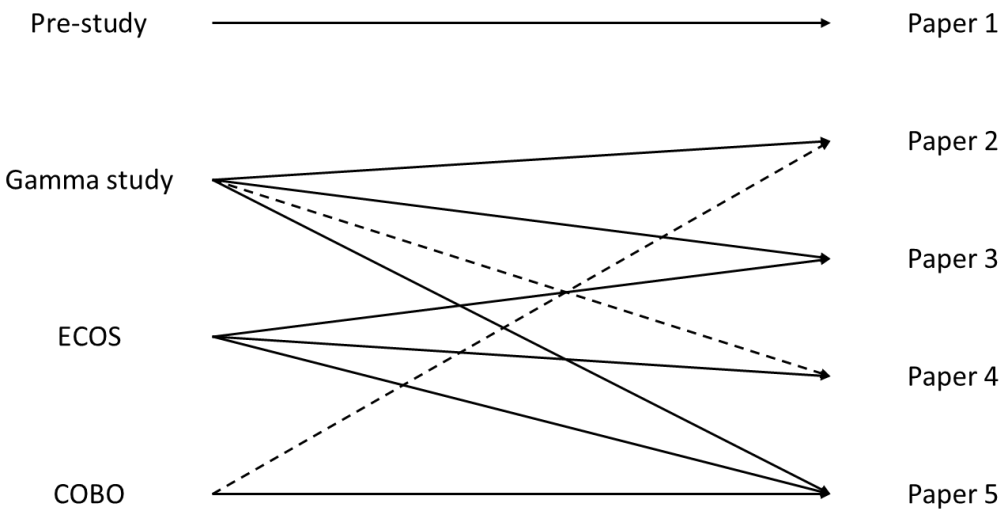

Figure 5: Connections between the studies and appended papers

Paper 1 is based solely on data from the pre-study. A first draft of the paper was presented at the 4th International Conference on Business Servitization, held on 19-20 November 2015 in Madrid, Spain. With reference to suggestions provided at the conference, the paper was reworked and submitted to the *International Journal of Technology Management* in June 2016.

The case study examining Gamma formed the basis for Paper 2, which was submitted for publication as a book chapter in September 2017. The paper was co-authored with an industrial doctoral student also involved with Gamma, as well as with the supervisor of this thesis' author. In the paper, the joint understanding of the case company and the phenomenon played an important role. In revised versions of the paper, insights into the COBO project were added to support those drawn from similar projects conducted at Gamma.

Interviews with representatives at Gamma formed the basis of Paper 3, an initial version of which was presented at the 17th International CINet Conference, held on 11-13 September 2016 in Turin, Italy. Because data collection at Gamma continued after that point, some insights from the ECOS project were added to Paper 3, which was subsequently submitted to the *International Journal of Innovation Management* in July 2017. After the first round of review, the paper was further developed based on the comments provided and with the addition of data from the ECOS project.

Paper 4 is largely based on data about the ECOS project, the analysis of which showcases the project's progress over time. A first version of the paper, using only a portion of the data ultimately collected, was presented at the 18th International CINet Conference, held on 10-12 September 2017 in Potsdam, Germany, and later invited to appear along with other papers from the conference in a special issue of the *International Journal of Technology Management*. Prior to being submitted for publication in the journal in December 2017, the paper was further developed to include data collected since the conference.

Last, the first version of Paper 5 was submitted to the *Journal of Business Research* in September 2017. The paper is based on collaboration with the industrial doctoral student who also co-authored Paper 2. In the paper, data came from the case study examining Gamma and from a study conducted by the industrial doctoral student. Revised versions of the paper additionally included data concerning the COBO project. Involving a third author as well, the paper was developed in a highly collaborative manner.

3.3 Data collection

The studies included in this thesis were all conducted by the author, who also collected all of the data.[13] Although interviews and observations generated most of the data, spending a considerable amount of time at Gamma enabled ongoing informal conversations, both in conversational interviews and reflection meetings, that proved useful in developing knowledge about the contexts of the cases. Other data came from internal documents and presentations. Taken together, the various sources of data contributed to an in-depth understanding of the cases as well as allowed data triangulation. At the same time, such a large amount of data required properly documenting and selecting data of interest to the research. How such documentation and selection proceeded is explained in the following sub-sections, which first account for why different sources of data were used. Thereafter, the interviews, observations, and informal conversations are described.

3.3.1 Using different sources of data

The lion's share of data used for this thesis comes from interviews and observations, where were supported by informal conversations. Whereas the pre-study involved interviews only, the main study examining Gamma, which included the sub-studies about the ECOS and COBO projects, involved interviews along with observations in addition to informal conversations and document

[13] Papers 2 and 5 include data collected by another researcher that are not accounted for in this thesis.

collection as supporting material. In the study examining Gamma, observations and interviews conducted for data collection complemented each other and enabled incisive as well as extensive insights into the case company. Bryman and Bell (2011) have identified several advantages of performing observations in relation to interviews and advantages of interviews compared to observations. Among other things, observation is regarded as an opportunity to see through others' eyes, for observers should be in contact with other people for long periods of time in order to boost the sensitivity to the contexts being studied. Observations also allow capturing aspects that are taken for granted in organisations and activities that may be hidden, all of which are liable to go unmentioned in interviews (Bryman & Bell, 2011). By contrast, interviews are considered to allow the reconstruction of events (Bryman & Bell, 2011), which is impossible to capture from observations. Interviews not only provide a great breadth of coverage but also offer the opportunity to focus exclusively on the topic being studied (Bryman & Bell, 2011; Kvale & Brinkmann, 2009). In that way, more specific questions can be posed during interviews, whereas observations may not be guided in the same way. Considering those advantages and disadvantages of the different means of data collection, all were deployed in combination while following the cases over time to gain first-hand access to events, challenges, and actions as they happened, as well as to allow the people involved in the projects investigated to provide their perspectives in the interviews. Combining observations and interviews to varying degrees at different points in time enabled capturing the cases and their contexts to a sufficiently thorough extent.

Table 4 summarises the sources of data used in the different studies.

Table 4: Data sources and volume

Source / Study	Interviews		Observations		Informal conversations	Documents
	Number of (formal) interviews	***Hours of recordings***	***Number of (formal) meetings***	***Hours of observations***	***Hours***	***Description***
Pre-study	14	12	0	0	~5	Descriptions of solutions officially available (online and marketing material)
Gamma study	12	9.5	19	27	~200	Descriptions of offerings, processes, organisation charts etc. (official and internal)
ECOS	11	10	42	56	~30	Notes from meetings, presentations, work-in-progress etc. (internal)
COBO	6	5	17	12	~15	Notes from meetings, presentations, work-in-progress etc. (internal)
Total	**43**	**36.5 hours**	**78**	**95 hours**	**~250 hours**	

Regarding the data shown in Table 4, all interviews were preceded by informal conversations that involved an introduction to the respective study being conducted. The conversations were not recorded and thus not included in the hours of recordings listed. Likewise, the data representing the observations refer to observations of formal meetings only. Nevertheless, shadowing and time spent on-site were essential to understanding the context of the cases, for they facilitated discussions at the coffee machine, for example, as well as ongoing informal interviews and meetings. Although such informal means of data collection are difficult to account for in absolute terms, largely because they were employed across 44 weeks of on-site research activity, a rough

estimation appears in the column titled ‘Informal conversations’. The informal conversations accommodated both work-related discussions and personal reflections, and although notes on the conversations seldom underwent coding, they did afford opportunities for data triangulation and enriched the understanding of the case at hand.

In addition to interviews and observations, documents such as process descriptions, work-in-progress reports, and information about different solutions and services provided were consulted. For purposes of data triangulation, emails containing meeting minutes not taken by the researcher, were also examined. Altogether, such data amounted to hundreds of pages of records that helped to illuminate the cases and that were used in reflections made throughout the research process.

3.3.2 Interviews

Developing product–service solutions relies heavily upon the people involved in that process. To capture their perceptions and viewpoints, interviews were used in all studies. In the pre-study, interviews were the chief means of data collection, together with reviews of official information about the solutions being provided. For the case study examining Gamma, interviews were also used to establish an understanding of the overall case. Likewise, interviews were conducted in the sub-case studies about the ECOS and COBO projects in order to complement the observations being performed in parallel.

In interviews, knowledge was constructed via interaction as the interviewer and interviewee conversed about a certain topic (Kvale & Brinkmann, 2009). In that process, in being asked rather open questions about specific areas of interest, the interviewees were allowed to highlight aspects of those areas that they found to be important. In that way, the interviews sought to follow the reasoning of interviewees while enabling coverage of the specific topic under study (Bryman & Bell, 2011; Kvale & Brinkmann, 2009). Although most of the interviews were semi-structured, open-ended interviews were also conducted. Enabled by the researcher’s continued presence at the organisations, the open-ended interviews were typically conducted when the opportunity presented itself, and the majority of them thus occurred during the study at Gamma. They hence relate to some kind of a mix of interviews and observations, that has been termed participant observation (Delamont, 2004).

Whether open-ended or semi-structured, the interviews provided a flexible means of data collection that generated rich, detailed data about the phenomenon of interest, which could be

further probed with follow-up questions encouraging interviewees to elaborate upon certain aspects of their statements. Following a description of a formal process, for example, questions could be asked about how the process is perceived and used, which helped to inform emerging understandings of that process.

Forming the majority of interviews in all studies, semi-structured interviews were recorded and usually scheduled to last an hour. Although often conducted in person, interviews conducted with personnel located at a distance took place via Skype or over the phone. The researcher conducted all interviews alone, except for one in which a co-researcher participated as well. All semi-structured interviews followed a basic, three-part structure. First, during an introduction, the researcher introduced herself, the aim of the study, and the goal of the interview, after which aspects of confidentiality were explained, and permission to record the interview was obtained. Those formalities completed, the key informants in the organisation were identified so that they could be referred to during the interviews if needed, and the interviewee was asked to describe her or his role in the organisation and, when applicable, in the project. In the second part, structured by an interview guide, a series of questions was asked about various topics. In the third and final part, the interviewee was thanked for participating, and permission to ask follow-up questions at a later time was requested. Last, the interviewee was asked whether he or she had expected to be asked any questions that were not in fact asked during the interview. That final step provided insights into what the interviewees perceived to be especially important (e.g. if a topic discussed during the interview was again mentioned) or had expected from the interviews.

As is typical, the semi-structured interviews followed interview guides. In the pre-study, interviews followed an exploratory interview guide structured by topic to reflect the exploratory nature of the study. In the study examining Gamma, by contrast, an interview matrix was used containing general who, what, why, and how questions in all the four categories of platforms suggested by Robertson and Ulrich (1998). Although those general questions directed the interviews, more specific questions representing each category also provided guidance. By some contrast, for the interviews addressing the ECOS and COBO projects, it was considered to be important to have questions that partly overlapped topics in order to enable cross-case comparison. Thus, whereas the interview guides addressing each project differed to some extent, more general topics appeared in both interview guides to clarify the project's purpose, its progress, challenges encountered, and

its perceived focus. In interviews for the projects, interviewees were also asked to rate mechanisms of and barriers to product–service integration in the projects on a 7-point scale while they spoke about how those mechanisms and barriers were being addressed in the projects. Although the numerical ratings that interviewees recorded were not analysed, the technique was nevertheless useful, because it prompted them to reason about the project in their own words and, in turn, take a stand on its rationale in one way or another.

Identified by the key informant(s), prospective interviewees for each study were thought to have knowledge about the areas being investigated and to collectively represent a range of perspectives. Because developing solutions is cross-functional work involving people from different functions in organisations, it was useful to have the key informants identify possible interviewees, as well as provide the researcher with their contact information. Initial contact with the interviewees was made directly by the researcher with reference to the key informant(s). Thereafter, in the interviews, additional interviewees were identified in a process of snowball sampling as the current interviewees referred to others' work or colleagues with more knowledge about specific topics. In that way, the overriding goal of identifying interviewees with different perspectives on topics in focus was achieved.

In the studies about the ECOS and COBO projects, interviews were conducted with project managers who were thus necessarily also participating in the meetings observed. In fact, such interviewees were initially identified in the meetings as representatives of the different aspects of the project in question. Thus, the project managers interviewed represented both staff from the organisation's technical department as well as more commercially oriented departments. During the projects, interviews commenced only after the projects had been active for several months, mostly for two reasons. One, that strategy enabled the interviewees to reflect on events and challenges encountered during the project thus far. Second, at that time, because the researcher had participated in several meetings and long been in contact with the project, the interviewees were familiar with the interviewer to some extent. For the same reason, the researcher was more knowledgeable about the project's context, including the language being used in the firm and about the project in question, which precluded needing clarification about terminology, commonly used abbreviations and acronyms, and the names of people involved. Such knowledge enhanced both

the questions asked and the interviewer's understanding of the answers given. In turn, it afforded the possibility to ask follow-up questions that were more detailed and focused.

3.3.3 Observations

Observations of the ECOS and COBO projects focused largely on meetings with the project managers, although observations of project-associated meetings were also performed. Being on-site at the companies in a part-time capacity enabled the researcher to participate in such meetings, which were often scheduled on short notice, for example, in response to a project-related setback or at the request of stakeholders. In that way, the observations reflected Bryman and Bell's (2011) description of sampling in observational studies as a combination of both snowball and convenience sampling, because attendance at the meetings was made possible by the key informants by virtue of their organisational function and their networks within the company. Following project managers associated with service development meant that meetings of great technical character, for instance, were not attended. Even though that circumstance was perceived as a delimitation, it was not to the disadvantage of the study's focus.

To some extent, the observations in the research showed similarities to shadowing, defined as 'a research technique which involves a researcher closely following a member of an organization over an extended period of time' (McDonald, 2005, p. 456). In that sense, the person shadowed was a commercial project manager. The meetings observed, especially the less formal, ad hoc ones, were nearly all attended by the commercial project manager. In implementing such a shadowing technique, several strategies outlined by McDonald (2005) were adopted: taking the time to get to know the context, the organisation, and the individuals; writing down as much as possible; planning data management; taking notes in a notebook (i.e. recordings are not suitable); consulting a mentor outside the organisation; and performing a so-called 'daily tape dump' of notes. However, adaptations were also made in order to manage time and practical issues arising from combining some of those recommendations. For instance, notes were taken primarily on a laptop computer, not a paper notebook, on formal occasions (e.g. weekly meetings) due to the difficulty of writing quickly by hand without having a table as well as problems with the lack of structure for searching in the notes in retrospect. However, a hard notebook was used for more informal occasions when notes were taken throughout the day.

To become familiar with the organisation, interviews at Gamma were conducted before observations commenced. The interviews, described in Section 3.3.2, were geared towards not only collecting data but also gaining initial insights into the organisation overall. Starting to spend time on-site further familiarised the researcher with the context before studying the projects. Another strategy was taken from Delamont (2004), who has argued that one of the most important tasks for researchers is recording what they see, which is usually achieved by taking field notes. At the same time, one of the greatest challenges in preparing for fieldwork is determining what to observe and how, as well as how to write it down for future reference (Delamont, 2004). Due to the different settings studied, it was indeed challenging to find explicit descriptions in the literature of how recording observations can be achieved. At the case companies, using a paper notebook was initially attempted, as suggested by McDonald (2005), and 'as much as possible' was written down. However, considering the time spent on typing notes into the computer and the amount of data produced, it was decided to shift notetaking primarily to the computer.

In taking notes, an observation scheme was used in which information about setting, discussions, and personal impressions was recorded in a structured way. Aside from general information (e.g. dates and occasions), the environment and context of the observations, as well as who attended meetings, were noted. The observation scheme was thereafter structured to include general area of the discussion, duration (not initially included), observation of what was discussed or happened in the meeting, illustrative statements from the discussions, activities and actions, decisions, and personal note(s) about the subject discussed. Therefore, the observation scheme (see Appendix A) provided a basis for distinguishing descriptions, quotations from participants, and the researcher's personal interpretations. During observations, focus largely fell to the reasoning of participants and their discussions during meetings. In terms of language, notes about the observations reflected the language used by the actors involved: Swedish, English, or some combination thereof. Because some recorded information was highly confidential, codes were used for especially sensitive information.

It was also considered important to take the searchability of the documents into account. Given that need, all observations of ad hoc, non-recurring meetings (e.g. sporadic meetings), were marked with hashtags concerning their subjects. As such, data regarding observations were already partly

categorised during data collection in order to be easily accessible and displayable later in the research process.

In addition to notes taken during the day, a reflection diary was kept by the researcher, as advised by Spradley (1980) and Delamont (2004). In the diary, notes were taken regarding not only personal concerns and thoughts regarding the cases but also data collection itself and, more broadly, the methods being employed. Thus, the diary provided a way of reflecting upon the time spent in the field, concerning methodological choices and struggles as well as progress in the organisation's operations. For instance, if the way in which recordings were made was altered, then a note was made in the diary. Another example was when duration began to be included in the observation scheme. Aspects of confidentiality and ethical considerations were also reflected upon in the diary.

3.3.4 Informal conversations

Essential to building contextual knowledge, the informal conversations held throughout the studies mostly occurred at Gamma, entirely due to the disproportionate amount of time spent there in order to achieve proximity to the case company. Having a desk on-site enabled a range of informal conversations to occur throughout any given day. For some of the conversations, notes were taken, either directly on the computer or in a paper notebook, whereas other interesting aspects or reflections were noted retrospectively in the diary at the end of the day or week.

Overall, the informal conversations seldom influenced coding but nevertheless provided valuable insights into the cases and their contexts. The conversations helped the researcher to understand the language of the organisation, including the terminology and abbreviations used, which aligns with McDonald's (2005) advice to spend time in the organisation being studied in order to become familiar with both the context and the individuals operating therein. Learning that language facilitated the researcher in asking appropriate questions during interviews, as well as to focus on essential issues during observations.

As with observations, key informants at Gamma played a vital role in what informal conversations the researcher engaged in. The researcher followed the project managers to meetings considered to be of interest and often ate lunch and had coffee with them and their colleagues. Thus, the key informants were crucial means to becoming familiar with the organisation as well as facilitated access to and acceptance from the people there. However, that dynamic also affected with whom the informal conversations were held, because the settings attended were mostly associated with

the company's service and commercial development function. In response, to broaden the perspective, the researcher engaged in conversations with more technically oriented personnel in connection with the project management meetings for the ECOS and COBO projects.

During the study of the projects, informal conversations were held mostly in association with the weekly meetings attended. By being present in the meeting room well before meetings commenced, the researcher was able to engage in discussions about the projects with the project managers. Such conversations were especially frequent with the primary project manager of each project, who was usually preparing for the meeting. As attendees arrived, conversations on important issues and concerns for the project managers provided valuable input. Such conversations proved valuable in forming an overall understanding of the challenges faced by individual project managers. Often, similar conversations were held after meetings to clarify topics discussed for the researcher.

3.4 Data analysis

A reflective stance was taken throughout the research for this thesis, meaning that the findings accounted for herein drew from data from all studies conducted during the research process. Likewise, analysis continued throughout the case studies as is common in abductive research (see e.g. Dubois & Gadde, 2002). The interpretation of data as well as the cases evolved as knowledge about the cases and their contexts developed and expanded. For the sake of a holistic perspective, contextual knowledge was essential, and to establish such knowledge, closeness and collaboration with the company played vital roles. While data from interviews and observations fed into the coding process, as described below, the informal conversations and documentation were used to enhance the understanding of the cases and their contexts, which ultimately informed the findings in this thesis. As aforementioned, they also established an opportunity for triangulation.

The data analysis generally followed the steps of the iterative procedure proposed by Miles, Huberman, and Saldana (2014): condensating the data, displaying the data, and drawing and verifying conclusions. Although the actual process differed from paper to paper, general notes on the process are provided here, because the findings in the thesis derive from insights gained over all studies combined. Moreover, as part of the abductive approach taken in the research, analysis involved a continuous iteration between the cases and theoretical insights from the literature.

In the first step of analysis, condensating the data was performed by assigning codes to chunks of data. In that sense, codes refer to words or brief comments indicating or summarising relevant

material in the data considering the aim of the research (King & Brooks, 2018; Saldaña, 2015). By extension, coding can be described as the process of indexing and arranging information in a certain order, followed by forming categories or themes (King & Brooks, 2018; Saldaña, 2015). Coding is thus a cyclical act (Saldaña, 2015). However, differing between papers, the first coding cycle contained codes either derived from the empirical data or identified in the literature, which were thereafter clustered in a highly cyclic process to form themes.

Researchers commonly code their data both during and after data collection (Saldaña, 2015), and the coding performed during data collection described here is referred to as pre-coding. Especially during the collection of data during observations, pre-coding was applied in taking notes. In the field notes, for example, codes were assigned to chunks of texts to indicate the area of topics under discussion in the meetings. Often, those areas were dictated by the meeting agenda and were thus quite general in nature. However, thoughts also surfaced during note taking that were recorded in the observation scheme in the column titled 'Observer's thoughts'; such thoughts could also be considered as a type of pre-coding. In that way, pre-coding largely depended upon codes derived from the empirical data.

To display the data, different kinds of matrixes, among other methods, can be employed (Miles et al., 2014) and were indeed used in several of the papers. Into those matrixes, data were continuously added as the studies progressed. In Paper 3, for instance, the matrix was constructed based on four categories of platforms on the y-axis and the questions of who, what, why, and how. For the ECOS and COBO projects, the data were displayed on timelines with weeks or months appearing on the x-axis, thereby presenting the chain of events in the projects focusing on perceived challenges, discussions, and actions taken in response. The timelines also included illustrative statements as well as a general note, or theme, summarising each specific period (i.e. a week or month). In that way, themes were developed that could be called 'intrinsically recurrent' (King & Brooks, 2018). Forming those themes was thus part of drawing preliminary conclusions as well. The data were then revisited, data from other sources were reviewed, and discussions with representatives of the company were held to verify the conclusions. All papers were also read by those representatives and, when applicable, the project manager and the one responsible for confidentiality aspects of the project. Overall, the dialogue about the findings throughout the study was considered important to address aspects of the research's quality.

3.5 Reflections on research quality

This final section of the chapter reflects upon the quality of the research conducted for the thesis. It takes its point of departure in the increasingly acknowledged need for both relevance and rigor in research (e.g. Van de Ven, 2007; von Krogh et al., 2012), which were in this thesis manifested in phenomenon-driven research following a collaborative and abductive approach. First, this section reflects upon the research's rigour, followed by a look at its relevance. In closing, the chapter presents a table summarising the means used in the research to gauge or ensure its quality, expressed in terms of trustworthiness and relevance.

3.5.1 Rigour

Acknowledging that contextual knowledge is highly important in phenomenon-driven research and in applying a collaborative approach, this thesis adopts the concept of trustworthiness (e.g. Guba, 1981; Guba & Lincoln, 1989) as a basis for the reflection of the research's quality. Although the criteria of objectivity, reliability, external validity, and internal validity are commonly used in naturalistic research, they do not necessarily suit all paradigms of research. The qualitative approach adopted in the research called for measurements of its quality that reflects the intentions and emphasis of such a design. Guba (1981) has acknowledged that rationalistic and naturalistic paradigms differ in relation to several key assumptions that can affect the evaluation of research quality, including the nature of reality, the nature of so-called 'truth statements', and the nature of the relationship between the researcher and the participants—altogether, ontological and epistemological aspects. The research presented here followed an approach in which the relationship between the researcher and the participants was characterised by collaboration and closeness. Whereas the conventional criterion of objectivity seeks an objective distance from the phenomenon being studied (Guba, 1981) and the general criterion of generalisability seeks independence from context, neither of those criteria was achievable in the research reported here, due to the embeddedness of the case in context and the relationship between the researcher and the case that emphasised proximity instead of distance.

It has been argued that evaluation criteria originating from naturalistic research do not take context into consideration, aside from statistically or physically controlling for it (Guba & Lincoln, 1989). This thesis reports a case study approach, dictated partly by the importance of context to understand the phenomena (Eisenhardt & Graebner, 2007). Therefore, the concept of trustworthiness was perceived to provide a better foundation to account for reflections on the research's quality, despite

that the concept is proposed mainly for the constructivist paradigm (e.g. Guba & Lincoln, 1994). In that paradigm, all realities are subjectively constructed, and in response, constructivist researchers often adopt a methodology characterised by an inductive approach (Corbetta, 2003; Guba & Lincoln, 1994), which reflects an even more subjective view than what underlies this thesis. The aspects of trustworthiness, however, provide a foundation for elaborating upon the research undertaken by reflecting a more subjective, context-dependent view than what naturalistic evaluation criteria offer. The aspects of trustworthiness, credibility, transferability, dependability, and confirmability correspond roughly to the more conventional criteria of internal validity, generalisability, reliability, and objectivity (Guba, 1981; Lincoln & Guba, 1986). In relation to those aspects, some reflections already made throughout this chapter are again outlined here along with others.

In the research process, discussions about the findings were held with representatives of the companies, as well as with external parties knowledgeable about the phenomenon of using platforms for product–service solutions. Such discussions reflected the notion of credibility, which corresponds to the idea of internal validity. Discussions with representatives, in which findings and insights were presented, were continually held during the studied themselves as well as after the studies has been conducted. In that effort, the collaborative approach proved helpful, for it enabled and enhanced interaction throughout the research process. An ongoing dialogue welcomed discussion about interpretations made in the process and provided a forum in which potential misunderstandings could be discussed and corrected. Such an approach can be referred to as respondent validation, which is a valuable strategy for making findings more believable (Maxwell, 2012).

In addition to such respondent validation, peer debriefing can be used to enhance credibility (Guba, 1981; Lincoln & Guba, 1986). During attendance at conferences and seminars, findings could be discussed with scholarly peers, at which time peer debriefing was undertaken. Especially valuable to this study were discussions with other researchers conducting studies at the same company who were concerned with similar or associated phenomena. Because such individuals were under non-disclosure agreements, those discussions could be more open than discussions at seminars and conferences.

Addressing the notions of credibility and confirmability, data triangulation was applied in the studies for the thesis, as suggested by McCutcheon and Meredith (1993), among others. Several different sources of data were used to understand each of the cases, including interviews, observations, informal conversations, and documentation. Close, prolonged contact with the companies enabled the collection of data from those various sources, which also provided an opportunity to use the sources in an iterative manner to enhance the understanding of the cases.

Confirmability concerns whom is being heard in research. The notion differs from objectivity (Guba, 1981), because it is concerned with the degree of which the researcher's values have biased the results rather than aiming for completely distance therefrom. When a researcher is close to the data, as in the research reported here, it is necessary to 'shift the burden of neutrality from the investigator to the data' (Guba, 1981, p. 81). Using triangulation during the data collection, as well as a diary to practice reflexivity, as suggested by Guba (1981) and Spradley (1980), are considered to increase the confirmability of research. That diary included reflections on the findings, the process, and the methodological choices and changes made. The observation scheme (see Appendix A) was also helpful in notetaking, for it separated communicated actions and discussions from the researcher's interpretations and comments.

Using overlapping methods and leaving an audit trail can also be important for a study's dependability (Guba, 1981; Lincoln & Guba, 1986)—that is, the degree to which the findings apply to other times if replicated. Associated with consistency and transparency, dependability corresponds to reliability in conventional evaluation criteria (Guba, 1981). To be able to track potential variations to sources, as well as over time, efforts were undertaken to ensure that the research process was thoroughly documented and recorded. Dependability was accordingly addressed in the recorded interviews and the properly structured observational notes. Because closeness to the case resulted in vast amounts of data, especially concerning more informal conversations and meetings, a system in which the documents were labelled with hashtags of the key topics was used. Using a diary also made it possible to not simply rely on retrospective sense-making of choices made along the way. The diary documented reflections after discussions with company representatives, thereby leaving an audit trail of the researcher's emerging insights.

Last, transferability is concerned with the possibility to evaluate the applicability of findings in another contexts (Lincoln & Guba, 1986) and, as such, underscores the need to carefully account

for the setting of a case. Thus, it does not imply a need for generalisability independent of time and space (Guba, 1981; Lincoln & Guba, 1986) but sensitivity to the context of the case. The research presented here adopted a design in which the cases were studied very much within the context in which they have existed. Such closeness enabled deep contextual knowledge. By accounting for the context in depth, it can be possible to evaluate whether theory from the case could be used in another case. That possibility therefore depends on the similarities of the contexts of the cases as contingencies (McCutcheon & Meredith, 1993). In workshops with participating companies (i.e. Beta and Gamma) and others, differences and similarities between industries and contexts were reflected upon. In those workshops, findings were presented and discussed in light of their individual contexts, which afforded insights into the transferability of the findings. However, though the contextual knowledge of the researcher was arguably high, the possibility for providing an in-depth description of the context was constrained by the case companies' need for anonymity. Although the research design enabled closeness to the case and contributed to the relevance of the research, it also prevented the sharing of sensitive knowledge held by the researcher due to reasons of confidentiality.

3.5.2 Relevance

The notion of trustworthiness principally concerns the rigour of research. In phenomenon-driven research, the notion of relevance is of equal importance, however, for it is concerned with making the research process, as well as the outcomes, matter to practitioners. In the research for this thesis, the adoption of an abductive, collaborative approach facilitated the creation of knowledge relevant to individuals who encounter the phenomenon in practice. Maxwell (2012) has suggested that research quality can be enhanced via intense, long-term involvement. In this thesis, such close engagement with the cases served to increase the research's relevance.

Overall, the relevance of this thesis is mainly associated to conceptual relevance, which is concerned, for instance, with new concepts and metaphors along with the identification of contingencies, causal relationships, and side effects, if any (Nicolai & Seidl, 2010). Such relevance does not imply a trade-off with rigour per se (Nicolai & Seidl, 2010), and strategies aiming to enhance relevance can also help to improve the rigour of a study. However, in the research for this thesis, a major challenge was in reporting on the case and its context. The case companies' need for anonymity, including what can be revealed here, was of major concern in the research process, along with the struggle of going native. Less thick descriptions than desired were provided due to

confidentiality, which especially affected the research's transferability. To share enough information to make the case hold in a research community proved challenging, for a great deal of information could not be shared in the papers due to its sensitivity to the companies. During the research process, as trust became more established, the need to leave out information in the papers decreased slightly. However, in handling information of high strategic importance, a company that allows the leakage of potentially harmful information can face devastating consequences. Therefore, to establish the trust, gain extensive access, and be able to fruitfully reflect on the topic with the case companies, some information had to be withdrawn from the papers. To balance the need for confidentiality with so-called 'thick descriptions' was accordingly a major challenge in the research process. At the same time, proximity to the case enabled an in-depth understanding of contextual factors, which proved useful in becoming able to provide input to the managers when they needed to make decisions about the phenomenon in focus. Overall, reflections and discussions throughout the research process provided various enlightening perspectives that were important to ensuring the research's conceptual relevance.

Table 5 summarises how the rigour and relevance of the research for this thesis were addressed in the research process.

Table 5: Means of enhancing the rigor and relevance of the research

Criterion	*Addressed through*
Credibility Degree to which reported findings correspond to the realities and constructs of respondents	▪ Intensive, prolonged contact with the cases [Section 3.2] ▪ Establishing familiarity with the cases (e.g. language and culture) achieved from existing contacts and pre-study meetings before data collection intensified [Section 3.2] ▪ Peer debriefing at conferences, discussions with supervisors, and presentations [Section 3.5] ▪ Discussions and debriefings with representatives of the case companies [Sections 3.2, 3.3 and 3.5] ▪ Using multiple sources of data (e.g. interviews, observations, archival data) [Section 3.3] ▪ Discussing and comparing findings with other researchers' findings about the same company [Sections 3.2 and 3.5] ▪ Having case company representatives review papers and findings [Sections 3.2 and 3.5] ▪ Organising workshops and presentations of findings after studies were conducted [Section 3.5] ▪ Asking follow-up questions in interviews in light of information from interviews and observations [Section 3.3]
Transferability Possibility of applying findings to other settings; requires contextual insights	▪ Establishing proximity to cases, which enabled the development of contextual knowledge and understanding [Sections 3.1 and 3.2] ▪ Using as thick descriptions of contexts as possible given the risk of leaks of sensitive information about the companies [Section 3.5] ▪ Sampling interviewees with a focus on gaining insights from different perspectives (e.g. especially in the ECOS and COBO sub-case studies) [Section 3.3] ▪ Identifying interviewees from emergent insights, both during interviews and with the aid of key informant(s) [Section 3.3] ▪ Organising workshops with multiple companies to discuss perceptions of their contexts and the potential applicability of the findings [Section 3.5]
Dependability Possibility of replicating the study at another time; requires the trackability of the research process	▪ Documenting the research process through several means [Section 3.3] ▪ Ensuring the traceability of data using keywords (i.e. hashtags) and dates [Section 3.3] ▪ Documenting methodological decisions and the research process (i.e. in a research diary) to allow recording ongoing reflections throughout the process [Sections 3.3 and 3.5] ▪ Using recordings and documentation during data collection and taking pictures (e.g. of schemes) when necessary [Section 3.3]
Confirmability Degree to which the researcher's values have biased the results in lieu of the impossibility of complete objectivity	▪ Discussions and presentations of the findings [Sections 3.1, 3.2 and 3.5] ▪ Performing an extensive documentation of the collected data [Section 3.3] ▪ Using multiple sources of data (e.g. interviews, observations, and secondary sources) [Section 3.3] ▪ Accounting for and reflecting upon decisions and acting in various situations in the diary [Sections 3.3 and 3.5] ▪ Separating the researcher's interpretations, thoughts, and observations (e.g. in discussions and actions taken) in the observation scheme [Section 3.3]

Relevance Significance to managers and organisations; aims to enrich the understanding of a phenomenon (to which decisions are made)	▪ Conducting phenomenon-driven research and steering the research towards issues deemed relevant by actors involved [Section 3.1] ▪ Taking a collaborative approach to engage in conversations, interactions with actors involved, and reflections on the topic together with practitioners [Sections 3.1 and 3.2] ▪ Ensuring conceptual relevance,[14] namely by uncovering potential ways of thinking about solutions development in general and how to communicate about platforms in solutions provision (e.g. about assets used) [Sections 3.1 and 3.5] ▪ Identifying and describing factors influencing the use of platforms for product–service solutions that may affect decisions made in developing solutions [Sections 3.1 and 3.5]

[14] See Nicolai and Seidl (2010) for different forms of practical relevance.

4 Summaries of the appended papers

The four journal articles and one book chapter, collectively referred to as 'papers', appended to this thesis are summarised in this chapter, with particular focus on their chief findings and contributions to fulfilling the thesis's purpose and answering the three research questions. Figure 6 illustrates the various contributions of the appended papers to answering those questions. Therein, a filled circle indicates major correspondence to the research question, whereas an empty one indicates minor correspondence.

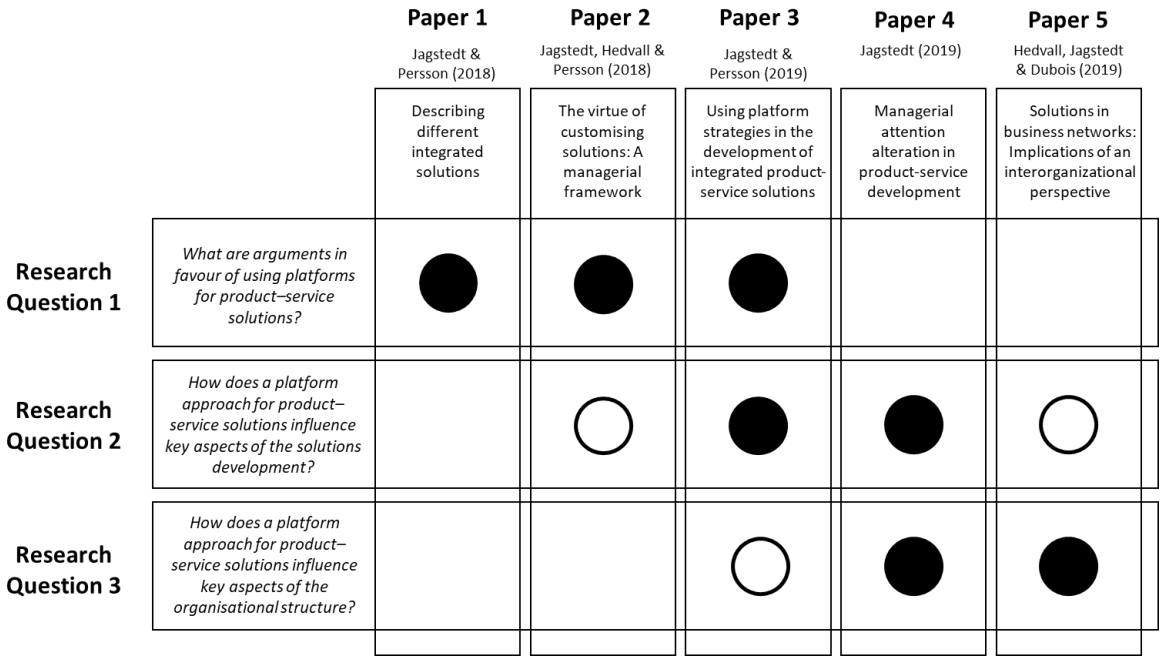

Figure 6: Relationships between the research questions and papers

In this chapter, each of the five papers is summarised one by one by briefly describing its motivation and the process of collecting data. Thereafter, the chief findings of the paper are presented, along with its contributions to answering the research questions and fulfilling the purpose of the thesis.

4.1 Paper 1: 'Describing different integrated solutions'

The purpose of Paper 1 is to investigate how various dimensions can be used to describe different integrated solutions. Definitions of integrated solutions have been argued to be generic (Brax and Jonsson, 2009), and classifications of solutions are often based on comparisons between companies

and their business models. However, such classifications do not take into account that different solutions exist within each company. In response, Paper 1 sheds light on those solutions by examining three dimensions that reveal differences and similarities among solutions: addressing the customer, integration, and customisation. To that end, the paper investigates two companies—Alpha and Beta—where data about the different solutions were collected from interviews and official documents on offerings currently provided.

In relation to the first dimension, addressing customers' needs, Paper 1 reveals that a solution can address a customer's needs by solving a problem, delivering functionality by focusing on usage, or by optimising the customer's operations. Because those three emphases require an in-depth understanding of the users of solutions, examining the customer's workflow is essential, especially in relation to solving problems faced by the customer, as well as to optimising operations. Those needs, in turn, also require acquiring new knowledge, and indeed, both Alpha and Beta highlighted the necessity of focusing on users, not purchasers, in providing solutions in order to be able to facilitate and optimise the flow of the customer's operations.

The second dimension, integration, is commonly perceived as a service, for it is the process of making a solution valuable. Only when a solution is integrated into the customer's operations can it create value. Integration occurs on at least two levels—between products and services as well as between the solution and the customer's processes. Thus, integration is not only internal but also the process of integrating various systems and resources to make the solution integrated into the customer's operations. Moreover, the degree and type of such integration differs, especially when it comes to integration with other systems in use by the customer. That sort of integration makes an important distinction in the provision of individual products and services. However, in the case companies of Alpha and Beta, it has been acknowledged that the customers can partly choose the degree of integration and purchase products and services at different times. Some integration could therefore be described as 'marketing-oriented' (Park et al., 2012), in which products and services are decoupled. By contrast, other solutions that, for instance, aim at optimising the customer's workflow require a more integral approach in which the customer cannot separate products from services.

Referring to the third dimension, customisation, Paper 3 reveals that unique product–service solutions, each developed for a specific customer, are common at Alpha and Beta. As a result, the

components of a given solution are potentially developed for a specific customer, especially if integration is considered to be a service. However, over-customisation at the case companies is perceived as being costly and difficult to manage. Beta's representatives particularly argued that developing repeatable solutions, using a joint basis, was a necessary next step towards enhancing standardisation as a potential benefit of taking a platform versus a modular approach. To be able to enhance standardisation and use knowledge across solutions, Beta has begun engaging in activities to develop its in-house knowledge of a specific group of users in one industry: healthcare.

Shared components, especially of products, are used in various solutions, as is knowledge about customers and market segments. Information about similar customers and solutions is stored for later access when approaching new customers. Paper 1 thus underscores the potential benefit of using platform strategies to be able to reuse knowledge. Both case companies bore witness to the importance of their technology and knowledge about customers to provide solutions. For instance, at Beta, knowledge of users is harnessed to develop general propositions about their needs and problems to be addressed by so-called 'standard solutions', in which a core offering is designed that integrates products and services. Such standardised solutions can be used to enable further interaction with customers about their specific needs. Thereafter, adaptations are made to the solutions to render them customer specific. In that process, viewing integration as a service in itself makes the solution customised—that is, integration becomes a service—whereas the standard solution is based on commonalities.

4.2 Paper 2: 'The virtue of customising solutions: A managerial framework'

Paper 2 introduces a managerial framework for the customisation of solutions by taking advantage of their commonalities. Robertson and Ulrich (1998) have posited that components, processes, knowledge, and people and their relationships are assets that can be shared between offerings. Different commonalities can also be exploited in different phases of an offering's life cycle (Halman et al., 2003; Sawhney, 1998; Zhang, 2015).

Paper 2 begins by presenting three categories of drivers in applying a strategy that leverages commonalities: external drivers, internal drivers, and interaction drivers. First, external drivers concern customers. A major objective of customisation is to increase the effectiveness of solutions by tailoring them to customers' operations and contexts. However, that idea does not necessarily mean that the solutions need to be unique. Instead, customers expect solutions that work well in

their contexts and address their needs. By ensuring commonalities among solutions, the lead times of developing them and the associated costs can be reduced. Commonalities can also enable a more extensive process of verifying and debugging shared assets in advance, which affords higher-quality solutions such that attention can be paid to validating solutions in a given customer's context, not verifying individual components. Second, internal drivers largely concern improving internal efficiency by achieving the effects of economies of scale and scope. Arguably, a commonalities-oriented strategy can benefit the internal communication among different departments in an organisation, providing a common language for personnel to use. Third, in a similar vein, interaction drivers concern facilitating interactions between customers and manufacturers. In that context, the concept of so-called 'referenceability' (Sawhney, 1998) seems to be significant, because a common starting point for discussions can support efforts to bridge possible gaps between the needs of customers and potential solutions provided by manufacturers. Similarity among solutions also seems to benefit demonstrations of potential solutions, because they showcase potential savings and improvements in various similar cases.

Paper 2 thereafter proposes subdividing a solution intro three major elements: product(s), services, and manufacturer–customer interaction. A three-layer model, shown in Figure 7, is thus proposed to guide the framework of how to provide customised solutions leveraging commonalities.

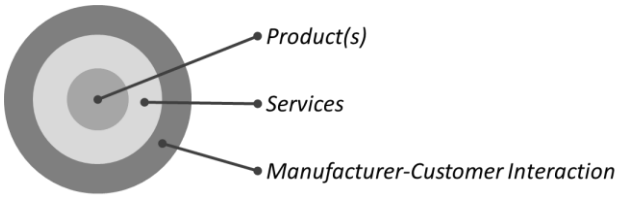

Figure 7: A three-layer model representing a solution

Following that visualisation, Paper 2 argues that commonalities can be achieved by sharing elements among solutions to various extents. In that process, solution providers are advised to start with the problem—that is, the needs of customers and their operations. Thereafter, following the proposal that a solution should be customised via integration, the paper presents a framework with five steps for customising solutions by utilising different commonalities at various stages. The framework is illustrated in Figure 8. Although a wide range of commonalities may be used in the

different steps, the general process does manifest some potential commonalities. Also, what needs to be considered is when the integration of products and services should occur, along with what the principal objectives of the strategy are.

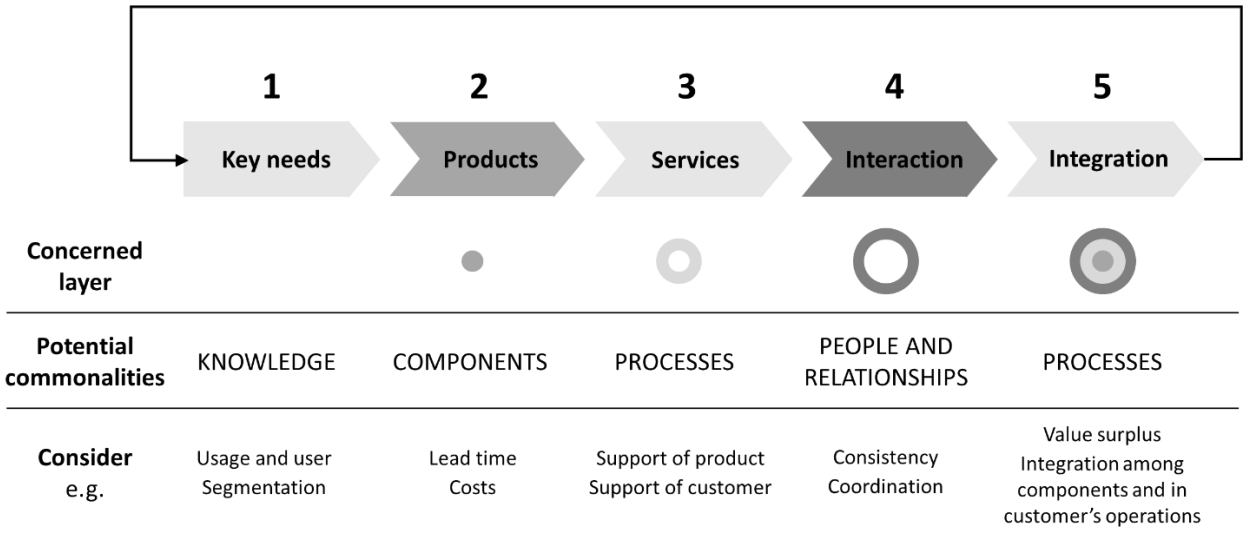

Figure 8: Five steps in customising solutions

As shown in Figure 8, the first step entails identifying key needs, particularly in relation to the three mentioned types of drivers (i.e. internal, external, and interaction drivers). In that step, knowledge about the use of solutions and their specific users is likely to play an important role. Such knowledge can thereafter form the basis for several solutions. A truck manufacturer, for instance, may organise so-called 'learning projects' in order to establish in-depth knowledge about its customers' operations. In those projects, ideas are tested, and new insights are gained about both the user and the technology used to address the problem. The knowledge is thereafter used in other projects with other customers, which further expands the overall knowledge base. In those projects, close collaboration occurs between the customer and the manufacturer. Although the process starts with the key needs of the customer, it is likely that additional needs are revealed throughout the development process.

The second step concerns products. In that step, component commonalities can be beneficially exploited in the solutions, thereby reducing the costs and lead times of developing new products.

In the development of goods, the manufacturing equipment and facilities form a significant part of the costs, and accordingly, commonalities among components could provide major benefits by enabling economies of scale. The third step regards elements of services, which are processual in nature. In that step, it is essential for services, the products forming a core of the solutions, and the specific customer's needs to be aligned. Services are likely to constitute processes, which if standardised can be shared among a set of different solutions—for instance, standardised ways of performing maintenance on trucks. The fourth step, by contrast, is associated with interaction between the customer and the manufacturer. For interaction, relationships and people are essential, and manufacturers should take advantage of those important resources in developing and customising solutions. For example, personnel with expertise in either technology or the operations of customers could be used in the provision of several different solutions. The fifth and final step concerns the thorough integration of various elements to suit the operations of customers. Such integration should be a process of matching an offering, along with the elements of the solution, to the customer's operations—that is, external integration instead of integration among components. In that process, the key needs of the customer should be revisited, the solution evaluated in light of those needs, and, if necessary, a new iteration of the process developed. In that way, the process ultimately becomes iterative as well as cyclic.

4.3 Paper 3: 'Using platform strategies in the development of integrated product–service solutions'

Paper 3 addresses the use of platform strategies in developing product–service solutions. In particular, the paper provides insights into the rationales of the case company to use such strategies and proposes assets that can be shared among solutions in efforts to form platforms. Paper 3 expands upon the findings of Paper 1 about the customisation of solutions.

The paper acknowledges that solutions require a high degree of customisability, even amid the need to develop repeatable solutions as over-customisation becomes too costly (Brax & Jonsson, 2009; Ceci & Masini, 2011; Davies & Brady, 2000). Platform strategies have been proposed as a way to combine standardisation with customisation, thereby enabling both customised offerings and efficiency. Although research on using platform strategies to develop physical products is extensive, less is known about using them to develop product–service solutions. In response, Paper 3, focusing Gamma and its development of solutions, draws from data collected in interviews and from observations of meetings and workshops with people associated with the company's service

and commercial development function. It is also concerned with observations of a project addressing solutions and platform strategies, and thereto associated interviews.

Opportunities to enable both customised offerings and achieve cost-efficient development are often acknowledged in literature on platforms (e.g. Labro, 2004; Meyer & Lehnerd, 1997). Contributing to that body of work, Paper 3 also considers rationales for adopting platform strategies in the development of product–service solutions. First among its findings, platform strategies seem to be a way of reducing the complexity associated with different development lead times in product development in relation to service development. By taking a platform approach, Gamma may be able to postpone decision-making about solutions provided to customers. For that reason, the company seeks to be more customer-oriented while also enhancing technology and product advancements required to provide new solutions in the future. Second, a platform could facilitate interaction among functions involved in developing product–service solutions. Platforms can achieve that dynamic by affording a common basis and arena for interaction and provides a shared objective: to provide integrated product–service solutions more efficiently. Third and last, platforms may be able to lower solutions' time to market. Such increased efficiency may also facilitate collaborate with external partners in providing solutions, since slowness is perceived as preventing those relationships from developing. If so, then those partners become involved later in the process, once the basis for the solutions is established.

On the topic of developing solution platforms, Paper 3 identifies two assets that can be shared among solutions: knowledge about usage and knowledge about technology. In general, such kinds of knowledge play increasingly important roles in the development of solutions. Such knowledge is associated with as well as embedded in people and their relationships, and it seems to also represent commonalities among different solutions. On the one hand, after all, solutions accommodate customers' processes and thus their usage, as acknowledged in literature about value-in-use (cf. Brax & Jonsson, 2009; Storbacka, 2011). Paper 3 adds to that literature by showing that knowledge about usage can also support the basis for a platform by putting the knowledge of users and usage to work in generating different solutions. For instance, applying knowledge of usage in a platform facilitates the definition of benchmarks for comparing optimal usage with the actual processes of a customer. Although knowledge of users and usage is often embodied in individuals with expertise, the work to define specific users and study their contexts

of usage seems to play a major role in facilitating the exploitation of that knowledge. Thus, activities of verification, otherwise commonly performed in the later phases of a development project, attract increased attention from both product and service development.

On the other hand, knowledge about technology may also represent an important asset to leverage in developing solutions. After all, cutting-edge technology seems to remain essential for many solutions. Most of Gamma's solutions are indeed based and dependent upon such knowledge accumulated at the company over the course of many years. Knowledge about technology is also a major reason for external companies to collaborate with Gamma, because each party can leverage its knowledge in exchange for the other's in that process.

However, because leveraging either kind of knowledge can be challenging, Paper 3 identifies barriers to that process, including having an organisation overly focused on products, in which the processes are designed for products and, for that reason, the value of solutions is difficult to understand in relation to the value of a product. In such contexts, running a platform-based project can be a struggle, because they are often costly. At the same time, because the value of solutions is more difficult to calculate, the business case may be lacking. Beyond that, the budget for service development is generally limited in Gamma compared to investments in product development.

Overall, while a platform approach appears to be a fruitful way of combining standardisation and customisation, such an approach also threatens several challenges and obstacles. Such possible advantages and disadvantages underscore the importance of weighing the benefits of adopting a platform approach for product–service solutions against the drawbacks before pursuing such an approach.

4.4 Paper 4: 'Managerial attention alteration in integrated product–service development'

Paper 4 focuses on managerial attention, which researchers have argued is crucial to achieving a more service-oriented organisation (Gebauer, 2009). Likewise, Kowalkowski et al. (2015) have posited that managerial attention at any company is a major barrier to it becoming a so-called 'industrializer' (p. 64). Briefly put, because the attention capacity of managers is limited, the outcomes of the company's operations are shaped by the priorities of its decision-makers (Ocasio, 1997). Thus, to be more service-oriented, managers need to pay increased attention to service-related issues.

To provide solutions, it is necessary to consider both product- and service-related aspects in solutions development. The purpose of Paper 4 is therefore to examine managerial attention alteration in an integrated product–service development project. That motivation stems from the idea that managers can attend to only a limited set of issues, meaning that the various focuses in integrated product–service development compete with each other. The paper also addresses how attention can alternate between product- and service-related aspects when managed in the same project and the consequences of such alternation.

Paper 4 analyses the joint development of products and services by taking an attention-based view (Ocasio, 1997), which clarifies that what an organisation ultimately does depends upon what decision-makers therein are focusing their attention on (Ocasio, 1997; Ocasio & Joseph, 2005). Of course, the opposite is also true, such that if management does not pay attention to services, servitization cannot progress. Therefore, attention is essential to which decisions are made and how development will proceed. Beyond that, this approach affords an opportunity to link managerial attention to product–service development by highlighting the interaction of structural and cognitive aspects.

In Paper 4, the product–service development is examined with reference to the ECOS project. The project was studied over time, which generated insights into how integrated product–service development has unfolded as the project has progressed. Data were collected mostly during observations of weekly project management meetings and during interviews with project managers. Studying the ECOS project revealed that attention to service-related aspects was suppressed as attention to product-related aspects continued to benefit from various structures and channels within the company. Although simultaneous attention to both product- and service-related aspects could be possible by focusing on the overall offering, maintaining that focus appears to be challenging in the long term. Organisational structures pressure the two aspects to be separated into different channels, given Gamma's tradition of separating service development from product development. Therefore, while it can be argued that a separate service function can somewhat protect an emerging service culture (Oliva et al., 2012; Oliva & Kallenberg, 2003), the findings of Paper 4 instead suggest that such a separation does not encourage attention to service-related aspects in integrated product–service development. The paper thereby adds to the list of benefits and drawbacks argued to be associated with the existence of a separate service business unit, with

particular focus on the impact of integrating products and services during the development phase. In effect, it showcases the relationships between solutions design and the organisational structure.

Paper 4 also provides insights into the dynamics of product–service integration and the impact of managerial attention in that process. It accounts for the progress of the ECOS project and how attention was redirected at different stages of the project. By linking cognitive and structural aspects, attention was shown to be a useful lens for studying servitization in general and product–service integration in particular. Among other results, the paper highlights that a service-oriented mind-set of the project managers is hardly enough to overcome the challenges associated with product-oriented structures at play in an organisation. On the contrary, structural and cognitive aspects need to interact in order to facilitate attention to both product- and service-related aspects in the integrated development of products and services.

4.5 Paper 5: 'Solutions in business networks: Implications of an interorganizational perspective'

In Paper 1, it was acknowledged that a solution can be understood as a process, because the provider of the solution must shift closer to the customer in order to integrate the solution into their operations. Taking a processual perspective and highlighting interactive and relational aspects in the network, Paper 5 analyses the provision of solutions in a business network context. On the topic, the paper takes a point of departure at the intersection between an inter-organisational perspective and a processual perspective on solutions. The paper thus contributes to conceptualisations of solutions as processes (Petri & Jacob, 2016; Storbacka, 2011; Tuli et al., 2007; Töllner et al., 2011) as well as notions about providing solutions in a business network (e.g. Cantù, Corsaro, & Snehota, 2012; Jaakkola & Hakanen, 2013), especially by highlighting the importance of relationships therein (Windahl & Lakemond, 2006).

Based on a case in the transport industry, Paper 5 adopts a scope encompassing both multiple solutions and multiple actors in a network. The case was studied over time, with data collected from multiple sources, primarily during interviews and observations, and proximity to the case enabled in-depth insights into various solutions provided in the network. Meanwhile, the analysis of the case drew from key concepts and assumptions grounded in the Industrial Network Approach, which highlights interdependencies and interaction among firms.

Paper 5 reveals that the provision of solutions in networks, when solutions are considered to be processes, is a complex matter. In such networks, multiple solutions are provided, and the actors engage in multiple business relationships to provide various solutions. Due to the limited resources kept by the actors, changes in one solution might affect other solutions as well as other actors. On top of that, the actors in the network take on multiple roles at once, such that the same company can occupy positions as both providers and customers. Furthermore, increased collaboration (i.e. partnerships) between some actors to provide solutions may cause other relationships to become obscured. The COBO project, for instance, has been undertaken in collaboration with an equipment contractor, an actor who typically adds its equipment to the product after purchase. By way of collaboration, surplus value can be created, because the equipment can be integrated into a solution during development. A partnership can also be established with an actor in the network previously not involved with the company. However, such collaboration also means that, for some solutions, the customer may be bypassed in favour of another with a closer relationship to the end user. That dynamic would of course affect other solutions in the network. In that way, relationships can shift due to the development of new solutions. Accordingly, interdependencies clearly exist among companies and solutions provided in the network.

In light of those findings, Paper 5 advances three propositions. The first concerns the multiple solutions provided in a network, stating that firms 'are simultaneously involved in the provisioning of multiple solutions. Thus, the resources activated in the provisioning of solutions are involved in several solutions at the same time' (p. 418). The second proposition addresses the multiple roles of the network's actors and how new solutions might affect those roles. More formally, the proposition states that firms 'take on multiple roles in the provisioning of solutions in a business network. Thus, a firm may simultaneously take a role as supplier (to one or several customers), a buyer of solutions, and a solution business partner' (p. 418). The third and final proposition is based on the conclusion from the network perspective that solutions and firms are interdependent—that is, the 'solutions provided in a network of firms are interconnected and subject to interdependencies. As a result, the solutions form "network of solutions"' (p. 418).

5 Discussion: On the use of platforms for product–service solutions

The purpose of this thesis has been to identify and describe factors influencing the use of platforms for product–service solutions, including answering three research questions, respectively concerned with 1) arguments in favour of using platforms for product–service solutions, 2) how a platform approach for product–service solutions influences key aspects of the solutions development, and 3) how a platform approach for product–service solutions influences key aspects of the organisational structure. This chapter discusses answers to those research questions one by one, with reference to the research's findings in relation to the literature reviewed in Chapter 2. After that, the chapter synthesises the answers to the questions in fulfilment of the thesis's purpose.

5.1 Arguments in favour of using platforms for product–service solutions

Research Question 1 is about arguments in favour of using platforms for product–service solutions. In the following sub-sections, those arguments are accounted for, starting with rationales for taking a platform approach. Next, the concept of solution architecture is elaborated upon, particularly by arguing that different conceptualisations of solutions could be associated to different levels of decomposition of a solution. The sub-section highlights the value of considering solutions as consisting of knowledge components while using a platform approach, comprising a level of decomposition suitable to understanding solutions architecture in the context of engineering-oriented integration. Thereafter are the concept of a solution family introduced, being the set of solutions that share assets.

5.1.1 Reasons for using a platform approach for product–service solutions

Paper 1 reports that the development of unique solutions is common, even while argued that repeatability is important and considered by the case companies to be 'the only way forward' (Jagstedt & Persson, 2018, p. 357) if they want to be profitable. As described in Papers 1–3, the reasons for adopting a platform approach extend beyond the mere aim of reducing costs, however, to also afford a means to manage time constraints, accelerate the process of bringing solutions to the market, and, in turn, responding more efficiently to customers' needs. The eligibility of a platform approach also appears to depend upon the objectives of the solution business, as well as upon the integration of products and services.

Literature on using a platform strategy has focused heavily on the cost-related benefits of the strategy in association with large investments such as manufacturing equipment. In the provision of products, a large proportion of the costs are fixed costs, and by increasing the volume of the use of such large investments, the cost per product will drop as per the notion of economies of scale. On the contrary, a higher proportion of the costs of services are associated with the personnel providing them. The total cost benefits of using a platform approach for services is thus arguably less than for products, because the top driver of costs does not necessarily benefit as much from increasing the volume. Also, platforms require stability in the customers' demands over time (Magnusson & Pasche, 2014), which are more likely to vary in the case of services. In the context of solutions, however, costs originate not only from the products and the services but also from their integration. Consequently, that reduced costs are associated with fixed costs only partly explains why companies adopt a platform approach for product–service solutions.

The papers appended to this thesis highlight that a platform approach is a way of facilitating communication, both internally in an organisation and externally with customers as well as partners.[15] As such, the approach enables the interaction and coordination needed to facilitate the creation of seamless solutions that generate surplus value for customers, because it forms part of a foundation for a shared language and provides a starting point for communication between actors in the business network, as demonstrated in Papers 1 and 2. Regarding customers, that foundation can promote referenceability (Sawhney, 1998) and foster opportunities for ongoing feedback from customers about specific solutions. Those dynamics benefit from the proximity and close relationships with customers in solution provision, and the presence *in* the customers' operations. Because a platform can establish a common foundation for communication, information exchanged in interactions between customers and providers can ultimately be of higher quality than otherwise. Also, by referring to and leveraging from knowledge gained from or about other customers, companies can better address similar customers and, in turn, their needs, all of which can improve the quality of solutions, as Paper 2 highlights. The reason for that dynamic is that knowledge already existing in a company can be reused, which further justifies taking a platform approach. It is also likely, given the more long-time oriented relationships with the customer established in solution provision as they rely on knowledge of the provider (Galbraith, 2002; Oliva & Kallenberg,

[15] *Partners* refer to other companies with which a company has strategic relationships, often characterised by interdependence as a means to achieve a surplus value and mutual benefits (Mohr & Spekman, 1994).

2003), that there is at least moderate stability in the customers' demands over time, facilitating to leverage on the assets used in the platform.

The costs of acquiring new knowledge to develop product–service solutions are however likely to exceed those needed to develop products. After all, to develop solutions, the shift in activities undertaken by a company requires extended knowledge about the customer's operations in order to understand the problem that the solution seeks to address. To leverage knowledge already gained for future solutions can lower the costs associated with each solution, because more solutions can be derived from the same initial costs of acquiring that knowledge. As a result, opportunities arise to achieve economies of scale as well as scope. Unlike with many product platforms, which leverage expensive equipment to manufacture products, the acquisition of knowledge needed for product–service solutions seems to be that process's major cost driver. Once knowledge is established, leveraging it to provide similar solutions can boost efficiency not only by harnessing economies of scale but also by lowering the overall average cost of each solution by providing an increased variety of solutions, thereby realising economies of scope. Although those benefits also apply to products, even significantly so when using a platform approach, they seem all the more interrelated when using such an approach for product–service solutions. In turn, it would enable a solution platform to allow for more variation in the customers' demands than a product platform would, leveraging on both economies of scale and scope. This is due to the nature of the investments made, which in the case of a product platform establishing components as the shared assets, are requiring investments in expensive equipment which deals with a predetermined set of variety.

Platforms have been argued to reduce lead times in the development (Meyer & Utterback, 1993; Robertson & Ulrich, 1998), because the underlying basis is already in place. Moreover, as the research for this thesis revealed, a platform approach thus serves as a means for responding to customers' orders more efficiently. Gamma characterised that possibility as one of the approach's overriding benefits and a major reason for initiating the ECOS project, as described in Paper 4. Although lead times for product development at Gamma are generally long, its service development is far faster, and that difference complicates development processes when the two types are integrated. Difficulties associated with long lead times, especially of goods, have also been identified in Paper 2 as inhibiting the provision of solutions. The paper also describes some

problems with commencing the development of new goods for specific customers, such as that the products developed might become obsolete before they can be incorporated into a solution to address the customers' pressing needs. Accordingly, the long lead times for developing products can obstruct the provision of solutions, which may result in missed market opportunities. That possibility is also discussed in Paper 3 in relation to partners, who may find such long lead times to be unacceptable and, in turn, grounds for not partnering with a company. To enable engineering-oriented integration while remaining or becoming able to respond quickly to the individual needs of customers and potential partners, companies may find the platform approach to be useful. Such an approach can reduce some of the complexity associated with divergent lead times, as shown in Paper 3. Conversely, applying a modular approach does not allow the same degree of engineering-oriented integration to occur, if the point where standardised processes are separated from processes focusing on specific customers is to be maintained.

In sum, a platform approach for product–service solutions is associated not only with reductions in costs but also with possibilities for increased revenue streams by shortening lead times for individual solutions. Because the shared assets for such solutions are already established, they necessarily furnish a foundation for continued development efforts, which consequently fosters opportunities for collaboration with external partners. Paper 2 refers to the rationales for adopting platforms for product–service solutions as internal, external, and interaction drivers, the last being focused on dialogue and cooperation. A focus on interaction is further acknowledged in Paper 5, as highlighted in the conceptualisation of any solution as a process occurring within a network. Deploying service logic, that conceptualisation follows a trend that downplays a view of products and services as opposites (Lightfoot et al., 2013; Luoto et al., 2017). At the same time, research on service modularity has often highlighted the need to consider the differences between products and services (Bask et al., 2010; Iman, 2016; Voss & Hsuan, 2009), which might also be needed to understand the use of modular and platform strategies, and what distinguish their use for services versus products. Therefore, to understand the use of platforms for product–service solutions, the solution can be fruitfully approached from an architectural perspective that considers different levels of decomposition (Voss & Hsuan, 2009) and different conceptualisations of a solution.

5.1.2 Solution architecture

The meaning of *solution architecture* is still to be defined in the literature, despite that the concept of architectures in relation to products, as well as in relation to services, has been addressed (e.g.

Ulrich, 1995; Voss & Hsuan, 2009). As shown in the appended papers of this thesis, solutions can be conceptualised as offerings consisting of products and services (e.g. as in Papers 1 and 2), as bundles of knowledge components (e.g. as in Paper 3), or as processes (e.g. as in Paper 5). The definition of *solution architecture*, in turn, depends on those conceptualisations, all of which can be associated with different perspectives on services and value creation. Viewing a solution as an offering, for example, takes a traditional approach to services, one focused on the differences between products and services. By comparison, the conceptualisation of a solution as a process is aligns more closely with the notion of service logic. Such a perspective on services has been highly influential in research on servitization (Martín-Peña et al., 2017), being a perspective that has its origins in marketing.

Meanwhile, research on platform and modular strategies has largely relied on literature streams associated with operations management (Frandsen, 2017). Therein, several underlying assumptions of modularity are concerned with the independence or 'loose coupling' of components (e.g. Sanchez & Mahoney, 1996), following the notion that architectures are hierarchical in structure and that the decomposition of these is the primary means of managing complexity (Simon, 1962). Therefore, modularity depends upon an ability to dismantle offerings into nearly independent components.

By contrast, the solutions examined in this thesis involve engineering-oriented integration that assumes the interdependence and even inseparability of products and services (Park et al., 2012) from development onwards. In that light, products and services appear seamless from a customer's point of view in line with a service logic. In a similar vein, the thesis argues that refocusing from goods to facilitating the customers' value creation by applying competences (Vargo & Lusch, 2004) implies that separating products and services for mixing and matching into a solution may not be the most fruitful approach in the case of engineering-oriented integration. That reasoning follows Gremyr et al. (2019), who, contradictory to the basic assumption of modularity, maintained that 'tight couplings between the service modules are beneficial' (p. 83). Despite their argument about the benefits of decoupling service processes, they have also contended that the output of processes should be clearly connected—that is, interlinked from a marketing perspective. Therefore, though applying a modular approach to processes may offer advantages, it is challenging to do so in integrated product and service development, because the coupling required

between those processes is exceptionally tight. While modularity can be an important means to enhance variety for products and services, a platform approach can fundamentally support the overall solution architecture by taking the tight coupling between products and services into consideration, allowing the integration to appear already in the solution platform architecture.

Solutions in which products and services are integrated during the design and development phases demonstrate such interdependence. Moreover, if increasing the volume, not the variety, of solutions is emphasised, then a platform approach can be beneficial. Economies of scale and scope are created by reusing as well as utilising assets that can benefit a family, or set, of solutions. By sharing assets among solutions, product and service development can be integrated, following the argument that servitization concerns the integration of product and service activities, not shifting from one to the other (Johnstone et al., 2009; Peillon et al., 2015).

In a platform approach, the most fundamental building blocks of solutions can arguably be concerned with knowledge, considering that exchange is a way of acquiring benefits from competences (Vargo & Lusch, 2004). Therefore, customers engage in solutions to accrue benefits from knowledge otherwise beyond their reach, as acknowledged by Valtakoski (2017). The same thinking is echoed in this thesis, albeit with a point of departure in understanding solutions, to the extent that different conceptualisations of solutions—as combinations of products and services, as knowledge, or as processes—are simply concerned with different levels of decomposition. As shown in Paper 5, to consider solutions at the level of processes helps to reveal aspects of the solution network and its high level of decomposition, as in line with the argument that services position the industry as the topmost level in decomposition efforts (Voss & Hsuan, 2009). Alternatively, considering solutions at the level of product–service combinations, as done in Papers 1 and 2, can help the internal development process (i.e. a lower level of decomposition assigning products and services different sets of knowledge) and appears to be more in line with the traditional approach of assuming the product, or the solution, as the highest level of decomposition. By contrast, viewing solutions as comprising knowledge components that operate as fundamental building blocks can provide guidance in understanding how a platform approach might be applied, spanning the mentioned differences between products and services in terms of architecture. This comprises a low level of decomposition, in which the solution architecture can be conceived as a

way in which components of solutions are decomposed into knowledge elements that, by way of integration, provide opportunities to create value-in-use within customers' operations.

5.1.3 Solution families

The architecture and decomposition of solutions relate to the notion of product families, defined as sets of products that share the assets comprising the platform (Meyer & Utterback, 1993; Robertson & Ulrich, 1998). In a broad sense, this thesis defines a *solution family* more particularly as encompassing solutions that share a set of knowledge assets, following the idea that such a low level of decomposition looks beyond the division of products and services. Accordingly, a solution family is likely to consist of solutions that for instance address the customers in a similar manner—that is, referring to the first dimension for describing a solution, as discussed in Paper 1. Beyond that, as argued in Paper 3, it is likely that a solution family consists of solutions that addresses a specific user (e.g. the fleet owner), not the customer's industry. Therefore, following the findings of this thesis, focusing on the user when identifying a customer's key needs is particularly important, as articulated at all of the case companies. In accordance to such a heightened focus on users, it is likely that a solution family is concerned not only with the customer's industry, which forms the basis for the customer's processes, but also with the users that the solutions address, who exhibit similarities across the various industries of customers.

Such a focus on knowledge about users and usage relates to the notion of value-in-use, because value is being created in the customers' processes (Grönroos, 2006; Grönroos & Voima, 2013), such that the user is assigned an increasingly important role in solutions development. In a solution-oriented mindset (Sawhney, 2006), establishing a solution family based on knowledge about the user stresses the importance of starting with the problem instead of the solution. Although technology knowledge (Magnusson, 2009; von Hippel, 1994) comprises an important means to solve the problem, representatives at Gamma reported a tendency of focusing on that knowledge. Conversely, through studying and utilising similarities among customers' problems as foundation for the solution families, attention might be directed to the problem at first.

5.2 Developing product–service solutions with a platform approach

As articulated in the foregoing sections, a solution platform architecture based on knowledge allows for the integration of products and services already during the design and development phases thereof. The development of product–service solutions by taking a platform approach thus

becomes a question associated with deciding what is to be shared among solutions—that is, what the platform will comprise—and what is to be customised for individual customers, which requires knowledge about their individual operations, determining the point when the development effort becomes customer-specific. As found in this thesis, the development of product–service solutions by applying a platform approach can occur in accordance with three main steps: the development of the platform, customisation, and personalisation.

In what follows, the first two sub-sections concentrate on the concept of the platform. The thesis highlights the potential of leveraging knowledge about usage and about technology as assets shared among solutions. Next, two major approaches for developing platforms are outlined. Thereafter, a third sub-section focuses on the period after the point in the development process when standardised processes are separated from customer-focused processes (Rudberg & Wikner, 2004), in which the thesis identifies two steps in taking a platform approach to develop solutions: customisation and personalisation.

5.2.1 The platform: Sharing assets among solutions

Papers 2 and 3 identify different assets that might be shared among solutions. As previously noted, a platform strategy entails sharing assets among a set of offerings in the same family (Meyer & Utterback, 1993; Robertson & Ulrich, 1998). This thesis suggests that a platform for solutions might comprise knowledge about usage and about technology as assets to be leveraged. In turn, it also argues that because product–service solutions involve a shift in the activities undertaken in the value chain, the knowledge retained by the solution-providing company has to be extended. Especially, the shift in activities executed by the solution provider calls for more extensive knowledge about usage and users.

Paper 2 underscores the need to focus on users and usages to identify the key needs of customers. To that, Paper 3 adds that knowledge about usage is important for a solution platform. To start with the problem instead of with the product reflects a so called solution-oriented mindset (Sawhney, 2006), and although knowledge about users is essential in individual service and product development (e.g. Magnusson, 2009; von Hippel, 1994), it becomes especially relevant when developing product–service solutions by taking a platform approach. In that process, the costs of acquiring sufficiently in-depth knowledge about usage are greater than in the process of providing products, because extensive knowledge is needed about the customer's overall operations,

including its business logic, daily work, and use of other products. Paper 1 offers an example of the development of knowledge about users and usage: Beta has focused on one segment in its development efforts in seeking to make its solution business scalable. The reason for that pursuit is to be able to focus and develop profound knowledge of the user—that is, nurses—in a specific context. Beta conducted user studies of nurses to incorporate a strong focus on them as users of solutions, and in the process, the company discovered that facilitating workflows in healthcare necessitates an emphasis on the work of nurses, including how they move around facilities, who they speak with, what they focus on, and what annoyed them. Their work, of course, is not concerned with Beta's products only but also with other products used in their various operations. Gamma also emphasises users in its solutions (Paper 3), who could have similar needs across a range of industries. Accordingly, a platform based on knowledge about usage could accommodate a solution family that targets the behaviour of specific users. Such a platform could even mean that a benchmark of an arguably optimal usage process can be defined—for example, by comparing different users—as discussed in Paper 3.

If knowledge about usage is understood in relation to the platform categories proposed by Robertson and Ulrich (1998), then knowledge platforms seem to be closely associated with platforms based upon people and their relationships, because knowledge about usage appears to be concerned, even largely so, with tacit knowledge (e.g. Nonaka, 1994). Knowledge about usage is commonly held by individuals, who develop it in relationships with others, including both customers and partners. To leverage that knowledge, Gamma relies upon individuals with extensive experience and knowledge about usage (e.g. in Paper 3). Thus, although a focus on the customer has been commonly highlighted in relation to solutions—for instance, to justify customer-centric organisations (Galbraith, 2002)—the findings of this thesis indicate that such a focus concerns not only knowledge about customers in general but knowledge about users in particular. Accordingly, individuals with such knowledge should play prominent role in solution development, especially in designing platforms for solutions, because they have accumulated knowledge about usage from their experiences, which can be leveraged on.

Although the costs of gaining in-depth knowledge about usage to develop solutions are likely to exceed the costs of gaining knowledge about developing products, they can be lower when a platform approach is used than when unique solutions are developed. After all, the effects of

economies of scale and scope that could be achieved by leveraging such knowledge can be used for many individual product–service solutions. The abilities to do so, however, are associated with the ability to identify core underlying problems to be addressed. Such problems could, for instance, be associated with so-called 'alarm fatigue' of nurses (e.g. in Paper 1), downtime for users, no matter the reason (e.g. in Papers 2 and 3), or lack of information about the vehicles and the auxiliary equipment in combination (e.g. in Paper 5). Because those problems do not simply concern the core products of the providers, knowledge about usage extends the scope of individual products, while knowledge about them can be used to address more general problems among customers.

Although a range of different platforms have been suggested, product platforms remain the most commonly discussed (Fixson, 2007; Zhang, 2015). In addition to knowledge about usage, this thesis shows, however, that knowledge about technology (Paper 3), instead of simply about components, might be shared among solutions. Therefore, while the installed base might play a vital role, as in Brax and Jonsson's (2009) model, it appears that in the process of developing a platform for product–service solutions, knowledge about technology is more important to leverage than the products per se.

Considering that customers buy products to gain access to competences and knowledge (Vargo & Lusch, 2004) rather than to get hold of the actual products, they use solutions to gain benefits from knowledge obtained by the solution provider. Knowledge about technology is one type of knowledge that customers' may be willing to pay for in order to access it. Such thinking aligns with the argument that problem-solving is concerned with knowledge about both users and usage, which is associated with the problem, and knowledge about technology, which is associated with solving that problem (Magnusson, 2009; von Hippel, 1994). This thesis argues that companies should leverage and expand upon those kinds of knowledge by positioning them as a basis for their platforms. Compared to knowledge about usage, knowledge about technology seems to be somewhat more easily expressed in words and is thus part of explicit knowledge. It can also be partly embodied in products, and while such knowledge might dominate in a product-oriented setting (e.g. Paper 4), in the development of a platform, it is important to consider knowledge about both usage and technology and how they relate to each other. Whether emphasis is put on one or the other initially however seems to be determined by the approach taken to develop the platform.

In general, to facilitate the integration of product and service development and the incorporation of both domains of knowledge, it appears that verification and testing activities are assigned an increasingly important role. Such activities are considered early in the development process, with an increased focus on usage instead of simply technical functionality (Paper 3). In those activities, knowledge about technology and knowledge about usage are connected, and people engaged with both the commercial and technical aspects cooperate to create use cases. Because knowledge creation is concerned with the interaction of explicit and tacit knowledge in addition to them separated (Nonaka, 1991, 1994), such activities seem to create a foundation for the necessary integration of those knowledge-related aspects in the platform.

5.2.2 Two approaches for developing a platform

In this thesis, two approaches for developing a platform for solutions have been identified: starting with an individual solution or with developing the basis, i.e. the platform. The first describes so-called 'learning projects' (Paper 2), which aim to develop both knowledge about technology and knowledge about users and usage by learning from an individual case. Along with the COBO project, Gamma runs several such learning projects. Usually, projects starting with an individual solution are conducted in close collaboration with a customer, thereby enabling in-depth insights into that customer's specific processes. Knowledge gained from such collaboration can thereafter be mobilised in developing new solutions for additional customers. Such an approach is closely associated with the development of repeatable solutions in the complex product systems context (Davies & Brady, 2000) and overlaps with the idea of customer platforms, in which expansion into related markets is made by using a beachhead as a base (Sawhney, 1998). Another common feature of the approach is its application when technology is still immature and when it remains unclear what the business model for the solutions will entail. In such projects, the establishment of the business model, sometimes together with a partner, as described in Paper 5, has been the point of departure. That situation also means that the development of technology, as well as the knowledge about the technology required, is greatly influenced by the service aspect that doubles as the foundation for the business model, especially in terms of revenue. Based on that newly established business model, the development of the solution occurs on a small scale, usually to solve a specific problem in close collaboration with the specific customer and partners. Accordingly, knowledge about technology and knowledge about usage are developed in an integrated fashion, and the knowledge gained will thereafter be used as the basis for another solution, meaning that the

platform evolves. That approach partly describes the replication of services discussed by Gremyr et al. (2019), albeit focusing on a platform architecture under development instead of a modular approach.

Because developing a platform by starting with an individual solution offers flexibility, it can be a suitable amid relatively high variation in customers' needs over time. After all, the platform will evolve as the knowledge gained by collaborating with different partners and customers accumulates, and in that light, it is also flexible in relation to emerging trends and problems. However, even if the approach enables closeness with the customers and affords considerable flexibility, it comes with challenges associated with its emergent nature. Because neither the platform nor the solution family is decided upon beforehand, the size of the potential market cannot be known, nor can the solution's value for the customer and how it will determine potential revenues. Those challenges were evident at Gamma. On the upside, the approach could be fruitfully applied if the company seeks to explore the solution business, for it can be implemented on a small scale at first. However, the approach also requires customers who want to participate in explorative projects. Furthermore, customers are likely unwilling to pay as high a price as they would if they had reference cases (Paper 2) which might have indicated the magnitude of the potential improvement and in turn the cost savings. Consequently, the individual solution could result in a negative business case. Ultimately, however, even if an individual solution may seem to end as a loss, it could be a necessary cost of acquiring and developing knowledge to be exploited in developing other solutions.

The other way of developing solutions through a platform approach is by first establishing its basis. The ECOS project, described in Papers 3 and 4, followed that approach. Therein, the functionality that needs to be delivered is defined, and in turn, the platform is developed based on capabilities needed to provide that functionality. For such an approach, knowledge about technology appears to receive initial emphasis. Of course, knowledge about usage is also involved, but it seems to be mostly concerned with usage at a more general level (i.e. targeting different segments or users), because the development of such a platform occurs remotely from the customer both in time and space. Accordingly, in-depth knowledge about usage is unavailable at the time of development, which burdens the approach which a few major challenges.

At Gamma, the product development function occupies a relatively strong position within the company. Representatives of service development, perceiving an overly 'industrialising' mindset of the product development function, argued that the function thus tries to 'make everything a platform'. That tendency creates inertia in development efforts, in which customers are seldom involved in the first place. By contrast, service development is usually more agile and with shorter lead times than product development. Developing a platform by taking the approach in which the basis is first established requires defining services well in advance. That process thus takes place removed from the customer's usage, which makes the platform's relationship to more specific problems less clear. This results in that the services are defined at a very general level. Also, to be able to do so, stability in the customers' problems are required. Due to the length of this development approach, the risk of delivering services that are addressing obsolete problems at the time of launch must be considered.

Moreover, as described in Paper 4, the ECOS project also confronted problems with being overly focused on product aspects at the expense of interest in services that were supposed to be integrated with those products. Another problem is the problem of mostly building business cases based on number of sold products, as noted in Paper 3, making it tricky to show the value of service development in general. However, this is even more challenging when the services are to be integrated with products. Further still, in platform projects, especially those in which the ultimate (economic) value comes from services, it is challenging to calculate the return on investment. The value deriving from a platform project of that sort is accordingly difficult to grasp from a business perspective, especially when the solutions have not yet been defined or priced in detail and because platform projects are typically costly, as Paper 3 shows. In fact, this difficulty was reported as a reason for the budget cut to the ECOS project as described in Paper 4.

5.2.3 Customer-specific development: Customisation and personalisation

As discussed in Paper 2, the therein proposed decomposition of a solution stresses the aspect of interaction as the layer surrounding both the products and the services. Thus, interaction is what the customer will ultimately experience. As noted by Gilmore and Pine (1997), customisation can be approached by making changes in the product or in its representation to the customer. In service provision, the latter arguably show similarities with the notion of personalisation, in which 'the personnel interacting with the customer adapt the delivery of a given service in response to the customer's expressed or implied needs' (Voss & Hsuan, 2009, p. 556). While personalisation might

bring to mind a business-to-consumer context, it may also be applied to a business-to-business setting for solutions. When delivering a solution, the solution's provision depends heavily upon the interaction between the company representative and the customers, in which activities directed at personalisation are undertaken. Such interaction will facilitate the experience of a customised solution, even if it is not customisation per se.

Because a solution is supposed to be integrated into the customer's processes, as explained in Paper 1, some configurations will be made to the so called 'standard solution' developed in Beta. That dynamic could be related to the layered view of solutions proposed by Brax and Jonsson (2009), which posits a basic solution (i.e. the foundation for the solution's architecture), a customisation layer, and an upgrading layer. The findings of this thesis support that view, and in relation to engineering-oriented integration (Park et al., 2012), products and services are already integrated in the development of the basic solution, as accounted for in Paper 4. Accordingly, relating the layered view of solutions proposed by Brax and Jonsson (2009) to the layered model proposed in Paper 2, the point of customer involvement emerges when a product–service solution moves into an integrated (or customer) solution, to apply Brax and Jonsson's (2009) terminology. To effect that transition, interaction with the customer is essential, at which time solutions can be tweaked by personalising the service delivery. However, following that logic, such minor modifications are not the same as the customisation of the solution. Overloading resources into that activity could result in overspending in an area that does not enable integration.

On the contrary, customisation is achieved by configuring the solution in relation to the customers' operations in order to realise a fit between the solution and the context in which it will operate. Integration competence is thus important in solution provision (Shepherd & Ahmed, 2000), and in this thesis, it appears that such competence relates to knowledge about technology possessed by the organisation. Accordingly, efforts geared towards customisation are associated with knowledge about the specific customer's use and operations as well as knowledge about technology used to configure the solution. Personalisation, by contrast, takes advantage of extensive knowledge about usage, all of which is used to adapt the delivery of the solution and to communicate with the customer.

Interaction has been identified as a key enabler of solution provision (cf. Tuli et al., 2007), as shown in Papers 2 and 5, one which necessarily relates to the personnel providing the solution. While

interaction is typically involved in providing customer-specific, personalised solutions (i.e. the third layer), this thesis argues, especially in Paper 2, that companies should also consider the benefits of leveraging commonalities in a bid to promote consistency in interactions with customers. After all, customisation needs to be allowed to occur in relation to the configuration of the service delivery system, following Voss and Hsuan's (2009) definition of customisation in a service context. Accordingly, separating customisation from personalisation does not lessen the importance of customer interaction. On the contrary, that interaction can facilitate the customisation of solutions and be important for customers' experiences of the solutions. Therefore, although intensive personalisation cannot substitute for customisation further upstream in the value chain, it nevertheless occupies an important role in the provision of solutions.

5.3 Platforms for product–service solutions and the organisational structure

The mirroring hypothesis suggests a relationship between the solution architecture and the organisational architecture (Colfer & Baldwin, 2016). Arguing that the benefits of a platform approach when assuming the inseparability of products and services in their development, this thesis proposes that a misalignment between the solution architecture and the organisational architecture, can explain some of the challenges arising in solutions development. The trend applies for both internal efforts geared toward organising the organisation based on functions and collaborations in the network, as elaborated upon in the following sub-sections.

5.3.1 Mirroring the solution architecture

Although the organisational structure should be determined by the strategy chosen (Raddats & Burton, 2011), the adoption of a suitable one that mirrors the strategy is a major challenge in servitization (Zhang & Banerji, 2017). In the case of product–service solutions, implications from both integration and the platform architecture need to be considered. This thesis highlights several challenges arising in solutions development following the absence of a link between the organisational architecture and the solution architecture.

Paper 4, for example, stresses the issue of suppressed service-related aspects in an integrated project. The paper underscores that the procedural and communication channels, as well as the structures,[16] of the company not only overlook the importance of service-related aspects but also

[16] Here, *structures* refers to a firm's attention structures: the 'rules of the game, players, structural positions, and resources' (Ocasio, 1997, p. 192).

steer product and service issues into separate channels, thereby preventing integration from occurring. Product and service aspects are also evaluated differently due to the different organisational structures and the rules applied therein, which cause challenges with communicating the value of solutions, because the combined product–service focus does not suit either of the channels, as discussed in both Papers 3 and 4. The ECOS project, for instance, is governed by Gamma's product development function; as such, it is evaluated based on measures adapted to development of products. However, the value of the project stems from services. The project therefore faced hurdles with translating the monetary benefits of providing value-in-use into a language that product-oriented decision-makers found understandable. The reason for that complication can be traced to the organisational structure, in which the profits from services were assigned to part of the organisation (i.e. a service business unit with profit-loss responsibility; cf. Gebauer et al., 2005; Oliva & Kallenberg, 2003), whereas the product development function principally focused on the number of products sold. That issue became especially evident when in the development of a platform beginning with the establishment of its basis, which is associated with high initial costs, as detailed in Papers 3 and 4.

An organisational structure separating product from service aspects also poses implications for the development of a platform for solutions, given that the development of a new architecture will be constrained by the setting in which the development occurs (MacCormack et al., 2012). The reason for that dynamic is that the organisational set-up, with its various channels and structures, doubles as the communication arena. Therefore, a separation of product from service aspects will result in a more modular architecture. On the contrary, a platform approach would call for a more centralised structure, in which overall responsibility for the platform is taken. If product and service aspects are to be integrated into the platform, then being governed by different structures reduces the efficiency of that process. On top of that, if the tasks to be executed include cross-boundary coordination, then the costs of efforts to do so will increase (von Hippel, 1990). Of course, informal coordination and integration activities undertaken are also costly, even if they might not be as visible as more formal activities.

In research on servitization, the ways in which the integration of products and services affects the organisational structure have been debated. Although this thesis highlights the separation of service development to be a challenge when adopting a platform approach for solutions, such separation

is commonly suggested (e.g. Gebauer et al., 2005, 2010; Oliva et al., 2012). Nevertheless, the degree of integration between products and services may also have an impact (Oliva et al., 2012), which stands in contrast to the proposition that the more mature a company in their servitization efforts, the more appropriate a separated organisation (Fliess & Lexutt, 2019). This thesis also reports that in solutions provision, comprising a mature level of servitization, Gamma, did *not* gain from separating product and service aspects in its organisation. Instead, when product and service responsibilities had been separated in the organisation, the ownership of the platform, as well as the deriving solutions, had become problematic, as recounted in Paper 4. In general, if competences related to different aspects of solutions are divided between various functions, then no function alone possesses the knowledge needed to manage the platform and the solutions derived. Put differently, the knowledge needed to develop the platform is distributed in a decentralised manner. Problem-solving will accordingly be an iterative process among the different functions, for not all knowledge is held within one site (von Hippel, 1994). That situation prompts high costs for the problem-solving activities, namely high costs of integration. Therefore, misalignment surfaces between the desirable solution architecture when based on a platform approach and the organisational architecture, which works to compromise efficiency.

When costs are high for problem-solving iterations, the activities can be task-partitioned (von Hippel, 1994). If product and service activities are separated to be performed in different functions, then the mirroring hypothesis suggests that such a loosely coupled organisation is more likely to develop modular offerings (MacCormack et al., 2012; Sanchez & Mahoney, 1996). Accordingly, an organisational separation of the product- and service-focused functions might explain the tendencies of separating product and service activities in the development efforts, as elaborated upon in Paper 4, for they might be operating too independently to allow for their integration in the platform architecture. Engineering-oriented integration (Park et al., 2012) assumes the interdependence of products and services already in the development thereof, which stands in contrast to the organisational separation of products and services, which is mirrored in the solution architecture. A solution architecture based on a platform approach accordingly implies that a separation of the service business unit may be inappropriate, for it misaligns the organisational architecture and the intended solution architecture. That reasoning contrasts Fliess and Lexutt's (2019) proposition that the more mature the organisation in servitization, the more appropriate a

separated service business unit, if assuming that product–service solutions developed by taking a platform approach exhibit a high level of maturity.

A major reason for having a separate service business unit is arguably the opportunity to protect the emerging service orientation (Gebauer et al., 2005, 2010; Oliva et al., 2012), for research has shown that a shift in cultural mindset is a challenge in servitization (Galbraith, 2002; Martinez et al., 2010; Oliva & Kallenberg, 2003; Salonen, 2011). However, separating the service organisation from the product organisation can also inhibit an integrated focus on product and service aspects. The establishment of a service orientation and its protection might be more important in the earlier phases of servitization. In that case, a separated service organisation may not be an obstacle, however, because the service strategy is to provide basic services with lower degrees of integration between product and service development. By contrast, when applying a platform approach and when problem-solving activities require knowledge about both product and service aspects, the costs derived from iteration and integration efforts across functions increase.

Therefore, this thesis argues that major obstacles and costs associated with taking a platform approach for product–service solutions appear due to the misalignment between the solution architecture and the organisational architecture. In that way, both the degree of integration, as acknowledged in Oliva et al. (2012) following the findings of Neu and Brown (2005, 2008), and the platform approach used to manage the solution architecture influence the appropriateness of the organisational structure. Following the proposition of utilising a platform approach for solutions, the mirroring hypothesis predicts that the organisational architecture should also comprise a tightly coupled core that establishes the assets to be shared among solutions. That set-up requires centralising decision-making about the platform. After the point at which development becomes customer-specific, however, more specialised, user-focused units could be appropriate. At the same time, in customising solutions, technical aspects need to move closer to the customer. Therefore, establishing knowledge about technology in those customer-facing units becomes necessary, despite the costs associated with doing so.

5.3.2 Collaboration in solution provision

Taking a platform approach also has ramifications for organising the development of solutions in terms of collaboration with actors in the network. Given that value is created in a network and that solution provision engages multiple actors (Jaakkola & Hakanen, 2013; Story et al., 2017), efforts

geared towards organising such development are realised beyond the company's boundaries—that is, in the network. According to the mirroring hypothesis, the solution architecture will mirror those efforts, which are also concerned with inter-organisational relationships (Cabigiosu & Camuffo, 2012). However, as shown in this thesis, there are major dynamics in place in the network that pose implications for the solutions architecture.

This thesis maintains that solutions are interconnected and, as such, form networks of solutions (Paper 5). That characteristic results in a lack of stability in the solution architecture initially, especially given the novelty of that approach at Gamma, which eventually means that more information is shared among specific actors in solutions development in order to develop the platform. For a modular architecture, that circumstance has been referred to as the 'complementary hypothesis', which proposes that a modular approach requires more information sharing among actors as a result of joint development efforts (Cabigiosu & Camuffo, 2012; Hsuan, 1999). Those joint efforts show that, at least in the establishment of the platform, coupling among actors involved in the solution family becomes tighter, not looser, which aligns with the notion that a partnership is associated with modularisation opportunities (Hsuan, 1999), because it is concerned with establishing an architecture. In this thesis, the platform is argued to develop in accordance with the mirroring hypothesis, albeit also partly as a result of knowledge accessed and gained in those partnerships.

However, as collaboration with some actors in solutions development increases, other couplings become looser. Paper 5 describes how third-party suppliers, who previously added their equipment (e.g. a crane) to finished trucks, became a partner in the development of a new solution, which potentially made the company to bypass its own customers with that specific solution. That arrangement could result in a lost business opportunity, as well as a need to ensure that new opportunities not only turn a profit as standalone cases but also cover the potential loss of another case. Solutions thus cause movement in the network, in which companies assume multiple roles dependent on the solutions in which they engage, as Paper 5 reveals. Therefore, though a modular architecture has been discussed to be associated with both less and more information sharing among actors in the network (e.g. Cabigiosu & Camuffo, 2012; Hsuan, 1999; Sanchez & Mahoney, 1996), a solution platform architecture formed by starting with an individual solution seems to be associated with more information sharing among the partners involved. Accordingly, transcending

not only internal but also company boundaries, the costs of joint development efforts for the platform are likely to increase compared to those of an individual project.

At the same time, this thesis also shows that companies seek to provide standardised interfaces for so-called ‘plug-and-play’ solutions, as detailed in Papers 1 and 3. Once the platform is developed, such interfaces can reduce the need for information sharing among actors, for they can simply ‘plug into’ standardised interfaces. That allowance indicates a combined platform-modular approach and enables the provision of a wider variety of solutions by collaborating with a wider range of actors. Such an approach would be associated with rather loose couplings between actors engaged in solution provision, especially compared to individual solutions, as evident in the ECOS project. Consequently, there could be various degrees of coupling among actors in the network simultaneously in play dependent on the different solutions, their origins, and the approach taken to develop the platform.

The information-extensive partnerships used to develop platforms originating from an individual solution pose implications for internal efforts to structure the organisation, especially when separating service development from product development. Related to the problem concerning the ownership of a platform, as previously reported, the separation of products and services also introduces complexity into the interface with partners. Partnerships that involve both technology and commercial aspects are somehow new to Gamma, as partly addressed in Papers 3–5. Purchasing is used to work with suppliers, in which the relationships are generally more transactional and focused on exchange. The aftermarket function collaborates with service partners, including maintenance workshops, used to deliver services of a more stand-alone character (Paper 5), mostly concerned with spare parts and working hours. However, partnerships with external actors to provide product–service solutions constitute a new arena for the company. In such endeavours, Gamma faces major challenges in determining which function should take the lead in those new partnerships, with little consensus about who should approach the partner. Gamma’s representatives thus highlighted the need to consider partners as customers and, in addition to responding to their needs, being flexible to changes in the network. That requirement appears to be a challenge, because the separation of the product and service scatters the information that the company has, meaning that an overview is missing, which in turn raises costs of developing the solution together with other actors in the network.

5.4 Synthesis: Factors influencing the use of platforms for product–service solutions

The purpose of this thesis has been to identify and describe factors influencing the use of platforms for product–service solutions. First, some factors are associated with the general applicability of a platform approach for product–service solutions, particularly concerning reasons for applying a platform approach, as well as what it requires from a solution architecture perspective. Second, other factors influence the development of the platform for those solutions, because different approaches are associated with various benefits and drawbacks.

5.4.1 Factors influencing the applicability of a platform approach

Whether a platform approach is applicable for the product–service solutions appears to depend upon what the company aims to achieve, as well as the nature of the offerings. Although taking a platform approach affords advantages for product–service solutions, as described in the first section of this chapter, the obstacles and costs associated with its development should not be underestimated. Following the different emphases of modular and platform strategies as outlined by Magnusson and Pasche (2014), whether a platform versus modular architecture is suitable for developing product–service solutions depends upon not only the integration of the solution but also variations in relation to customers' needs and in the environment.

Concerning the nature of offerings, four aspects appear to make important distinctions between products, services, and solutions in relation to a platform approach: the output (i.e. nature of the offerings provided) of the platforms, their dependence upon time and space, the primary cost drivers, and assets to be shared among offerings. Those factors are summarised in Table 6 and, later in this section, used to elaborate the applicability of a platform approach.

Table 6: Differences in products, services, and product–service solutions in relation to a platform approach

	Products	**Services**	**Product–service solutions**
Output	Goods	Processes	Processes including goods
Dependence on time and space	Consumption separated from production (Low dependence)	Consumption simultaneous as production (High dependence)	Three steps with various degrees of time and space dependence: platform (low dependence), customisation, and personalisation efforts (high dependence)
Primary cost drivers (subject to cost reductions)	Equipment (and partly material)	Personnel	Acquiring new knowledge about usage and partly technology
Major assets for the platform	Components	Processes	Knowledge

This thesis shows that a platform approach is suitable for solutions in which products and services are integrated in the design and development phases in engineering-oriented integration (Park et al., 2012). Therefore, the applicability of a platform approach is associated with the degree and nature of integration between products and services. When the integration of products and services is performed closer to the customers (e.g. by sales personnel), a modular approach could be more beneficial to enhance the degree of manageable variety. In using a platform for product–service solutions focused on in this thesis, however, such variety is not the chief objective but efficiently developing solutions that correspond to customers' needs. When those needs are not too heterogeneous, a platform approach facilitates economies of scale and scope as well as a range of other benefits, owing to the ability to decouple development focused on the customer from that providing the basis (i.e. the platform). Although customisation and personalisation depend highly upon the specific customer in time and space, the platform provides a head start in addressing them. A platform approach thus shortens lead times for specific solutions and allows for economies of scale and scope.

A platform is less suitable amid a high degree of change, both in customers' demands and technological advancements (Magnusson & Pasche, 2014). However, companies operating in environments characterised by technology uncertainty (e.g. early in the product life cycle) are more likely to offer product-oriented instead of customer-oriented services (Visnjic et al., 2019). Product-oriented offerings can be used to differentiate on the market, and by making the products and services loosely coupled, a modular approach can enable companies to boost the degree of manageable variety. Conversely, a platform approach is a suitable option amid lower degrees of technology uncertainty (i.e. when technology has matured) and when provided offerings include high degrees of integration between products and services.[17] That idea may partly explain the lack of attention given to platforms in literature on service architecture, which has focused mainly on pure services, not integrated product–service solutions. Efficiently managing the integration between products and services in the platform requires centralising decisions about the platform, not separating product and service development organisationally, which inhibits the integration of product and services, and using knowledge about both usage and technology to address customers' needs.

To adopt a platform architecture, the degree of (potential) commonality among the offerings should be high enough to allow the formation of solution families large enough to enable economies of scale. For products, equipment is a high-cost item, whereas personnel constitute such an item for services. For product–service solutions, a primary cost driver is establishing and developing knowledge of both technology and usage. Such knowledge about usage and technology will work as assets that can be shared among a set of solutions.

Sharing knowledge as an asset (i.e. the platform) among solutions using a platform approach involves the ability to manage variation among customers' needs. High variation can be dealt with by taking a platform approach, but it is not an objective to enhance it further. If demands for variation are high and the company would like to increase the manageable variety, then a modular approach would be a better choice. Furthermore, because a platform architecture is costlier to upgrade than a modular one, the customers' needs should have some stability over time. However, compared to a product platform, a platform for product–service solutions might be less costly to

[17] Visnjic et al. (2019) have identified a link between the provision of customer-oriented services and an industry characterised by value generation uncertainty rather than of technology uncertainty.

upgrade. A platform approach for products typically includes sharing components among a set of products, as developing and producing those components are costly undertakings. For product–service solutions, by contrast, the assets shared might be more easily changed or upgraded, especially if concerned with knowledge. Regarding knowledge about usage, the platform might even benefit from changes in customers' needs over time, which adds to the knowledge base. For major changes to be made, however, upgrades concerned with the products are also needed, which is more costly and time-consuming.

Overall, despite the benefits of a platform approach argued in this thesis, companies also have to consider what the customers are willing to pay for. If the customers are willing to pay for a highly customised, unique solution, then the value of adopting a platform will be limited, if not harmful to the business due to the high costs associated with its set-up. Table 7 accounts for factors influencing the applicability of a platform approach for product–service solutions. In addition to those factors, the use of a platform approach depends upon several factors influencing the platform's development, which are accounted for in the next section.

Table 7: Factors influencing the applicability of a platform approach for product–service solutions

Area	***Influencing factors***	**Applicability of a platform approach for product–service solutions**
Business strategy	*Objectives of the solution business*	A platform approach could be suitable when emphasis is placed on increasing the volume of solutions provided by creating economies of scale and scope.
Solution and organisational architecture	*Degree and nature of integration*	With a high degree of integration between products and services (e.g. engineering-oriented integration), a platform could be suitable due to the possibility of integrating products and services in the platform. For integration performed later in the process (e.g. marketing-oriented integration), a platform approach for the overall solution might be less valuable than a platform for the products and services individually, due to the primary cost drivers.
	Commonality potential	Commonality potential should be rather high, especially concerning knowledge about usage and users and/or knowledge about technology, corresponding to either the problem domain or the solution-domain.
	Organisational structure	Overall responsibility for platform is needed—that is, the centralisation of platform-related decisions. Separating products and service aspects into different structures prevents the platform approach and results in higher costs. An organisational structure corresponding to a platform approach and, in turn, the associated solution architecture is therefore needed.
Customers' needs	*Variation among customers*	Variation among customers in each solution family should be low regarding the usage and the technology needed to address their operations. Individual customers with highly specific needs should be managed by means outside the platform.
	Variation over time	The platform requires at least moderate stability over time. However, a platform for product–service solutions can accommodate more variation than a product platform, due to the evolving nature of knowledge, which enables extended knowledge to be incorporated in the platform via a lower cost compared to that of a product platform.

5.4.2 Factors influencing the development of a platform approach

As presented in this thesis, the development of platforms can take various approaches, including by starting with an individual solution or by first developing basis (i.e. the platform), the latter of which is aligned with a more conventional, product-oriented way of developing platforms. The former, starting with an individual solution, is similar to the notion of repeatable solutions (Davies & Brady, 2000), which seeks to secure economies of repetition rather than of scale or scope. Alike, so-called customer platforms have been proposed in product settings (Sawhney, 1998), using a beachhead as basis for expanding into related markets.

While both approaches are concerned with ultimately establishing a platform, there are nuances in what benefits and challenges are associated with their respective development. These differences are concerned with the starting point for acquiring knowledge about usage, the existing knowledge about the technology used, the commonality development, the volume, the visibility of knowledge development for the customer, relation to potential business partners in the platform development, and the adaption to changes over time.

First, the approaches relate differently to the kinds of knowledge, which in this thesis are acknowledged to be parts of the platform: knowledge about both usage and technology. Because the provision of solutions involves a shift in what activities the provider has to engage, new and extended knowledge is necessary. Acquiring that knowledge, especially knowledge about usage, poses significant costs for companies. A major difference between the two approaches appears to concern how that knowledge used in the platform is acquired in the process.

To develop a platform starting from an individual solution, the provider acquires that knowledge by studying a specific customer in depth and thereafter leverages it while approaching other customers. Such potential, however, requires access to a friendly customer, especially because the visibility of development efforts is high, which occur on the customers' site, commonly by taking a more experimental approach. Likewise, if a partner is engaged in the project, as in the case of the COBO project, then the relationship during development will likely be quite close, due to the collaborative efforts and insights gained from customers to be able to address their overall operations. Such collaboration also contributes to broader knowledge of the customers' problems, including ones related to partners' products.

Starting with the development of the basis, by contrast, appears to allow the leverage of existing knowledge about technology held by the organisation. Because the development of such a platform takes place more distantly from the users, the initially acquired knowledge is likely to be concerned with overall usage areas, not the individual, highly contextual problems of customers. For those kinds of platforms, development is likely to be based on predetermined commonalities with a focus on acquiring the knowledge needed for them, which can risk overlooking other opportunities and being insensitive to variation over time. Because platform development is then more focused on generic areas of usage, with uncertainties about specifics of the solutions, relationships with external partners will be quite distant in the development phase.

According to Simon (1962), 'Problem solving requires selective trial and error' (p. 463), namely with two sources of selectivity: heuristics to suggest different paths to be explored and previous experience. Because the latter is largely missing when developing the platform by starting with an individual solution, it has to rely heavily on the former. Accordingly, development will entail on going back and forth between the problem and the solution, with many interactions that are liable to make failures visible to customers. Such iteration might also be costly and result in the lack of profitability for the individual business cases for the project. To advocate for those kinds of projects may be challenging in the organisation. Conversely, compared to starting a platform development by first establishing the basis, the steps forward are small and have limited impact on other areas. Failures will thus have only limited costs (i.e. concerned with only one solution) and contribute to knowledge for later use. That dynamic explains why the approaches can be used in combination. In fact, the COBO project partly exists to create knowledge for the ECOS project.

It appears that the approach starting with an individual solution is used when there is limited knowledge about the technology involved. That potential tendency contrasts the idea that customer-oriented services are more commonly offered when technology uncertainty is lower (Visnjic et al., 2019). However, though the basic product technology may be known, the technology referred to here can be regarded as an enhancer that requires the development of new knowledge, albeit not involving the overall organisation in the short term. That circumstance means that the idea that a platform approach might not be the best option when there is high speed of change in the development of the technology (Magnusson & Pasche, 2014) still holds. Starting with the individual solution to develop the platform is simply a way of managing moderate levels of such

uncertainty at a lower cost than starting by developing its basis. It also allows for adaptions to changes over time compared to a platform predetermined well in advance.

On the downside, starting with the individual solution limits the volume that can be created based on the platform, at least in the short term. A platform established initially could allow for greater volumes once up and running. While a platform starting by developing the basis is associated with exceptionally high initial costs, the volume that can be derived from the platform appears to be considerably higher and targets a larger number of different areas of usage due to its more generic nature. That difference stems from the needs for various in-depth insights into the specific usage areas. Starting with an individual solution will also result in highly in-depth insights into a specific customer's operations, only a subset of which can be used as a basis for a platform applicable to other users as well. Such knowledge is required for the individual solution and would contain knowledge potentially already existing in functions operating more closely to the customers. Although such closeness to the customer may be costly, it is also an advantage to be able to foster a service orientation and a customer-centricity. In developing a platform by first establishing the basis, it appears more challenging to pay sustained attention to service-oriented aspects, because development happens more distantly from the customers both in time and space. Overall, a platform starting with the development of the basis appears more static in its structure, which keeps partners and customers at an arm's length.

The factors proposed to influence the development of the platform through one approach or the other are summarised in Table 8, in which the differences between a platform development starting in an individual solution, and by developing the basis, are accounted for.

Table 8: Factors influencing the development of platforms

Factors influencing the development of the platform	**Platform development starting with an individual solution**	**Platform development starting by developing the basis**
Starting point for acquiring knowledge about usage	Specific (individual customer)	General (usage area)
Existing knowledge about the technology used	Limited to moderate	Moderate to high
Commonality development	Emerging	Predetermined
Volume	Lower	Higher
Visibility of knowledge development to customer	High	Low
Relation to potential business partners in platform development	Close	Distant
Adaptability to variation over time	Higher	Lower

6 Conclusions and contributions

The purpose of this thesis has been to identify and describe factors influencing the use of platforms for product–service solutions. As an overall result, it suggests that taking a platform approach enables adaptability to customers' needs in developing product–service solutions and at once allows for economies of scale and scope. In its implementation, such an approach comes with opportunities as well as challenges, however. This chapter accounts for conclusions drawn from the research for the thesis, outlines its contributions to the literature, and presents some suggestions for future studies.

6.1 Conclusions

A customised nature is an essential characteristic of solutions, because suiting the customer's operations is crucial to a solution's capacity to facilitate its value-in-use. At the same time, pressure to improve the efficiency of developing solutions is ever-increasing, because by reducing the costs of each individual solution, economies of scale and scope can exert effects that boost profitability. Against that background, this thesis has addressed combining standardisation with customisation by focusing on the use of platforms for product–service solutions, particularly by identifying and describing factors influencing the use of a platform approach.

6.1.1 Influential factors

A first conclusion is that a platform for product–service solutions differs from both product and service platforms in terms of its output, time and space dependencies, primary drivers of costs, and the assets used for the platforms. While a solution architecture can be described at various levels of decomposition, the architecture still differs from those for products and those for services, which affects the use of a platform approach for product–service solutions.

Second, a platform approach for product–service solutions is suitable if the objective is to increase the volume of solutions provided by creating economies of scale and of scope. Under certain circumstances, a platform approach for product–service solutions benefits internal and external communication by serving as a reference point, in addition to facilitating cost-efficiency and effectiveness in responding to customers' needs. It additionally serves as a means of responding more quickly to customers' orders, because the development lead time could be reduced, thereby shortening the time to market for individual solutions. Beyond that, a platform approach can enable collaboration with external parties in order to provide more overall solutions by affording access

to additional knowledge about both usage and technology. Such collaboration and reductions in lead time derive from opportunities of dividing the process in which the assets used for the platform are established, from the efforts and activities required to make individual solutions suit customers' operations, i.e. delay the point in time when the development becomes customer specific.

Third, though the thesis describes several advantages in the use of a platform approach for product–service solutions, such an approach's applicability is constrained by several influential factors. It depends upon the business strategy, including the objectives of the solution business, the solution architecture, the organisational architecture and the nature of customers' needs in terms of both variation among customers and over time. While some variation can be managed in a platform for product–service solutions, the need for at least moderate stability should be met, because it is required to be able to achieve economies of scale.

Therefore, referring to the solution architecture, this thesis highlights that the use of a platform approach for product–service solutions is contingent upon the type and degree of integration between the product and the services. That integration, in turn, influences the use of a platform approach by giving it specific characteristics, particularly in the design and development of solutions, by making the products and services inseparable from the customer's point of view. Such integration also bears a major impact on the design of the solution architecture and activates the benefits of a platform approach, not a modular strategy, for those solutions, because interdependence of products and services from a design and development phase forward can be incorporated therein and leveraged on.

6.1.2 The use of a platform approach

Several challenges arise in developing product–service solutions through a platform approach, some of which are due to a misalignment between the solution architecture and the organisational architecture. The findings in this thesis especially underscore the difficulties occurring if separating product and service development in developing product–service solutions by taking a platform approach, in which the product and services should be integrated already in the design phase (i.e. in the solution platform architecture). That understanding follows the mirroring hypothesis, which identifies a relationship between the organisational and product architecture. An organisational separation of product and service development does not correspond to the solution platform architecture as suggested in this thesis, neither does it support required integration-oriented efforts

among product and service development activities. Due to that misalignment, it appears that a separation of product and service aspects structurally lead to a tension in solutions development, which can inhibit the platform approach for product–service solutions to evolve.

Recognising those challenges, this thesis suggests three major steps of developing product–service solutions by using a platform approach: developing the platform (i.e. establishing the assets to be shared among solutions), customisation (i.e. concerned with configuration of the solution to make it useful in the customers' operations), and personalisation (i.e. about adapting the delivery of the solution). First, knowledge about both usage and technology are identified as assets to be shared among solutions—that is, forming the platform itself. Those assets correspond to knowledge required in relation to the problem (i.e. applying knowledge about usage and users to understand the setting) and the solution (i.e. leveraging knowledge about technology to solve a problem). When considering how a platform approach influences the development of product–service solutions, ways of using those assets are influential, as a process in which both knowledge streams are used to establish the platform.

To develop a platform, acquiring and establishing the knowledge needed can take two approaches as identified in this thesis: starting with an individual solution or starting by establishing the basis for the solution family (i.e. the platform). Although those approaches can be used in combination, they constitute different points of departure, with different advantages and drawbacks. In determining the starting point for developing the platform, companies should consider the roles of knowledge about both technology and usage. Setting out to either focus on managing variation over time or volume within what is possible by using a platform approach, the point of departure makes development-oriented efforts visible to a larger or lesser extent to the individual customers, depending on the degree of closeness to them. Companies should also pay attention to their collaborations with other actors in the network, because the different approaches manage the relationships with those external actors differently.

The two subsequent steps in the development of product–service solutions using a platform approach are customisation and personalisation, both of which comprise activities targeting individual customers. This thesis distinguishes customisation from personalisation by highlighting the need to acknowledge the resources and efforts invested in those different activities that require partly different sets of knowledge. In customisation, knowledge about both technology and usage

are utilised, while personalisation mostly relies upon knowledge about usage alone in order to be able to adapt the delivery of the solution. Although that personalisation of the solution is essential for the experience of the solution, it cannot assure the solution's functionality in the customer's operations. To ensure an integration between the customer's operations and the solution to enable value-in-use, customisation efforts are needed.

6.2 Contributions

This thesis adds to the current body of knowledge about product–service solutions and platform literature by revealing benefits and challenges associated with the use of a platform approach for product–service solutions. It concludes that taking a platform approach can help to overcome obstacles in achieving the profitability of the solution business, for it enables economies of scale and scope. However, the applicability of such an approach is also constrained with several factors proposed in this thesis. The thesis thereby contributes knowledge to an area considered to be important by, for instance, Brax et al. (2017), concerned with the use of platforms for product–service solutions. This thesis shows that taking a platform approach for product–service solutions can, as in the case of modular solutions (Rajala et al., 2019), also can be seen as a next stage in servitization under specific circumstances. Those circumstances concern the objectives of the solution business, the solution and organisational architecture, and the needs of customers.

6.2.1 Contribution to literature on product–service solutions

A platform approach represents a promising avenue for simultaneously allowing for adaptability to the customer's needs, as well as fulfilling the need for efficient operations. Referring to the framework proposed by Bask et al. (2011), that capacity of a platform approach facilitates a transition from a solution developed in an engineer-to-order process to one that is made-to-order. However, whereas Bask et al. (2011) examined aspects of modularity, this thesis expands that thinking by highlighting platforms in particular.

The application of a platform approach appears especially suitable when the integration of the products and services is engineering-oriented, thereby assuming the inseparability of products and services (Park et al., 2012). That circumstance requires the integration of products and services in the design and development phases—that is, in designing the solution platform architecture. With few exceptions, modular approaches have dominated research on managing the architecture of

services,[18] and further focus on a platform approach could therefore provide additional insights suitable when, for instance, seeking to realise economies of scale and scope instead of economies of substitution (Magnusson & Pasche, 2014).

While acknowledging the shift towards the customer when providing solutions, to move too close can result in costly development efforts in which the intended economic benefits of the service provision are not achieved. To enable closeness to customers and adaptability to their needs while remaining efficient, this thesis suggests a platform approach pursued in three steps, similar to the approach proposed by Brax and Jonsson (2009). The first concerns sharing assets among solutions—that is, the platform itself. The next steps, focused on specific customers, make a distinction between the customisation and personalisation of solutions, following Voss and Hsuan's (2009) thinking that much of what has been described as the customisation of services could instead be described as personalisation. This thesis adds to previous research by arguing the need to balance the efforts of those steps. Pursuing personalisation only—for instance, as part of efforts of sales personnel—is not enough to adapt solutions to the context in which they will be used and will generate low returns relative to the efforts and resources invested. This thesis has shown that the customisation of a solution starts further upstream in the value chain and requires integration competencies. Therefore, while customer-centricity is highlighted to be crucial for solution provision (e.g. Galbraith, 2002), the findings in this thesis support Brax and Jonsson's (2009) argument for the need to balance product- and customer-centricity to leverage knowledge about both usage and technology.

Adding to the debate of whether to separate or integrate the service business from the product when servitizing (e.g. Neu & Brown, 2005; Oliva & Kallenberg, 2003; Oliva et al., 2012), this thesis joins Neu and Brown (2005) in revealing challenges in separating the development of services when applying a platform approach to the development of product–service solutions. A separation of products and services establishes a misalignment between the solution architecture and the organisational architecture that inhibits integration from occurring. While the development of modules for solutions (cf. Gremyr et al., 2019) can mirror an organisational set-up in which product and service development are separated, a platform approach requires a higher degree of coupling for the core to enable seamlessness between products and services in the platform.

[18] See Frandsen (2017) for an overview of literature on managing product and service architectures.

6.2.2 Contribution to literature on platforms

In research on platforms, product platforms have dominated the agenda, whereas attention to the application of a platform approach for services has been limited. In response, this thesis adds to the discourse about product platforms, particularly from the service perspective and in terms of the integration between products and services. Such product–service solutions possess a different set of features in terms of their architecture in comparison to both products and services respectively. In this thesis, such features are identified as being related to the output provided, dependency upon time and space, primary cost drivers, and assets shared that might provide the greatest benefits given the nature of the output and the associated costs. That understanding underscores the need to pay attention to differences in architectures when using the platform approach to be able to understand the potential use of platforms for product–service solutions.

This thesis has introduced and articulated the concept of a solution family at a general level, comparable to that of the product family in literature about platforms. Due to the different architecture of products and solutions, the concept of the solution family will differ, however, from that of a product family. This thesis acknowledges that it is likely that a solution family addresses a user or a usage area, not an overall market or customer segment (e.g. Meyer & Utterback, 1993; Sawhney, 1998), which further calls for extended knowledge about usage in providing solutions using a platform approach.

This thesis also provides examples of the application of knowledge platforms, including the associated notion of people and relationship platforms (Robertson & Ulrich, 1998). That insight adds to the current focus on component platforms in literature and points to the relevance of turning to other variants of platforms when dealing with services and solutions. Another approach to developing a platform—that is, starting with the individual solution—is associated to a so-called customer platform (e.g. Sawhney, 1998) in the context of product–service solutions. This thesis articulates that such approach can be used to thoroughly understand each individual customer's context and usage as well as apply that understanding as a point of departure for developing a platform. That perspective contributes to the dominant idea of a platform's evolution by offering an alternative approach.

6.3 Directions for future research

This thesis outlines how a platform approach can be used for product–service solutions by identifying and describing factors influencing the use of platforms. Further research needs to follow the case study underlying the research to uncover in greater depth how those platforms can be leveraged, as well to provide guidance on avoiding the pitfalls associated with such an approach. Therefore, it is necessary to further scrutinise challenges encountered in the process of developing a platform approach for product–service solutions, for much remains to be uncovered.

First, the research presented in this thesis has focused exclusively on solutions in which products and services are assumed to be inseparable from a customer's point of view. That type of integration has been argued to affect the applicability of a platform approach. Future research should also consider other types of product–service bundles in which products and services are not as entangled. Overall, managing services in a product-dominant context constitutes a specific arena for platform and modular strategies that requires further examination. Especially considering the case-based nature of the research, studies in the future should involve examining whether the propositions put forward in this thesis hold weight in other contexts, as well as for product–service solutions in general.

Second, the relation between product customisation strategies and servitization, as described by Sousa and da Silveira (2019), deserves additional attention in research, especially given the acknowledgement of the coexistence of different kinds of products and services (Kowalkowski et al., 2015; Martinez, Neely, Velu, Leinster-Evans, & Bisessar, 2017), ranging from standardised to customised and from separated to integrated. Although this thesis puts forward challenges of a misalignment between the solution architecture and organisational architecture in the specific case of engineering-oriented integration, such solutions form only a fraction of the overall portfolio for the company. The organisational structure will thus also depend upon other architectures. Research should examine how to deal with the coexistence of various offerings in relation to the application of platform strategies, particularly by taking the corresponding organisational structures into account. Gamma, for instance, has adopted a platform and a modular strategy for the development and manufacturing of products. Those strategies might affect the solutions provided, as well as the organisational set-up, and research could beneficially delve into how that approach affects the solutions provided.

Although the research for the thesis was conducted by following cases over time, research applying an even more protracted longitudinal approach is encouraged in addition to the application of a more quantitative approach. In particular, following the execution of several, interdependent learning projects over time would provide fruitful insights into how knowledge can be developed and leveraged to provide solutions more effectively to new customers. It would also provide insights into the dynamics of the solution architecture. Even if the product architecture is somewhat static, the solution architecture developed by taking such an approach is more likely to evolve in dynamic ways. To provide guidance on ways of managing such dynamism, research that accounts for that process over time is required.

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Appendix A: Observation scheme

Date:

Occasion:

Participants

Context/environment

Area	**Time**	**Discussion/observation**	**Illustrative statement(s)**	**Activities/ actions**	**Decisions**	**Observer's note(s)**

General notes: