# Enabling digital service innovation in medical technology firms: An organizational capability perspective

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The President:

Prof. Dr. Bernhard Ehrenzeller

# Vorwort des Autors

Die vorliegende Dissertation ist im Rahmen meiner Tätigkeit als wissenschaftlicher Mitarbeiter am Institut für Technologiemanagement der Universität St. Gallen entstanden. Als Mitarbeiter im Bereich Produktionsmanagement konnte ich an zahlreichen Industrie- und Forschungsprojekten mitwirken und so einen umfassenden Einblick in die aktuellen Herausforderungen produzierender Unternehmen im Kontext der Digitalisierung gewinnen. Hervorzuheben ist an dieser Stelle ein Konsortial-Projekt mit vier führenden Medizintechnikunternehmen, welches das Fundament dieser Dissertation bildet. An dieser Stelle möchte ich mich bei den beteiligten Projektpartnern für die Zusammenarbeit und das entgegengebrachte Vertrauen vielmals bedanken. Ohne die offenen Diskussionen und gewährten Einblicke wäre diese Arbeit nicht möglich gewesen.

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Bonaduz im Februar 2020 Lorenz Stähle

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# List of abbreviations

| | |
|---|---|
| B2B | Business-to-business |
| B2C | Business-to-consumer |
| BU | Business unit |
| cf. | Confer |
| DCV | Dynamic capabilities view |
| e.g. | Exempli gratia (for example) |
| et al. | Et alii (and others) |
| etc. | Et cetera |
| GBF | Global business franchise |
| i.e. | Id est (that is) |
| ICT | Information and communication technology |
| IHIP | Intangible, heterogeneous, inseparable, and perishable |
| IoT | Internet of Things |
| IP | Intellectual property |
| IT | Information technology |
| KPI | Key performance indicator |
| MVP | Minimum viable product |
| NPD | New product development |
| NSD | New service development |
| p. | Page |
| pp. | Pages |
| PSS | Product-service system |
| R&D | Research and development |
| RBV | Resource-based view |
| RMT | Remote monitoring technology |
| SME | Small and medium-sized enterprise |
| SRQ | Sub-research question |
| USP | Unique selling proposition |

# Summary

Nowadays, manufacturing firms are increasingly providing services or are even adopting service-oriented business models. By referring to the term servitization of manufacturing, research and practice discuss benefits, barriers and organizational implications of service-oriented growth strategies. In the past, the shift towards services was mainly considered as a strategic response to shrinking product margins in mature industries with cost-based competition. However, by implementing latest technologies like the Internet of Things, manufacturers are increasingly augmenting physical functions with digital and data-based services, making services an inherent part of the product. Thus, in many manufacturing industries, services become more than a reactive strategy for mature product markets. For example, in the medical technology industry, firms increasingly seek to create value beyond the physical function of the device by offering digital services that support healthcare providers to increase efficiency and outcome of care delivery.

However, many firms still struggle to develop and commercialize digital services successfully. Several scholars have adopted a capability perspective to study the service transition of manufacturing firms. However, the latest research on the role of digital technologies in servitization mainly discusses required technological competencies but neglects the organizational requirements. This dissertation addresses the gap in the literature by identifying organizational capabilities to facilitate digital service innovation in medical technology firms. Additionally, it provides first insights into organizational and managerial levers to foster digital service innovation.

This research is rooted at the intersection of research on servitization and service innovation and addresses the emerging topic of digital service innovation. Following a theory-guided case study approach, the thesis is structured into a conceptual and empirical part. First, by adopting an organizational capability perspective and utilizing insights from the theory of dynamic capabilities, a conceptual research framework is developed. The research framework guided the data collection and analysis by providing a basic understanding of relevant theoretical constructs and their relationship. Second, by conducting multiple case studies with four medical technology firms, the research framework is further refined and critically reflected. Finally, based on the findings of the case studies, a management framework to determine appropriate organizational designs, as well as an exemplary digital service innovation process, are developed. Thus, providing medical technology firms with managerial and organizational levers to support the management of digital service innovation.

# Zusammenfassung

Dienstleistungen und dienstleistungsorientierte Geschäftsmodelle gewinnen in produzierenden Unternehmen zunehmend an Bedeutung. So diskutiert die betriebswirtschaftliche Forschung unter dem Begriff Servitization, Chancen, Herausforderungen sowie organisatorische Konsequenzen von dienstleistungsorientierten Wachstumsstrategien. Bisher wurde die zunehmende Bedeutung von Dienstleistungen als unternehmerische Antwort auf schrumpfende Margen und steigenden Kostendruck in reifen Industrien verstanden. Durch das Aufkommen neuer technologischer Möglichkeiten, wie dem Internet der Dinge und der damit einhergehenden Konvergenz von physischer und digitaler Welt, verschwindet jedoch zunehmend die Trennlinie zwischen Produkt und Dienstleistung. So haben digitale Dienstleistungen das Potential, zukünftig in vielen Industrien fester Bestandteil des Angebots zu werden. Die Service-Transformation produzierender Unternehmen kann somit nicht mehr nur als eine Reaktion auf reife Absatzmärkte interpretiert werden. Als Beispiel lässt sich hier die Medizintechnikindustrie nennen. So versuchen Medizintechnikunternehmen vermehrt Kundenwert zu schaffen, indem sie ihre Medizinprodukte mit digitalen Dienstleistungen ergänzen, die neben der diagnostischen oder therapeutischen Funktion weitere Kundenprozesse adressieren.

Die initiale Forschung zeigt jedoch, dass viele Unternehmen noch Schwierigkeiten haben, digitale Dienstleistungen erfolgreich zu entwickeln und zu vermarkten. Aktuelle Forschungsarbeiten im Bereich der Servitization untersuchen besonders die notwendigen technologischen Fähigkeiten, während organisatorische Fähigkeiten sowie Konsequenzen noch wenig Beachtung finden. Die vorliegende Dissertation adressiert diese in der Literatur identifizierte Lücke.

Die Arbeit gliedert sich in einen konzeptionellen und einen empirischen Teil. Aufbauend auf der Theorie der organisatorischen Fähigkeiten wird ein konzeptioneller Bezugsrahmen entwickelt. Der Bezugsrahmen liefert ein grundlegendes Verständnis über relevante theoretische Konstrukte sowie ihre Beziehungen. Im empirischen Teil der Arbeit wird der konzeptionelle Bezugsrahmen basierend auf vier Fallstudien mit führenden Medizintechnikunternehmen weiter vertieft und kritisch reflektiert. Abschliessend werden auf der Grundlage der empirischen Ergebnisse ein Management-Framework zur Bestimmung geeigneter Organisationsstrukturen sowie ein beispielhafter Innovationsprozess für digitale Dienstleistungen entwickelt. Das Ziel der Arbeit ist es, Medizintechnikunternehmen bei der Identifikation geeigneter organisatorischer Massnahmen zur Förderung digitaler Dienstleistungsinnovationen zu unterstützen.

# 1 Introduction

## 1.1 Motivation and background

### 1.1.1 Practical relevance

The importance of services in manufacturing and product-oriented firms is widely recognized (Cusumano et al., 2015; Ulaga & Reinartz, 2011; Vandermerwe & Rada, 1988) and is also reflected in the growing revenues manufacturing firms derive from services (Fang et al., 2008). The shift towards services is also referred to as servitization, which describes the transformation process of manufacturers into solution providers by adding services to their core products (Lightfoot et al., 2013; Vandermerwe & Rada, 1988). In the past, developing service offerings to generate additional and more stable revenues, was mainly a strategic response to shrinking product margins due to commoditization and competition from low-cost economies (Kindström, 2010; Reinartz & Ulaga, 2008).

Nowadays, however, the process of servitization is further accelerated by new digital technologies and connected products, as services and service-oriented business models are becoming a new imperative in many industries and for many manufacturers (Lerch & Gotsch, 2015; Porter & Heppelmann, 2014; Rust & Huang, 2014). Hence, an increasing number of manufacturing companies augment their physical products with digital and data-based services such as remote diagnostics and predictive maintenance services by using information and communication technologies (ICT) (Allmendinger & Lombreglia, 2005; Wünderlich et al., 2015). These technologies and services offer several benefits to the providing companies, allowing them to gather data of the installed base to derive insights about product usages and performance (Grubic & Peppard, 2016), resulting in reduced machine downtimes (Allmendinger & Lombreglia, 2005), advanced service offerings (Lightfoot et al., 2013), and even new business models (Iansiti & Lakhani, 2014). Therefore, digital and data-based services are becoming of strategic importance in Business-to-Consumer (B2C), as well as in Business-to-Business (B2B) environments and are gaining much management attention (Wünderlich et al., 2015).

To exploit these new business opportunities, manufacturing firms invest in building competencies for digital technologies such as the internet of things, cloud computing, and predictive analytics (Ardolino et al., 2017; Iansiti & Lakhani, 2014). However, despite comprehensive investments into digital infrastructure and technological competencies, many companies still struggle with the successful exploitation and commercialization of

these technologies (Brax & Jonsson, 2009; Kohtamäki et al., 2020; Wortmann et al., 2019).

Transitioning into service-oriented business models requires distinctive capabilities (Oliva & Kallenberg, 2003; Story et al., 2017; Ulaga & Reinartz, 2011) and is often associated with organizational change (Baines et al., 2017). Accordingly, Lütjen, Schultz, Tietze, and Urmetzer (2019, p. 506) find that "[i]n order to deliver service innovations, manufacturing and other product-centric firms are increasingly undergoing substantial organizational and resource transformation." This organizational change is further reinforced by "smart, connected products" and its associated digital and data-based services (Porter & Heppelmann, 2015, pp. 108–114). Accordingly, Porter and Heppelmann (2015, pp. 109–110) indicate that "smart, connected products" will affect how manufacturing firms innovate and develop these products and digital services, as they require an increasing integration of R&D, IT and after-sales services. Thus, managing the organizational change of servitization is a complex and challenging task that requires a clear understanding of the necessary capabilities (Martinez et al., 2010).

The research at hand aims to investigate the phenomenon of digital and data-based services in the context of the medical technology industry. The medical technology industry is strongly affected by the increasing digitalization of healthcare (Bloching et al., 2015; Taylor, 2015). Healthcare systems in developed countries are under constant financial pressure. Hence, cost containment measures are implemented to prevent further increases in healthcare spending (Hedberg & Martina, 2015). Recently, these measures started to focus on using information and communication technologies to increase the efficiency and outcomes of care delivery (Taylor, 2015). As a result, medical technology firms are asked to provide relevant device data and services for monitoring and improving clinical workflows. Furthermore, as value-based reimbursement models are introduced, device data and associated services that demonstrate and improve clinical outcomes are gaining relevance (Barnes et al., 2016).

Due to the medical technology industry's high gross margin, the companies have not experienced the same pressure as other manufacturing industries to servitize their business model (Gerecke et al., 2017). Additionally, as the industry is mainly composed of small and medium-sized enterprises (SME) (Schröter & Lay, 2014), which often do not distribute their products directly, after-sales services have been out of reach for many manufacturers and in the responsibility of local distributors or third-party service providers (Fuchs, 2016). However, with the digitalization of healthcare, digital services and servitization are gaining much attention within the industry (Synder & Bandyopadhyay,

2015). Moreover, also ICT companies with their dedicated capabilities in cloud computing and data analytics are attracted by these new opportunities (Bloching et al., 2015). Accordingly, a current industry study states: “The opportunity to establish a proprietary digitalization business model is diminishing. The MedTech industry may end up being a product supplier to platforms run by ICT giants” (Hofrichter, 2017, p. 7). Therefore, identifying and building relevant capabilities for developing and providing digital will be of high relevance for medical technology firms.

### 1.1.2 Scientific relevance

Service provision by product-oriented firms and servitization of manufacturing has gained interest from different research communities, including operations management, product-service systems, and service science (Baines et al., 2017; Lightfoot et al., 2013). By discussing the empirical phenomenon from different theoretical perspectives, research has attempted to identify the organizational characteristics of the transformation towards service-oriented business models (Eloranta & Turunen, 2015). Required capabilities, processes, structures, and business models gained much scholarly attention (Baines et al., 2017), as empirical findings suggest that the expansion into services is not always linked to increased financial performance (Brax, 2005; Gebauer et al., 2005; Neely, 2008). Gebauer et al. (2005) refer to a so-called “service paradox”, when investments into services are not linked to expected and corresponding returns. Therefore, understanding the necessary organizational setting for developing and providing services in product-oriented firms has been identified as a strategic research priority (Ostrom et al., 2015).

The ability of manufacturing firms to develop new services is a prerequisite for successful servitization (Burton et al., 2017, p. 30). Research on service innovation studies the processes and structures underlying the development of new services and has suggested distinctive process models for the development of services (Biemans et al., 2016, p. 383). However, research on service innovation has mainly focused on service industries such as financial services (Biemans et al., 2016, p. 395) and only limited research on service innovation in manufacturing firms is existing (Droege et al., 2009, p. 132; Johansson et al., 2019, p. 328; Kindström & Kowalkowski, 2014, p. 97). Early research on service innovation in manufacturing firms finds that “a simple transfer of antecedents for service development derived from traditional service industry to the context of manufacturing companies seems to be limited” (Gebauer, Krempl, et al., 2008, p. 391). Accordingly, manufacturing firms need to develop distinctive organizational processes and structures to enable service innovation (Kindström et al., 2013, p. 1071; Kindström & Kowalkowski, 2014, pp. 104–105).

Several studies on servitization have adopted a capability perspective (Gebauer et al., 2017) and discussed the moderating role of organizational capabilities on the relationship between service offerings and performance (Partanen et al., 2017). Organizational capabilities ”refer to the ability of an organization to perform coordinated set of tasks, utilizing organizational resources, for the purpose of achieving a particular end result” (Helfat & Peteraf, 2003, p. 999). Research has discussed various resources and capabilities required for servitization and showed that initially, manufacturers' existing capabilities are often not sufficient or even inadequate for providing services (Story et al., 2017). Although various distinctive capabilities have been identified, it is suggested that they differ for the type of provided service (Gebauer et al., 2017; Raddats et al., 2015; Story et al., 2017; Ulaga & Reinartz, 2011). Referring to Raddats et al. (2015, p. 98), „[…] further investigation is required to understand which capabilities better enable manufacturers to develop and deliver successful services.“

Recently, the role of information, communication, and digital technologies in servitization received scholarly attention (Ardolino et al., 2017; Coreynen et al., 2017; Opresnik & Taisch, 2015; Vendrell-Herrero et al., 2017). By using the term digital servitization, scholars refer to the interplay of digitalization and servitization. Digital servitization is defined “as the transition towards smart product-service-software systems that enable value creation and capture through monitoring, control, optimization, and autonomous functions” (Kohtamäki et al., 2019, p. 383). Accordingly, research on digital servitization utilizes various concepts such as smart products, Internet of Things (IoT) Industrial Internet, or Industry 4.0 to study the role of digital technologies in the service transition of manufacturing firms. (Kohtamäki et al., 2020). Scholars agree that digital technologies are an important driver and enabler of servitization (Vendrell-Herrero et al., 2017), as they allow firms to “extract knowledge from the installed base data and develop advanced services” (Ardolino et al., 2017, p. 13). Furthermore, to profit from digital technologies, firms need to adopt service-oriented business models (Parida et al., 2019), which further drive the service transition of product-oriented firms.

For the exploitation of these digital and data-based services, firms need to build capabilities related to data processing and interpretation (Lenka et al., 2017; Ulaga & Reinartz, 2011). However, Grubic and Peppard (2016, p. 169) indicate that “having a technological capability to acquire, process, transfer and store data is a necessary but not sufficient precondition for providing RMT[1]-enabled services.” Similar, Kohtamäki et al.

[1] RMT refers to remote monitoring technology

(2020, p. 2) highlight that "[m]ere technological investments are not sufficient, but often, the greatest challenges are faced regarding the organizational practices and capabilities […]". This finding highlights the importance of organizational capabilities, which derive from the deployment and integration of tangible and intangible resources using organizational routines (Amit & Schoemaker, 1993). Hence, the pure application of digital technologies will not generate an advantage unless manufacturers adopt adequate organizational processes and structures. However, the organizational implications of digital servitization are still unexplored (Sklyar et al., 2019, p. 450). Accordingly, Kohtamäki et al. (2019, p. 385) find that "[t]he IoT seems to transform capability requirements of manufacturers significantly, and further research is needed to define manufactures capabilities in digital servitization." Additionally, no research could have been identified that investigates organizational routines and practices for developing digital services in manufacturing firms.

Research on the interplay of digital technologies and servitization is in an early phase (Grubic, 2014; Hasselblatt et al., 2018; Kohtamäki et al., 2020; Wünderlich et al., 2015) and little is known about the required capabilities and the impact on the organizational structure and processes of manufacturing firms (Bustinza et al., 2018). Therefore, this dissertation investigates the required organizational capabilities and its constituting routines and practices for developing digital services. Furthermore, the author seeks to study organizational and managerial levers to foster digital service innovation in product-oriented firms. By studying this empirical phenomenon through the theoretical perspective of organizational capabilities, the research at hand follows the recent call for more theoretically grounded research on servitization (Eloranta & Turunen, 2015; Kowalkowski et al., 2017).

### 1.1.3 Research gaps and objectives

The literature review and previous discussion of recent studies on servitization, digitalization, and service innovation have revealed several research gaps, which will be outlined in the following.

The phenomenon of an increasing service provision by manufacturing firms is widely recognized and discussed under the concept of servitization (Ulaga & Reinartz, 2011; Vandermerwe & Rada, 1988). Recent studies indicate that digitalization and emerging digital technologies like the Internet of Things (IoT), cloud computing, and data analytics will further drive the transition of manufacturers towards services (Vendrell-Herrero et al., 2017). Literature shows that expanding the service business has broader organizational implications and will require the development of new competencies and the adaptation of

existing processes, structures, and business models (Baines et al., 2017; Eloranta & Turunen, 2015). However, scientific research on digital technologies in servitization is limited and little is known about the dedicated organizational requirements for developing digital services. Therefore, further studies on this topic are necessary.

Research agrees that organizational capabilities offer an adequate theoretical lens to investigate the organizational implications of servitization and to understand what enables the successful development of services. The literature on servitization and relating concepts has identified several distinctive capabilities across various hierarchical levels and corporate functions (Gebauer et al., 2017). Nevertheless, research on service innovation capabilities in manufacturing firms is still very limited (Gremyr et al., 2014, p. 123; Kindström & Kowalkowski, 2014, p. 97), although scholars agree that the ability to develop new services and engage in service innovation is a key enabler of the service transition of product-oriented firms (Burton et al., 2017, p. 30).

Existing literature indicates that organizational implications depend on the scope and scale of the service strategy (Oliva & Kallenberg, 2003). However, many studies on organizational capabilities do not account for differences in the type of service (Story et al., 2017). Initial research indicates that the critical capabilities might be different for different types of services (Ulaga & Reinartz, 2011, p. 6). Accordingly, studies on digital servitization highlight that there is a need for a better understanding of manufacturers' capabilities for digital and IoT-enabled services (Hasselblatt et al., 2018; Kohtamäki et al., 2019). Moreover, studies that address the organizational implications of digital servitization on the innovation process of manufacturing firms are still missing.

Hence, to identify implications for the organizational structure and the innovation process, an in-depth understanding of the organizational barriers that manufacturing firms face when developing digital services is required. Furthermore, a holistic view of necessary routines and practices will allow determining organizational and managerial levers that enable manufacturing firms to foster and facilitate digital service innovation.

Finally, the discussion of digital services in the medical technology industry is mainly driven by practitioners, who highlight the opportunities of emerging digital technologies for healthcare systems and manufacturers of medical technologies. However, comprehensive research from a management perspective, which focuses on the organizational implications, is missing.

## 1.2 Terms and definitions

***Digital services***

Digital services are information-intensive services that are provided through a digital interaction by using data science techniques to derive valuable information (cf. 2.1.3.1)

***Service innovation***

Service innovation is defined as an intangible offer not previously available to the firm's customers, which is derived from the introduction and configuration of the following constituting dimensions: a new service concept, a new customer experience, a new revenue model, or a new service delivery system (cf. 2.2.2.1).

***Medical technologies***

Medical technologies refer to products, devices, software, or procedures that are used for the prevention, diagnosis, treatment, or monitoring of diseases (cf. 2.3.1).

## 1.3 Research questions

Current research does not provide a holistic understanding of the organizational implications of digital services innovation in medical technology firms. Based on the identified research gaps, the following main research question is formulated: How can medical technology firms foster their innovation capabilities for digital services. To fully address the main research question, three sub-research questions (SRQ) will be answered (see Table 1).

*Table 1: Research questions*

| **How can medical technology firms foster their innovation capabilities for digital services?** | |
|---|---|
| *SRQ 1:* | *What are the main organizational barriers to digital service innovation in medical technology firms?* |
| *SRQ 2:* | *What organizational routines and practices facilitate digital service innovation in medical technology firms?* |
| *SRQ 3:* | *What are organizational and managerial levers to foster digital service innovation in medical technology firms?* |

This dissertation aims to increase the understanding of organizational and managerial implications of digital service innovation in medical technology firms. Prior research has shown that the adoption of digital technologies by manufacturing firms does not

automatically result in superior firm performance (Kohtamäki et al., 2020; Wortmann et al., 2019). Therefore, this research study examines the processes and structures that enable successful digital service innovation in medical technology firms.

The purpose of SRQ 1 is to investigate the organizational aspects that hinder the successful development of digital services in product-oriented medical technology firms. Gaining a better understanding of barriers to digital services innovation will help to identify organizational capabilities that facilitate digital service innovation. These organizational capabilities are subject of SRQ 2. This research question focuses on the underlying routines and practices for developing digital services. Organizational routines are considered as the building blocks of organizational capabilities (Dosi et al., 2000, p. 4). Finally, SRQ 3 builds on the previous research questions and aims to derive organizational and managerial levers that support medical technology firms in managing digital service innovation.

## 1.4 Research design

The identified research gaps illustrate that current research does not provide sufficient insights and guidance on how medical technology firms should organize their innovation activities to enable digital service innovation. Therefore, this dissertation applies an inductive, multiple case study approach, as described by Yin (2009). Case studies are "rich, empirical descriptions of particular instances of a phenomenon that are typically based on a variety of data sources" (Eisenhardt & Graebner, 2007, p. 25). Inductive research originates from the interpretation of individual observations to find generalizable patterns to build theory (Tomczack, 1992, p. 77). Inductive case-study research is especially suitable for new and emerging topics with a limited knowledge-base and provides a reliable basis for the development of new, and the refinement of existing theory (Eisenhardt, 1989; Voss et al., 2002). Case study research allows deriving a "relatively full understanding of the nature and complexity of the complete phenomenon" (Voss et al., 2002, p. 197). According to Yin (2009), case-studies are an adequate research format, if why, how or what questions are posed, the researcher has limited control over events, and a contemporary phenomenon is studied (Yin, 2009, pp. 8–14). Therefore, case study research provides an adequate approach to answer the outlined research questions.

As this dissertation builds on the theory of organizational capabilities, it follows a theory-guided case study approach, as proposed by Yin (2009, pp. 35–40). Compared to Eisenhardt (1989, p. 536), who describes an ideal case-study approach with no prior theory or hypotheses under consideration, Yin (2009, p. 18) suggests a "prior development of

theoretical propositions to guide data collection and analysis." Therefore, a guiding research framework, which consolidates prior research, is developed (cf. chapter 3.2)

The motivation for this dissertation originates from a practical management problem of medical technology firms that aim to implement adequate organizational structures and processes to enable digital service innovation. Hence, this research follows the understanding of management research as applied social sciences (Ulrich, 1981). Accordingly, "it tries to describe, explain and solve practical and relevant problems and phenomena by theory-guided research" (Tomczack, 1992, p. 83).

To develop and refine existing theory and to derive managerial implications from a case-study approach, the research process follows an iterative learning process, as illustrated in Figure 1. Accordingly, research is understood as a theory-guided and systematic experience-based learning process that creates empirical insights and knowledge, as well as theoretical implications (Kubicek, 1977, p. 13; Tomczack, 1992, p. 84). The research process starts with the creation and deepening of (preliminary) theoretical knowledge by considering prior research. This prior knowledge guides the formulation of relevant questions to practice and the collection of empirical data, which provides insights into the posed questions. By a critical reflection and abstraction of the derived insights and experiences, new theoretical knowledge is created.

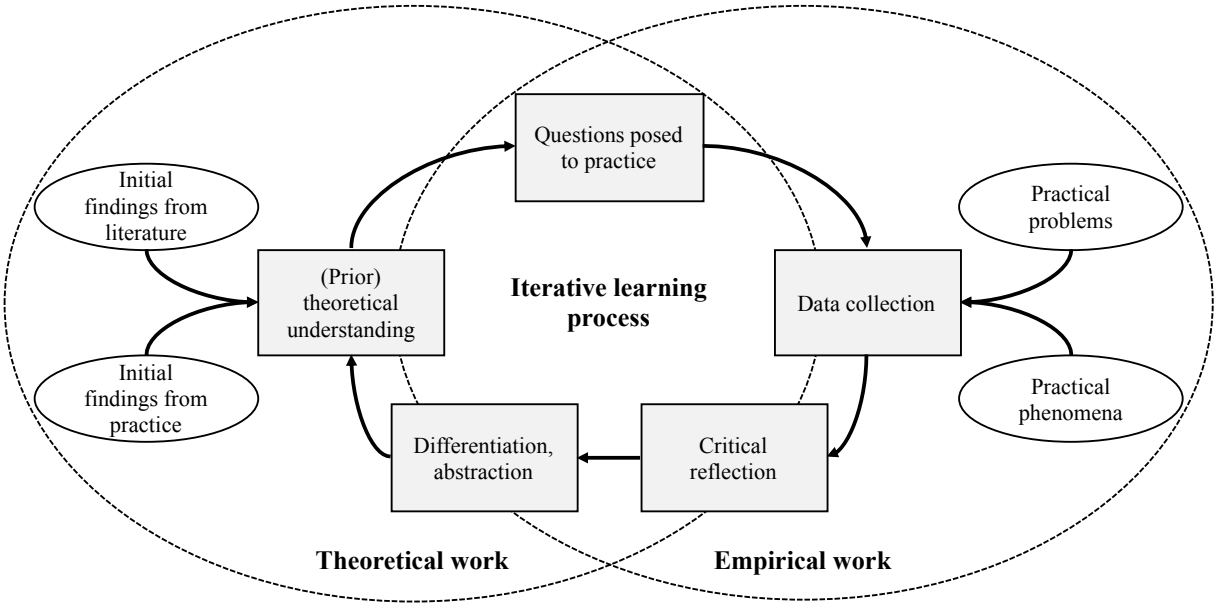



*Figure 1: Iterative research process* (adapted from Baumbach, 1998, p. 15; Kubicek, 1977, p. 14; Tomczack, 1992, p. 84)

First, based on expert interviews and focus group meetings, practical opportunities and challenges regarding digital service innovation in medical technology firms were

identified. An initial review of prior servitization and innovation research has resulted in the definition of the research problem. In a second step, a systematic literature review on the identified research problem was conducted, and research gaps and research questions were identified, as well as a guiding research framework was derived. Next, multiple in-depth case studies with four medical technology firms were conducted. These in-depth case studies provided relevant insights to analyze and refine the key elements and relationships of the research framework. Based on the case-studies, organizational routines and practices that facilitate digital service innovation could have been identified. Finally, the empirical results of the case studies were conceptualized to derive organizational and managerial levers for medical technology firms in their endeavor of digital service innovation. These levers provide guidance on how to implement adequate organizational structures and processes to facilitate the development of digital services. Furthermore, the insights that were derived from the case studies also deepen the theoretical understanding of service innovation in manufacturing firms.

## 1.5 Structure of the dissertation

This dissertation is structured into seven chapters, which reflect the chosen research design. In the following, the contribution of the individual chapters to the research objectives is briefly outlined.

***Chapter 2: State of research***

Chapter 2 summarizes the knowledge base of the most relevant research streams of servitization, digital services in manufacturing firms, as well as innovation management. Additionally, the empirical context of medical technology firms and the relevance of digital service innovation within the industry are outlined. Thus, the review of the knowledge base provides the scientific background of the dissertation and helps to understand the introduced constructs and their interrelations.

***Chapter 3: Conceptual background***

Chapter 3 introduces the conceptual background of the dissertation. Based on the theory of organizational and dynamic capabilities, a guiding research framework is derived. Furthermore, based on the guiding research framework, a systematic literature review on service innovation capabilities is conducted. Thus, the chapter provides relevant implications that justify the research at hand, as well as guide the empirical research.

***Chapter 4: Empirical research***

Chapter 4 presents the results of the case studies of German and Swiss medical technology firms. The case studies provide in-depth insights into relevant organizational antecedents,

as well as routines and practices that drive digital service innovation in medical technology firms. The case studies are structured according to the guiding research framework, which facilitates the cross-case comparison.

***Chapter 5: Cross-case analysis***

The cross-case analysis compares the similarities and differences across the cases along the dimensions of the guiding research framework. Additionally, the cross-case findings are further validated against the background of relevant literature. Thus, the chapter synthesizes the insights from the individual case studies, as well as derives generalizable findings. Finally, based on the cross-case findings, the research framework is further refined.

***Chapter 6: Organizational and managerial levers***

In chapter 6, organizational implications for the management of digital service innovations in medical technology companies are derived. Based on the research on organizational ambidexterity, different organizational designs are proposed, as well as an innovation process in the context of medical technologies is suggested.

***Chapter 7: Summary and outlook***

The final chapter summarizes the results with regard to the research questions. Furthermore, the contributions of this research to theory and practice, as well as its limitations, are discussed. The dissertation concludes with an outlook on future research opportunities.

# 2 State of research

The dissertation is rooted in the research field of servitization and service innovation in the context of the medical technology industry. Chapter 2.1 and 2.2 will introduce the theoretical background and relevant definitions of both research fields, whereas chapter 2.3 describes the empirical context.

## 2.1 Research on servitization

Since the late 1980s, research on service growth in manufacturing firms has attempted to understand the drivers and implications of providing industrial services (Baines et al., 2009; Lightfoot et al., 2013; Vandermerwe & Rada, 1988). Industrial services are defined as customer services provided by manufacturing companies to organizational customers (Homburg & Garbe, 1999). Research in this domain has discussed various advantages of providing services and introduced different conceptualizations to describe manufacturers' shift towards services. It was realized that service provision in product-oriented firms has far-reaching organizational implications. Therefore, barriers and success factors for services in manufacturing firms gained much scholarly attention (Kowalkowski et al., 2017).

### 2.1.1 Conceptualization of servitization

Researchers have introduced various conceptualizations to capture the phenomenon of service provision by product-oriented firms. These conceptualizations include “servitization” (Baines et al., 2009; Vandermerwe & Rada, 1988), “transition from product to services” (Oliva & Kallenberg, 2003, p. 160), “product-service systems” (PSS) (Mont, 2002; Tukker, 2004), “integrated solutions” (Davies, 2004), “service infusion” (Brax, 2005) and “hybrid offerings” (Ulaga & Reinartz, 2011). Although these concepts cover the same phenomenon, they emphasize different aspects. Whereas “transition from product to services”, “service infusion”, and “servitization” focus on the organizational transformation of the manufacturer, “product-service systems”, “integrated solutions”, and “hybrid offerings” stress the transformation of the value proposition. However, both aspects are closely related and rather reflecting different perspectives of the phenomenon. Especially, the concepts of servitization and PSS are widely used in the research on service provision by product-oriented companies.

The term servitization was first coined by Vandermerwe and Rada (1988) to describe the phenomenon that “[m]odern corporations are increasingly offering fuller market packages or ‘bundles’ of customer-focused combinations of goods, services, support, self-service,

and knowledge" (Vandermerwe & Rada, 1988, p. 314). While the initial definition of servitization highlights the transformation of the value proposition, recent research has emphasized the transformation of the entire organization, as structures, processes, and competencies have to be adapted to enable and support the shift towards services (Baines et al., 2009; Brax & Jonsson, 2009; Gebauer et al., 2005; Lightfoot et al., 2013). Accordingly, Baines et al. (2009, p. 547) define servitization as "the innovation of an organisation's capabilities and processes to shift from selling products to selling integrated products and services that deliver value in use." Shifting towards services is considered as sequential move along the product-service continuum, whereas the relative importance of service increases and the importance of the tangible good decreases (Gebauer, Bravo-Sanchez, et al., 2008; Gebauer & Friedli, 2005; Neu & Brown, 2005; Oliva & Kallenberg, 2003). Oliva and Kallenberg (2003) find that increasing the service orientation of the firm requires the development of new capabilities and the separation of service and manufacturing operations.

A product-service system describes "a marketable set of products and services capable of jointly fulfilling a user's need. The product/service ratio in this set can vary, either in terms of function fulfilment or economic value" (Goedkoop et al., 1999, p. 18; Mont, 2002, p. 238). According to Tukker and Tischner (2006, p. 1552), PSS is "a specific type of value proposition that a business (network) offers to (or co-produces with) its clients." Scholars referring to this concept typically distinguish between product-oriented, use-oriented, and result-oriented PSS. Similar to the product-service continuum of servitization, moving from product-oriented to result-oriented PSS decreases the importance of the product as a core component of the PSS (Tukker, 2004). Hence, differences between PSS and servitization arise from the unit of analysis. PSS focus on the composition of the offering and the transformation of the value proposition, while servitization considers the transformation of the entire organization. Thus, both concepts complement each other. Besides, Baines et al. (2009) argue that the differences rather stem from the motivation and geographical origin of the research domains. PSS is a Nordic concept with a strong focus on the environmental impact and sustainability of the PSS.

### 2.1.2 Benefits and challenges of servitization

Shifting towards services and expanding the service business is seen as a strategic response to increasing competition from low-cost economies and shrinking product margins in mature industries (Kindström, 2010; Ulaga & Reinartz, 2011). Research has highlighted the strategic, financial, and marketing benefits associated with an increased service orientation. In terms of financial benefits, providing industrial services creates additional

and more stable revenue streams (Eggert et al., 2011; Oliva & Kallenberg, 2003) and is typically associated with a higher profit margin compared to product sales (Reinartz & Ulaga, 2008). Strategically, due to their intangible nature, services are more difficult to imitate and thus can be a source of competitive advantage and, when co-produced with customers, create market entry barriers for competitors (Mathieu, 2001; Oliva & Kallenberg, 2003). Furthermore, from a marketing perspective, by combining products and services and providing solutions, manufacturers increase customer loyalty and retention (Sawhney, 2006). Finally, as industrial companies are increasingly focusing on their core competencies, they are demanding more external services, which offer new and additional business for the service provider (Gebauer et al., 2010; Oliva & Kallenberg, 2003).

Despite several benefits of providing industrial services, servitization is not always linked to increased financial performance, as manufacturers might face the so-called service paradox (Brax, 2005; Gebauer et al., 2005; Neely, 2008). Thus, challenges and barriers associated with servitization gained significant scholarly attention (Martinez et al., 2010; W. Zhang & Banerji, 2017). According to Lütjen et al. (2017, p. 3), these challenges and barriers can be grouped into three categories: (1) strategy-related, (2) implementation-related, and (3) market-related challenges. Strategy-related challenges concern the adequate alignment of service and product portfolio and the formulation of an appropriate service strategy (Gebauer et al., 2005). Furthermore, servitization might lead to a loss of the strategic focus of the manufacturer (Fang et al., 2008). Implementation-related challenges deal with organizational conflicts that occur when shifting towards services. Manufacturers might struggle to implement a dedicated service development process (Kindström & Kowalkowski, 2014), an appropriate organizational structure (Fang et al., 2008; Oliva & Kallenberg, 2003), and have problems to transition from a transactional to relational customer-relationship (Neely, 2008). In addition, establishing a service-oriented culture in conjunction with a dominating product-oriented culture requires a certain degree of organizational ambidexterity (Fang et al., 2008; Gebauer et al., 2005; Kowalkowski et al., 2017). Market-related challenges gained more attention recently with the notion of service networks and platforms (Eloranta, 2016). For delivering industrial services and solutions, many manufacturers rely on complex inter-organizational networks of multiple stakeholders like suppliers, third-party service providers, and customers (Gebauer et al., 2013; Windahl & Lakemond, 2006). Hence, missing capabilities for orchestrating and managing the different actors of the service network, are a major challenge for manufacturers when providing services (Story et al., 2017; Y. Zhang et al., 2016).

### 2.1.3 Digital servitization

#### *2.1.3.1 Defining digital services in manufacturing firms*

Recently, the digitalization of physical products gained much attention in research and practice. Digitalization is the convergence of the physical and virtual world (Kagermann, 2015) and is enabled by recent performance and price advances of memory, storage, communication, and processing technologies (Anderson, 2008; Yoo et al., 2010). Digitalization of physical products refers to the concepts of Internet of Things (IoT) (Atzori et al., 2010) and Cyber-Physical Systems (Broy, 2010), whereas physical products are connected to the internet allowing them to exchange data and interact with other physical and digital objects (Lerch & Gotsch, 2015). Thus, the primary function of the physical product can be augmented and enhanced by additional digital services (Wortmann & Flüchter, 2015). In addition, data gathered by connected products can be integrated into broader systems of disparate physical and digital products to offer digital and data-based services beyond the core product. For example, manufacturers like John Deere are combing data of their connected tractors with weather and soil data to improve the overall farm performance (Porter & Heppelmann, 2014). Therefore, digital and data-based services are seen as an important enabler of servitization in manufacturing (Coreynen et al., 2017; Grubic & Peppard, 2016; Vendrell-Herrero et al., 2017). Research that studies the interplay of digitalization and servitization often refers to term digital servitization, whereas digital servitization describes "the transition towards smart product-service-software systems that enable value creation and capture through monitoring control, optimization and autonomous functions" (Kohtamäki et al., 2019, p. 383).

Although various authors refer to the phenomenon of digital and data-based services in manufacturing firms, there is no consistent definition and terminology of these types of services (Grubic, 2014). Based on a systematic literature review Grubic (2014) finds a great diversity of terms used when referring to digital and data-based services in manufacturing. Based on Grubic's (2014) findings, Table 2 gives an overview of selected terms and their underlying definitions. The overview shows that most definitions rather describe a certain type of digital and data-based services than giving a general definition. Initially, research focused mainly on remote maintenance and repair services (Biehl et al., 2004; Jonsson et al., 2009; Kuschel & Ljungberg, 2004; Westergren, 2011), whereas Wünderlich (2009, p. 19) introduces a more general definition, which highlights that the "service object is remotely modified via control and feedback devices." Recently, the term *smart services* was widely disseminated, while the prefix *smart* emphasizes that the service is provided "to or through intelligent [and connected] products" and is rather

preemptive instead of reactive (Allmendinger & Lombreglia, 2005, p. 2; Wünderlich et al., 2015, p. 3).

*Table 2: Terminologies and definitions of data-based services (adapted from (Grubic, 2014, p. 108) and extended by the author)*

| Term | Definition | Source |
|---|---|---|
| Remote diagnostics | *"'remote diagnostics' concerns the subset of services concerned with diagnosing and solving vehicle problems remote"* | (Kuschel & Ljungberg, 2004, pp. 212–213) |
| | "*The use of ubiquitous IT capabilities in production environments enables continuous condition-based machinery and production process monitoring. When the monitoring takes place at a distance, we call these systems remote diagnostics systems."* | (Jonsson et al., 2009) |
| Remote monitoring system | *"A remote monitoring system (RMS) is […] a technological innovation that incorporates sensors and data transmitters into a system that is attached to existent products and used to create remote monitoring services."* | (Westergren, 2011, p. 226) |
| Remote repair, diagnostics, and maintenance (RRDM) | *"RRDM is a broad term that incorporates various technologies and applications. At its most basic, it can be a phone call for simple troubleshooting support. At its most complex, it consists of fully integrated computer and network applications that automatically monitor performance, diagnose problems, and request attention from service technicians for specific problems."* | (Biehl et al., 2004, p. 101) |
| Remote Service | *"Remote Services are provided in a technology-mediated production process independent of the physical separation of customer and provider. Hereby, the service object is remotely modified via control and feedback devices."* | (Wünderlich, 2009, p. 19) |
| Smart Services | *"Services delivered to or through intelligent products that feature awareness and connectivity are called 'smart services.'"* | (Allmendinger & Lombreglia, 2005; Wünderlich et al., 2013, p. 3) |
| | *"[…] enabling off-site access to and electronic monitoring tool via a secure internet browser […]. Such smart services allow the company to perform first-level maintenance without deploying field technicians for on-site visits."* | (Reinartz & Ulaga, 2008, p. 6) |

However, despite differences in the addressed type of service, all definitions have in common that they describe product-oriented services, meaning that the physical product is the main channel for providing the service or even the service object. Digital and data-based services beyond the core product are not included in these definitions. For example, John Deer's digital services that address the overall farm performance using data of multiple sources (Porter & Heppelmann, 2014), or Siemens's IoT platform MindSphere

that offers digital and data-based services to other original equipment manufacturers (Siemens, 2018). Therefore, a more inclusive definition is required.

For this dissertation, the following definition of digital services is used:

> *"Digital services are information-intensive services that are provided through a digital interaction by using data science techniques to derive valuable information."*

This definition includes the following defining aspects:

- *Information-intensive service* is "a type of service in which value is created primarily via information interactions rather than physical and interpersonal interaction, between customer and provider" (Lim et al., 2018, p. 121).
- *Digital interaction* is a technology-mediated interaction over the internet. Thus, the service is provided under the physical separation of customer and provider (Rowley, 2006).
- *Data science:* "is an interdisciplinary field that combines statistics, data mining, machine learning, and analytics […]"(George et al., 2016, p. 1493) to derive valuable information from data. It includes techniques for data collection, data storage, data processing, data analysis, reporting, and visualization (George et al., 2016, p. 1496).

Hence, this definition does emphasize not only a technology-mediated provision of service but also a data-driven value creation.

In manufacturing firms and the industrial context, digital services are often closely related to the concept of the Internet of Things (IoT). According to Lee and Lee (2015, p. 431), the IoT "is a new technology paradigm envisioned as a global network of machines and devices capable of interacting with each other." Thus, IoT describes the increasing convergence of the physical and digital world, which creates hybrid solutions of connected products and digital services (Fleisch et al., 2014, p. 819; Wortmann et al., 2019, p. 1095). Accordingly, information about the condition and usage of connected products builds the foundation of digital services. Therefore, IoT-enabled digital services are of high relevance for this dissertation, as digital services in medical technology firms are often based on the processing of installed base data of connected medical devices.

#### *2.1.3.2 Characteristics of digital services*

Research on servitization has been influenced by an earlier debate within the domain of service marketing on the unique characteristics of services compared to goods (Turunen, 2013). Accordingly, services are different to goods as services are intangible,

heterogeneous, inseparable (simultaneous production and consumption), and perishable (non-storable) (IHIP) (Fisk et al., 1993, p. 68; Zeithaml et al., 1985, p. 33). Referring to Grönroos (2001, p. 150), "[a] physical product exists before consumption starts." Thus, "a service is a process that leads to an outcome during partly simultaneous production and consumptions." It has been argued that these characteristics create unique problems for the organization that require a different kind of marketing practice (de Brentani, 1989; Lovelock & Gummesson, 2004).

However, recent research has challenged the IHIP characteristics to distinguish physical products from services (Araujo & Spring, 2006; Lovelock & Gummesson, 2004; Vargo & Lusch, 2004). Cusumano et al. (2015, p. 561) for example, have argued that "[t]he definitions and insights coming from service industry research, however, do not help to fully understand the special nature of services offered by product firms […]." For example, digital goods seem to fall into a grey area between a tangible product and an intangible service. Table 3 compares the characteristics of digital services according to the IHIP characteristics.

*Table 3: Characteristics of digital services (based on Segal-Horn (2006) and extended by the author)*

| Characteristics | Product | Service | Digital Service |
|---|---|---|---|
| Intangibility | Tangible | Intangible | Intangible |
| Variability | Easy to standardize | Difficult to standardize | Easy to standardize |
| Inseparability | Production and consumption occur separately | Simultaneous production and consumption | Partly simultaneous production and consumption |
| Perishability | Durable | Perishable | Partly durable |

Digital services are intangible to the user, but also have characteristics of physical products (Cusumano et al., 2015, p. 561). First, digital services are often homogenous across users, as the underlying software is easy to be standardized. However, although the development and deployment of the software underlying the digital service occur separately from the consumption, the provider of the service needs to establish and maintain a digital infrastructure while the user is consuming the service. Thus, the production and consumption of digital services can only be partly separated. Finally, digital services are neither durable nor perishable. While the software code to deploy the service is durable,

the availability of the digital infrastructure is not. As with other service businesses, capacity utilization of the infrastructure is a major issue for the providers of digital services. If the digital infrastructure is not available or overloaded, the quality of service is substantially influenced. Therefore, digital services are only partly durable.

The comparison of digital services according to the IHIP characteristics, which are used to define and differentiate services from physical products, shows that digital services often have a hybrid nature of a physical product and an intangible service. Accordingly, Schultz and Tietze (2014, pp. 64–65) find that challenges that are associated with the IHIP characteristics have to be considered in the innovation management of product-service systems. Therefore, paragraph 2.2.2.3 of the next chapter discusses the importance of these characteristics for the innovation process.

## 2.2 Research on innovation

Innovation is one of the central topics in strategic management (Keupp et al., 2012) and is seen as a major source of a firm's competitive advantage (Dess & Picken, 2000; Lengnick-Hall, 1992). This chapter introduces relevant constructs and definitions in the context of innovation research. Chapter 2.2.1 provides the general background on innovation research, whereas chapter 2.2.2 focuses on service innovation. Finally, chapter 2.2.3 discusses research findings on the success factors of product and services innovation.

### 2.2.1 Conceptualization of innovation

The concept of innovation in management research is strongly linked to Schumpeter's (1934) seminal work "The Theory of Economic Development" and his finding that economic development is mainly driven by innovation. Schumpeter defines innovation as "the doing of new things or the doing of things that are already being done in a new way" (Schumpeter, 1947, p. 151). He describes five different types of innovation. Innovation can be (1) introducing a new product, (2) applying a new method of production, (3) opening a new market, (4) acquiring a new source of supply, or (5) a new organizational structure (Korhonen, 2016; Schumpeter, 1934). Schumpeter's definition and description of different types of innovation show that innovation can be conceptualized as a process of generating something new, or as an outcome of such a process. Therefore, Crossan & Apaydin (2010, p. 1166) define "innovation as a process" and "innovations as an outcome" as two distinct dimensions of innovation.

#### *2.2.1.1 Innovation as an outcome*

Recent research on innovation as an outcome generally distinguishes between product or service innovation, process innovation, and business model innovation (Crossan & Apaydin, 2010, p. 1168). Utterback and Abernathy (1975, p. 642) define a product innovation as "a new technology or combination of technologies introduced commercially to meet a user or market need", whereas process innovation is the "introduction of new production methods, new management approaches, new technology that can be used to improve production and management processes" (Wang & Ahmed, 2004, p. 305). Business model innovation recently gained much scholarly attention and refers to "the search for new logics of the firm and new ways to create and capture value for its stakeholders." Accordingly, "it focuses primarily on finding new ways to generate revenues and define value propositions for customers, suppliers, and partners" (Casadesus-Masanell & Zhu, 2013, p. 464).

A central feature of all definitions of innovation is the novelty or newness of the subject of innovation (Damanpour & Wischnevsky, 2006). By referring to the degree of novelty and change associated with the innovation, research distinguishes between incremental and radical innovation (Gopalakrishnan & Damanpour, 1997). Furthermore, novelty can be assessed from the perspective of the customer and market or the innovating firm. Regarding product innovation, it can be new to the customer, new to the firm, or even both of them, whereas the latter is also called new-to-the-world innovation (Danneels & Kleinschmidt, 2001).

In the context of technological innovation, Christensen (1997) has introduced the concept of disruptive technologies, which describes "a technology that changes the bases of competition by changing the performance metrics along which firm compete" (Danneels, 2004, p. 249). Thus, it relates to a new technology that overtime "surpass seemingly superior technologies in a market" (Markides, 2006, p. 19). The term "disruptive" recently gained much popularity in academia and by practitioners and is now also associated with other types of innovation like business model innovation (Christensen et al., 2015). Despite differences in the underlying mechanisms and managerial implications, the various types of disruptive innovation have in common that incumbent firms are threatened by innovating new entrants, or are even replaced by them (Danneels, 2004; Markides, 2006). Markides (2006) highlights that incumbent firms struggle to cope with disruptive innovation and associated changes in the marketplace due to the inertia of existing processes, structures, and culture.

#### *2.2.1.2 Innovation as a process*

Schumpeter highlights the difference between invention and innovation (cf. Schumpeter, 1947, p. 152). Whereas invention deals with the creation of new ideas, innovation additionally includes the exploitation of an invention for useful application. As such, innovation is more than a creative process; it also includes all activities related to the development and commercial dissemination of an invention (Roberts, 2007). Accordingly, research on innovation as a process explores how innovations are generated and adopted by organizations (Damanpour & Aravind, 2012a; Garud et al., 2013). Roberts (2007, p. 37) conceptualizes the innovation process as a multi-stage process consisting of the phases of "recognition of opportunity", "idea formulation", "problem solving", "prototype solution", "commercial development", and "technology utilization and/or diffusion". However, this conceptualization refers to technological and product innovation, whereas research is indicating that the innovation process differs for the type of innovation (Damanpour & Aravind, 2012a). Until recently[2], most research on innovation processes has focused on technological innovation in manufacturing industries (Birkinshaw et al., 2008; Gallouj & Weinstein, 1997) and has discussed innovation processes in the context of new product development (NPD) (Booz-Allen & Hamilton, 1982; Cooper, 1990).

Cooper (1990) has introduced the well-known "Stage-Gate" model, a linear process that consists of five stages, as well as corresponding gates from ideation to product launch (Figure 2). The Stage-Gate process is an approach to apply process management methodologies from the manufacturing of physical goods to the innovation process. Accordingly, during development, new ideas and products move along different "work stations" and must pass through pre-defined gates with specified quality criteria. By using such gating approaches, risks and uncertainty of innovation shall become manageable (Cooper, 1990, pp. 45–46).

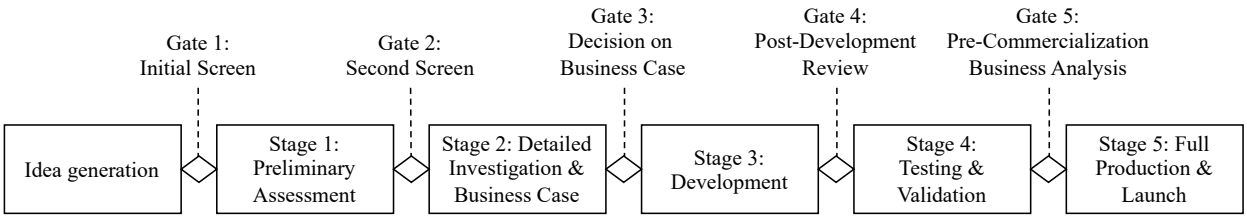



*Figure 2: Stage-Gate Process (own representation according to Cooper (1990, p. 46))*

However, linear new product development processes have been criticized that they do not account sufficiently for the complex interactions between stages, as well as actors involved

[2] Recently, a research stream on service innovation has emerged and will be discussed in chapter 2.2.2

in the innovation process (Garud et al., 2013; Tidd & Bessant, 2013). Therefore, more complex multi-actor innovation processes have been proposed that require higher levels of intra- and inter-firm collaboration and networking (cf. Rothwell, 1992, p. 236; Tidd & Bessant, 2013, p. 77). Accordingly, Rothwell (1994, p. 27) has conceptualized the so-called "fifth-generation" innovation process as an organizational learning process consisting of internal and external learning. Especially for external learning, he highlights the role of lead users, key suppliers, and horizontal partnerships.

The role of external knowledge and its integration into the innovation process has been discussed within the research field of open innovation (Gassmann et al., 2010). Open innovation is defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand markets for external use of innovation respectively" (Chesbrough, 2006, p. 1). Therefore, research has conceptualized three core open innovation processes. (1) An outside-in process to access external knowledge through integrating suppliers and customers. (1) An inside-out process to exploit internal knowledge that is not used inhouse through selling and licensing intellectual property (IP), as well as multiplying technology (e.g. through spin-offs). And finally, (3) a coupled process that combines outside-in and inside-out process by working in alliances with partners (Gassmann & Enkel, 2004). In general, firms that implement open innovation processes are found to sense future changes in markets and technologies earlier, as well as to acquire relevant knowledge and competencies faster (Chesbrough & Prencipe, 2008; Schweitzer et al., 2014).

### 2.2.2 Service innovation

#### *2.2.2.1 Defining service innovation*

Past research on innovation was mainly dominated by studies on technological innovation in manufacturing industries (Drejer, 2004; Nijssen et al., 2006). With the growing importance of service industries in developed economies, service innovation has received growing attention from various research disciplines, forming a new stream within innovation research (Toivonen & Tuominen, 2009; Witell et al., 2016). The service innovation stream deals with the antecedents and consequences of service innovation, as well as analyzes and discusses the distinct features and characteristics of innovation in service industries (Droege et al., 2009). However, despite the growing number of publications, service innovation is still seen as a developing research field (Biemans et al., 2016; Ettlie & Rosenthal, 2011). Hence, a general and widely accepted conceptualization

and definition of service innovation have not emerged yet (Snyder et al., 2016, p. 2401; Witell et al., 2016, p. 2863).

According to Smith-Eckhardt (2015, p. 12), existing approaches to define service innovation can be grouped into four categories: substitution, transmission, comprehension, and explication. Conceptualizations within the substitution approach do not distinguish between service development, new service development, or service innovation. Their focus is mainly on the underlying operational processes for developing new services without conceptualizing the resulting service innovation. Thus, new service development (NSD) is defined as "the overall process of developing new service offerings" (Yang, 2007, p. 637) and "[n]ew service development (NSD) is the process of creating new services to fulfill target customers' needs" (F. R. Lin & Hsieh, 2014, p. 113).

Definitions and conceptualizations that follow the transmission approach do not provide a distinctive definition of service innovation. Thus, these authors follow the Schumpeterian view on innovation, whereas product and service innovation are considered as similar (Smith-Eckhardt, 2015, p. 13).

The comprehension approach describes conceptualizations that focus on type and mode of service innovation without providing a detailed definition of service innovation itself (Smith-Eckhardt, 2015, p. 14). These authors describe service innovation according to the degree of change such as incremental to radical innovations (Snyder et al., 2016, p. 2404), as well as different modes of innovation such as improvement, ad hoc, recombinative and formalization innovation (Gallouj & Weinstein, 1997, pp. 547–554). These studies demonstrate that service firms innovate, although the type of innovation might be different from innovation in manufacturing industries (Chan et al., 1998, pp. 122–123; Smith-Eckhardt, 2015, p. 14).

Studies within the explication approach provide detailed definitions of service innovation and its constituting dimensions. Table 4 shows an overview of selected definitions of service innovation. These definitions show some common characteristics. Accordingly, service innovation is defined as an intangible offer not previously available to the firm's customers (Ordanini & Parasuraman, 2011, p. 5; Zomerdijk & Voss, 2011, p. 65), which is derived from the introduction and configuration of the following constituting dimensions: a new service concept, a new revenue model, a new customer experience, or a new service delivery system (den Hertog et al., 2010; Gotsch & Hipp, 2012; Zomerdijk & Voss, 2011).

*Table 4: Definitions of service innovation (adapted from Smith-Eckhardt* (2015, pp. 16–17) *and extended by the author)*

| **Definition** | **Source** |
|---|---|
| *"New service or such a renewal of an existing service which is put into practice and which provides benefit to the organisation that has developed it; the benefit usually derives from the added value that the renewal provides the customers. In addition, to be an innovation the renewal must be new not only to its developer, but in a broader context, and it must involve some element that can be repeated in new situations, i.e. it must show some generalizable feature(s)."* | (Toivonen & Tuominen, 2009, p. 893) |
| *"A service innovation is a new service experience or service solution that consists of one or several of the following dimensions: new service concept, new customer interaction, new value system/business partners, new revenue model, new organizational or technological service delivery system."* | Den Hertog et al. 2010, 494 |
| *"[…] service innovation can be considered as an offering not previously available to the firm's customers—either an addition to the current service mix or a change in the service delivery process—that requires modifications in the sets of competences applied by service providers and/or customers."* | (Ordanini & Parasuraman, 2011, p. 5) |
| *"new service is here defined […] as an offer not previously available to customers, resulting from the addition of offerings to the experience, radical changes in the service delivery process that creates the experience, or incremental improvements to existing service and experience packages or delivery processes that customers perceive as being new."* | (Zomerdijk & Voss, 2011, p. 65) |
| *"[…] service innovation is a new, or significantly modified, service concept, client interaction channel, service delivery, or technological concept that individually, but more likely in combination, leads to one or more new service functions."* | (Gotsch & Hipp, 2012, p. 2169) |
| *"[…] service innovation as new or enhanced intangible offerings, and/or new or enhanced ways to deliver them."* | (Troilo et al., 2017, p. 619) |

The *service concept* refers to the elements of the intangible offering, which provide a solution to customer needs or problems (Troilo et al., 2017, p. 619). Therefore, it describes the value proposition offered to the customer (den Hertog et al., 2010, p. 494; Goduscheit & Faullant, 2018, p. 704). The *revenue model* relates to the distribution of costs and revenues among the multiple actors involved in the production of the services. Accordingly, firms have to find the right revenue model that fits a new service concept (den Hertog et al., 2010, p. 495). Additionally, switching from a hardware-based to service-based revenue model is considered as a type of service innovation. The *customer experience* refers to way the service provider interacts with customers by describing the customer journey and its physical and digital touchpoints through which customers experience the intangible offering (Goduscheit & Faullant, 2018, p. 704; Troilo et al., 2017, p. 620; Zomerdijk & Voss, 2011, p. 65). Finally, the *service delivery system*

describes the intra- and inter-organizational processes, as well as technological and organizational resources to provide the service (Barrett et al., 2015, p. 140; den Hertog et al., 2010, p. 495). It is highlighted that the constituting dimensions of service innovation are interrelated and that innovation in one dimension might trigger changes in the others (Troilo et al., 2017, p. 619).

#### *2.2.2.2 Perspectives on service innovation*

The different approaches to define service innovation also relate to different perspectives on service innovation, its antecedents, and consequences in comparison to product and process innovation in manufacturing industries (Carlborg et al., 2014; Drejer, 2004; Droege et al., 2009; Gallouj & Savona, 2009; Toivonen & Tuominen, 2009). Considering the differences between product and service innovation, different research perspectives have emerged within the field of service innovation. Coombs and Miles (2000) distinguish between three different perspectives on service innovation: assimilation, demarcation, and synthesis:

**Assimilation perspective**

Following the assimilation perspective, concepts and models to study product innovation in manufacturing industries can be applied to service innovation, as service innovation is fundamentally similar to product innovation (Coombs & Miles, 2000, p. 85; Hughes & Wood, 2000; Nijssen et al., 2006; Sirilli & Evangelista, 1998). Studies adopting the assimilation perspective tend to focus on the impact of new technologies (especially information and communication technologies) on services and see the adoption of technological innovations as the main driver of service innovation (de Vries, 2006; Gallouj & Weinstein, 1997; Witell et al., 2016).

Research within the assimilation perspective was influenced by Barras (1986, 1990) findings that innovation in services follow a so-called “Reverse Product Cycle” compared to the patterns of innovation in manufacturing industries (Abernathy & Utterback, 1978). According the “Reverse Product Cycle”, service innovation is initiated by the adoption of ICT which leads to “process improvements to increase the efficiency of delivery of existing services, moves on to process innovations which improve service quality, and then leads to product innovations through the generation of new types of services” (Barras, 1986, p. 161). However, Barras’s model is criticized for not providing a distinct theory of innovation in services, instead rather describing the adoption and diffusion of technological innovations within service industries (cf. Gallouj & Weinstein, 1997, p. 538). Additionally, Barras model follows the distinction of product and process innovation

in manufacturing industries, which is difficult to apply to services industries, due to the intangible nature, as well as simultaneously production and consumption of services (Droege et al., 2009; Gallouj & Savona, 2009).

Other critique of the assimilation perspective highlights the role of non-technological aspects of innovation in services such as organizational innovation by introducing a new type of restaurant (e.g., fast food restaurants) or a type of airline (e.g., low-cost carriers) (cf. Drejer, 2004, p. 554; cf. Gallouj, 2002, p. 148). Accordingly, while focusing primarily on technological innovation, the assimilation perspective neglects relevant specificities of service innovation (Gallouj & Savona, 2010).

**Demarcation perspective**

According to the demarcation perspective, the unique characteristics and specificities of services make it difficult to apply innovation concepts and models developed in the context of manufacturing to service industries (Coombs & Miles, 2000; Droege et al., 2009). Therefore, studies of the demarcation perspective seek to develop service-specific innovation frameworks and concepts that take the distinctive characteristics of services into account (Gallouj & Savona, 2009). These characteristics mainly relate to the intangibility, heterogeneity, inseparability (simultaneous production and consumption), and perishability (non-storable) of services (Carlborg et al., 2014; Zeithaml et al., 1985). Especially due to the intangibility and inseparability of services, the dichotomy of product and process innovation seems to be an inadequate analytical concept in the context of service innovation (Gallouj & Savona, 2009), as services are conceptualized as acts or processes instead of products (de Vries, 2006; Gallouj & Weinstein, 1997).

Research within the demarcation perspective emphasizes certain idiosyncrasies of service innovation (Droege et al., 2009). These studies highlight the importance of customers and the customer interface in the innovation process, as well as the relevance of interactive models of innovation involving various actors compared to linear models within specialized R&D departments. Furthermore, compared to product innovation, service innovation is difficult to protect. (Djellal & Gallouj, 2001; Drejer, 2004; Gadrey et al., 1995; Sundbo, 1997). Other studies, such as Hertog (2000) and Edvardsson and Olsson (1996), deal with the outcome of service innovation and develop new frameworks to understand better how services are innovated. Following Hertog's four-dimensional model, service innovation can relate to the development of (1) new service concepts, (2) new customer interfaces, (3) new service delivery systems, as well as by applying new (4) technological options (Hertog, 2000, p. 491). Similar, Edvardsson and Olsson (Edvardsson & Olsson, 1996, p. 159) distinguish between three main types of development activities.

The development of the (1) service concept, (2) service system, and (3) service process. Thus, studies of the demarcation approach enlarge the existing innovation perspective and show the relevance of non-technological aspects in service innovation (Drejer, 2004; Gallouj & Savona, 2009; Witell et al., 2016).

As research within the demarcation perspective often focuses on sector-specific studies, it is criticized for offering no general frameworks of innovation (Carlborg et al., 2014; Gallouj & Savona, 2009). Additionally, despite the relevance of demarcation studies for providing a better understanding of the specific features of service innovation, some researchers argue that most findings are also relevant for product innovation, although they might be less explored in the context of manufacturing industries (Drejer, 2004; Droege et al., 2009). Therefore, a new stream of service innovation research emerged, which proposes an integrated perspective of innovation in services and manufacturing industries, combing technological and non-technological aspects of innovation (Coombs & Miles, 2000; Drejer, 2004; Gallouj & Weinstein, 1997).

**Synthesis Perspective**

The synthesis perspective follows the notion that manufacturing and service industries increasingly converge, as product and service innovation in many cases are strongly interrelated (Carlborg et al., 2014; Coombs & Miles, 2000; de Vries, 2006). Therefore, the synthesis perspective tries to develop an integrative approach to study innovation in manufacturing and service industries by combining findings from the assimilation and demarcation perspective (Coombs & Miles, 2000; Drejer, 2004; Gallouj & Weinstein, 1997; Witell et al., 2016). Accordingly, Drejer (2004) argues that research that follows a technology-driven assimilation approach, which studies innovation in the dichotomy of product and process innovation, is too narrow for services. However, research that emphasizes the specificities of innovation in service industries such as the important role of organizational innovation, the integration of multiple actors into the innovation process, as well as the importance of codification of knowledge, might neglect the relevance of such features within manufacturing. Thus, a unifying synthesis approach to innovation is required that considers all types of innovation as described by Schumpeter (see 2.2.1.1), and which is applicable “regardless of whether this is carried out in manufacturing, in services, or in an expanding grey area embracing both” (Drejer, 2004, p. 561).

Gallouj and Weinstein (1997) were among the first who developed an integrative framework for studying innovation in manufacturing and service industries (de Vries, 2006). They consider material and immaterial products as a combination of technological characteristics, service characteristics, and internal and external competences to produce

the product. Therefore, innovation can be defined as any change of one or more characteristics and competencies of the product (good or service) (Gallouj & Savona, 2009). According to this conceptualization, innovation is defined as a process compared to an outcome. Instead of identifying different types of innovation such as product, process, or organizational innovation, Gallouj and Weinstein distinguish different modes of innovation, such as radical, improvement, incremental, ad hoc, recombination, and formalization innovation. These models of innovation result from the extent to which the underlying characteristics are changed, replaced or improved (Gallouj & Weinstein, 1997, pp. 547–554).

Although the synthesis perspective is seen as the most promising perspective to study innovation in the context of an increasing convergence of manufacturing and service industries such as in the case of servitization of manufacturing (Carlborg et al., 2014), it has certain limitation. First, integrative frameworks like by Gallouj and Weinstein (1997) are mainly theoretically developed concepts, lacking empirical testing and validation, especially outside the service industry (Droege et al., 2009). Furthermore, by developing all-encompassing and unifying concepts and models of innovation, service innovation might lose focus and relevance (Carlborg et al., 2014; Toivonen & Tuominen, 2009). Finally, the synthesis perspective is still missing a consolidated and widely accepted conceptual framework, which allows research of innovation across manufacturing and service industries (I. Miles, 2016).

To conclude, only a limited number of research papers define the concept of service innovation explicitly (Witell et al., 2016). Furthermore, most existing research does not distinguish between service innovation as an outcome and as a process (Toivonen & Tuominen, 2009). Thus, in many research articles, the constructs service innovation and new service development are used interchangeably (Biemans et al., 2016; Menor et al., 2002). However, both constructs originate from different research fields. Whereas service innovation is rather associated with the economics and business strategy field, new service development (NSD) is mainly used by researchers from the field of service management and marketing (Menor et al., 2002, p. 139). Menor et al. (2002, p. 139) find that both concepts can be distinguished as “service development focuses on the understanding of service development practice while service innovation typically focuses on developing abstract theories.”

#### *2.2.2.3 New service development process*

A systematic new service development (NSD) process is considered as a critical success factor of service innovation (De Brentani, 1991; Griffin, 1997; Yu & Sangiorgi, 2018;

Zomerdijk & Voss, 2011). However, it is found that compared to manufacturing firms, service firms often do not apply systematic and formalized development processes (Cooper & de Brentani, 1991; Menor et al., 2002; Zomerdijk & Voss, 2011). Thus, considerable research focuses on the activities and structures of NSD activities and proposes various process models, ranging from the adaptation of linear new product development processes to nonlinear service-specific process models (Froehle & Roth, 2007; Johne & Storey, 1998). Especially within the demarcation perspective, scholars emphasize that due to the special characteristics of intangibility, inseparability, heterogeneity, and perishability (Fitzsimmons & Fitzsimmons, 2000), services have to be developed differently compared to tangible products (Johne & Storey, 1998; Johnson et al., 2000; Papastathopoulou & Hultink, 2012).

**Implications of service specificities**

Intangibility refers to the fact that services compared to physical products are not touchable and often remain conceptual during the development process. Due to missing tangible prototypes, it is more difficult for service firms to create a shared vision and a common understanding of the intended new service (Menor et al., 2002). Furthermore, as services are intangible and rather easy to develop, service firms tend to use less formalized development process, which increases the risk of "a poorly researched service concept, a haphazard design process, inadequate testing and too little planning for an effective market launch" (De Brentani, 1991, p. 39) Thus, it is suggested to use service blueprinting (Bitner et al., 2012) or other methods to make the service concept more tangible during the development process (Papastathopoulou & Hultink, 2012).

The inseparability of production and consumption is seen as another feature that affects the development of new services. As services are co-produced by front-office employees and customers, NSD research highlights the importance of customer involvement and the role of front-office employees during the development of new services (De Brentani, 1991; Menor et al., 2002; Smith-Eckhardt, 2015). Thus, front-office employees can provide important insights on customer needs and opportunities and should be involved early during the NSD process (de Brentani, 2001). Regarding customer involvement, Melton and Hartline (2010) find that firms should directly involve customers during the development to receive feedback on service concepts and delivery process, as well as to refine service prototypes.

Heterogeneity of services relates to the variability of service outcome and experience due to the direct influence of front-office employees and customers on the service delivery process (Johne & Storey, 1998). Hence, services are more difficult to standardized, which

increases the risk of inconsistency and inadequate service quality (De Brentani, 1991). However, De Brentani (1991) also finds positive effects of service variability, as service providers are able to customize services more effectively to address customer needs directly. Nevertheless, the heterogeneity of services requires firms to develop adequate measures to decrease and control the variation of service outcomes along the entire service delivery process (Jaw et al., 2010; Papastathopoulou & Hultink, 2012).

Finally, perishability means that services compared to products cannot be produced in advance and then stored (Johne & Storey, 1998). Hence, demand fluctuation is a major challenge for service firms, as it may lead to an under- or overcapacity issue. Therefore, firms need to tackle capacity issues during the development stage, e.g., by considering potential service line extensions, by developing peak load versions of the services, as well as by using appropriate technology to automate and industrialize service delivery processes (De Brentani, 1991; Jaw et al., 2010; Papastathopoulou & Hultink, 2012).

Johnson et al. (2000, p. 2) highlight the necessity of dedicated NSD process models and concludes: “Given the inherent differences between the production of goods and services, particularly the role of customer contact in service delivery, service intangibility, and heterogeneity of demand, the application of NPD models to services might not suffice in adequately describing how new services are optimally developed.”

**NSD process models**

Within the context of new service development, various process models have been proposed (Johnson et al., 2000; Yu & Sangiorgi, 2018). These process models are focused on structuring the different activities and concepts related to the development of new services (Froehle & Roth, 2007). According to Johnson et al. (2000), NSD process models can be categorized into partial models, translation models, and comprehensive models. Models that adapt and translate existing linear process models from the field of new product development to the context of NSD are classified as translational models. Many of these models are based on the NPD model proposed by Booz et al. (1982), which consists of seven generic stages: (1) NPD strategy development, (2) idea generation, (3) screening and evaluation, (4) business analysis, (5) development, (6) testing, and (7) commercialization (Johne & Storey, 1998; Menor et al., 2002). However, translation models are considered to not adequately representing the underlying complexity of NSD, as they tend to ignore the specificities of services (Johnson et al., 2000).

Shostack (1984) was among the first, who developed a service-specific linear process model by dividing the development process into ten distinct stages and three phases. Central to the model of Shostack (1984) is the attempt to provide an adequate approach to

specify the service and its process conceptually before implementation (Johne & Storey, 1998). Thus, the author introduces service blueprinting as a method to systematically map and analyze service processes prior to launch (Biege et al., 2012; Johnson et al., 2000). As the process model mainly deals with service design and focuses on the design of the service concept and delivery process, it is classified as a partial model (Johnson et al., 2000).

One of the first comprehensive process models for NSD was proposed by Scheuing and Johnson (1989). Their model is based on 15 process steps, which are grouped into four stages: Direction, design, testing, and introduction. Within the design phase, the authors make a clear distinction between the design of the service concept and the delivery process. The service concept is defined as detailed description of the new service and includes "a description of a problem that a prospect might experience, the reasons why the new service is to be offered, an outline of its features and benefits, and the rationale for its purchase" (Scheuing & Johnson, 1989, pp. 31–32). Accordingly, the design of the service delivery process refers to the operationalization of the service concept. By providing a very detailed process model, the authors highlight the iterative nature of service development and the importance of comprehensive testing after each design iteration. Additionally, the model emphasizes the necessity of involving front-line and operations personnel, as well as customers to successfully develop new services.

Edvardsson and Olsson (1996) develop an NSD model, which distinguishes between three different types of development activities: [1] the development of the service concept, [2] the development of the service system, [3] and the development of the service process. Compared to prior process models, the development activities are not represented as sequential and linear process steps, but as parallel processes whose interdependency varies between development projects. Besides, the service concept and service delivery process, the authors add the service system as another component that needs to be developed prior to launch. The service system refers to the human, technical, and organizational resources required to deliver the service.

Johnson et al. (2000) synthesize and integrate prior research and propose a general NSD process model involving four stages and 13 sub-tasks (see Figure 3). The NSD process is conceptualized as a nonlinear and cyclic process model highlighting the interplay of design and development activities, as well as the necessity of feedback loops (Froehle & Roth, 2007, pp. 171; 174; Johnson et al., 2000, p. 18). The authors divide the process model into a planning phase consisting of the stages of design and analysis, as well as an execution phase involving the stages of development and full launch. While the planning phase focuses on the viability of the intended NSD project and considers available resources and

capabilities, the executions phases deal with the development and implementation of the service delivery process and system. The model defines the service concept in the dimensions: people, systems, and technology, as well as emphasizes the importance of enabling factors such as teams, tools, and organizational context (Menor et al., 2002, p. 140). According to Johnson et al. (2000, pp. 19–20), to develop an NSD capability, firms need to formalize their NSD process to foster efficiency of effectivity of service design and development activities.

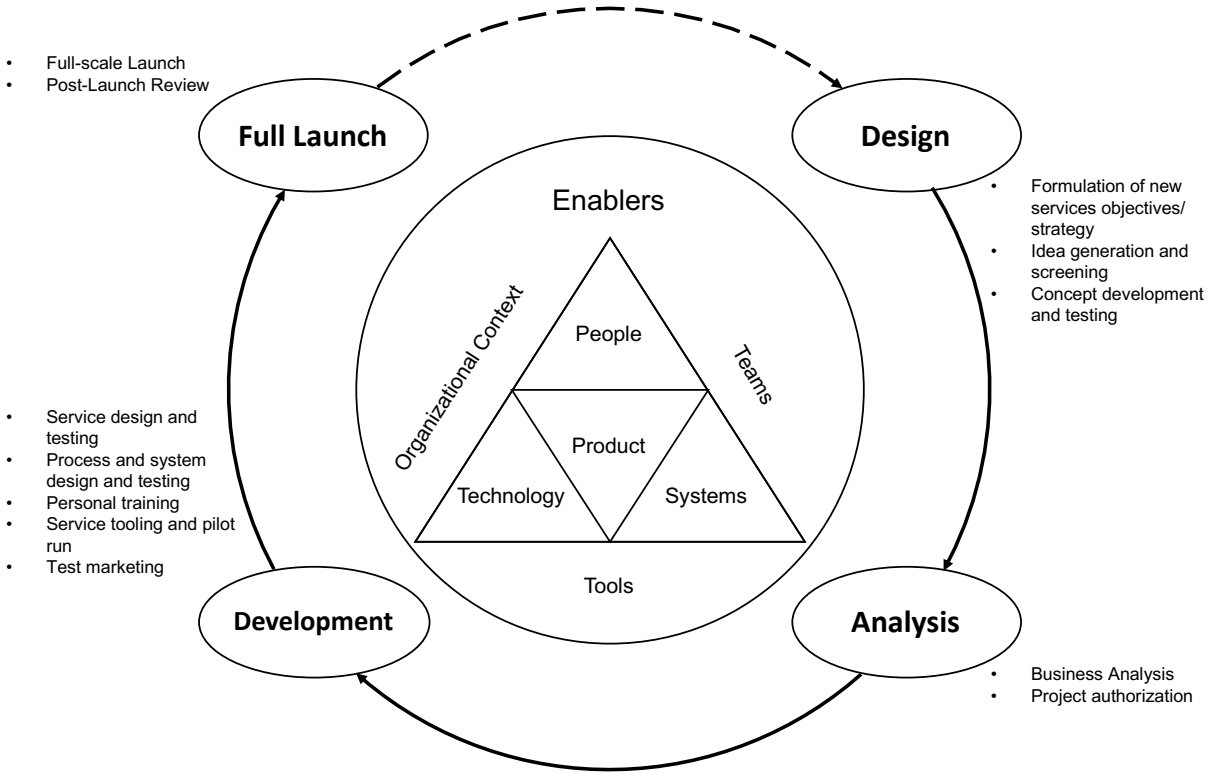



*Figure 3: NSD process cycle (adapted from Johnson et al. (2000))*

Earlier NSD research has been criticized for being industry- and firm-specific (Biemans et al., 2016, pp. 394–395). By synthesizing and integrating prior process models that are developed in the context of various industries, Johnson et al.'s (2000) model is considered as generalizable (Froehle & Roth, 2007, p. 174; Yu & Sangiorgi, 2018, p. 41). Nevertheless, it has been noted that the service development process is contingent on the type of services, as well as the service context (MacCormack & Verganti, 2003, p. 217; Zomerdijk & Voss, 2011, p. 66). Thus, Biemans et al. (2016, p. 382) most recently conclude: "There are many different types of services, but it is not clear how the service context impacts the new service development process."

#### *2.2.2.4 Service innovation in manufacturing*

Research on service innovation and new service development (NSD) has mainly focused on innovation in service industries such as financial services, telecommunication services, professional services (Biemans et al., 2016; Papastathopoulou & Hultink, 2012) However, research within the synthesis perspective of service innovation has acknowledged the convergence of product and services highlighting the increasing importance of service innovation in manufacturing firms (Carlborg et al., 2014; Papastathopoulou & Hultink, 2012). Nevertheless, studies in the manufacturing context are limited within the field of service innovation and NSD (Droege et al., 2009, p. 132; Kindström & Kowalkowski, 2014, p. 97).

Initial research within the field of servitization investigates how service innovation in manufacturing industries differs from service industries (Burton et al., 2017, p. 30; Gebauer, Krempl, et al., 2008; Lightfoot & Gebauer, 2011). Gebauer et al. (2008) find that the antecedents of different product-related services differ in the effect and importance and that "a simple transfer of antecedents for service development derived from traditional service industry to the context of manufacturing companies seems to be limited" (p.391).

In the context of servitization and product-related services, new product and service development are closely interrelated (Burton et al., 2017, p. 30) and research analyzes if NPD and NSD should be integrated or separated (Gremyr et al., 2014), and how NSD processes should be adapted to the context of manufacturing (Gremyr et al., 2010; Kindström & Kowalkowski, 2009). In a benchmarking study, Gebauer, Friedli, and Fleisch (2006, p. 379) observe that manufacturers are more successful when following a precisely defined service development process. Nevertheless, initial findings indicate that most manufacturers do not follow structured NSD processes (Gebauer, Krempl, et al., 2008, p. 399; Gremyr et al., 2010, p. 171) and that applied NSD processes are rather adaptations of existing NPD processes without considering the differences of products and services (Gremyr et al., 2014, p. 129; Kindström & Kowalkowski, 2009, p. 161).

Kindström and Kowalkowski (2009, pp. 158–159) propose a generic NSD process for manufacturing firms involving four stages: (1) market sensing, (2) development, (3) sales, and (4) delivery highlighting that manufacturers have to focus on all four stages and not only on the development stage. Especially stage three and four are resource-intensive, costly and complex to manage, and therefore critically for the NSD success. Furthermore, they show that NPD and NSD differ, as NSD require a higher degree of customer involvement in all stages, as well as that the locus of NSD is more decentral at the customer interface compared to central R&D units in NPD (Kindström & Kowalkowski, 2009, pp.

161–162). Additionally, they find that NPD and NSD processes in manufacturing firms are strongly interrelated and cannot be performed separately, which is especially relevant for information-based and data-driven services such as remote services (Kindström & Kowalkowski, 2009, p. 167). This finding is supported by Burton et al. (2017, p. 36), who emphasize the importance of relevant touchpoints between NPD and NSD processes to ensure an integrated development of products and services. However, Gremyr et al. (2014, p. 129) found that manufacturers more often follow a structured NSD process, if NPD and NSD processes are separated. Thus, the understanding of NSD processes and its interrelation to NPD processes is still limited (Burton et al., 2017, p. 30; Kindström & Kowalkowski, 2014, p. 97).

Besides studying specific elements of NSD processes in manufacturing firms, initial research has adopted a capability perspective to investigate organizational requirements for service innovation in manufacturing. Kindsröm, Kowalkowski, and Sandberg (2013) discuss dynamic capabilities and their microfoundations that enable service innovation. The authors identify eleven key microfoundations related to the three generic categories of dynamic capabilities: sensing, seizing, and reconfiguring (cf. Teece et al., 1997). Their findings indicate that existing manufacturing-driven capabilities are not sufficient and that firms need to develop distinctive skills, organizational processes and structures to enable service innovation in the manufacturing context (Kindström et al., 2013, p. 1071).

Kindström and Kowalkowski (2014) adopt a business model perspective to identify the resources and capabilities required for service innovation. Therefore, they related the identified resources to specific business model elements (e.g., offering, revenue model, customer relationship, or value network). The authors underline that strong interdependencies between the different business models elements and underlying capabilities exist, as well as that an adequate alignment of the resources and capabilities is necessary to foster service innovation (Kindström & Kowalkowski, 2014, pp. 104–105). However, neither Kindström et al. (2013) nor Kindström and Kowalkowski (2014) discuss how these microfoundations and capabilities vary in their manifestation and importance according to different service strategies and types of services (cf. Burton et al., 2017, p. 31).

Summarizing, research acknowledges that manufacturing firms' ability to develop new services and engage in service innovation is a key success factor for servitization (Burton et al., 2017, p. 30). However, studies that link servitization and service innovation, as well as analyze service innovation in the manufacturing context are still limited (Beltagui, 2018, pp. 1041–1042; Gremyr et al., 2014, p. 123; Kindström & Kowalkowski, 2014, p.

97). Furthermore, existing studies do not provide conclusive and consistent results on service innovation and new service development in manufacturing firms.

### 2.2.3 Success factors of product and service innovation

Research on antecedents of innovation success and success factors of innovation is among the most studied topics within the research field of new product development, as well as new service development (Evanschitzky et al., 2012; Hauschildt et al., 2016; Papastathopoulou & Hultink, 2012). Research on success factors goes back to the seminal studies of Rothwell and colleagues, as well as Cooper and Kleinschmidt, who have identified various internal and external factors that influence the success of new product development projects (cf. Brown & Eisenhardt, 1995; Cooper, 1979; Cooper & Kleinschmidt, 1987; Rothwell et al., 1974). Early research on antecedents of innovation success did mainly focus on products as opposed to services (de Brentani, 2001, p. 170; Kuester et al., 2013, p. 534; Page & Schirr, 2008, p. 244). Motivated by specificities of services and the call for dedicated studies on new service development, de Brentani (1989), as well as Cooper and de Brentani (1991), were among the first who studied success factors of NSD.

#### *2.2.3.1 NPD success factors*

Several meta-analyses have synthesized the considerable empirical research on success factors of NPD (Ernst, 2002; Evanschitzky et al., 2012; Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1994). Ernst (2002) reviews the findings of the series of studies by Cooper and Kleinschmidt, as well as related studies on new product success and summarizes the following most relevant success factors.

Accordingly, the basis for the success of product innovation projects is the presence of a formal or informal NPD process, as well a comprehensive preliminary planning, including feasibility studies and commercial evaluations. Furthermore, every NPD process step needs to be aligned with the market requirements, resulting in a strong market orientation of the entire innovation project. Additionally, the integration of lead users into early and late phases of the innovation process is also associated with superior NPD performance. Another important success factor is a dedicate project organization with sufficient time resources and adequate project-specific performance incentives. With regard to the project organization, an experienced project leader and cross-functional team composition to foster cross-functional communication are also seen as beneficial. Additionally, the project team should have substantial autonomy and be rather responsible for the entire NPD process instead of single parts. Finally, top management support and sufficient resources

for activities not directly related to the core NPD activities (e.g. market research) are regarded as relevant determinants for the success of new products. Regarding the role of organizational culture and the existence of a dedicated NPD strategy, Ernst (2002) finds indications of their relevance for the success of new products. However, their exact link to innovation performance is vague and requires further empirical research.

Most recently, Evanschitzky et al. (2012) conducted a comprehensive meta-analysis to synthesize findings on the success factors of NPD. Based on the earlier meta-analyses, the authors cluster success factors into five categories: (1) product-related, (2) strategy-related, (3) process-related, (4) marketplace-related, and (5) organizational-related success factors (Evanschitzky et al., 2012, p. 23; Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1994). They find that the factors product advantage and market orientation have the strongest effect on new product success. On an aggregated level, comparing the categories of success factors, strategy-related (e.g., dedicated human resources, dedicated R&D resources, and strategic orientation) and process-related (e.g., market orientation, predevelopment task proficiency, and marketing task proficiency) success factors are the most important success factors (Evanschitzky et al., 2012, pp. 24–26). In general, the study finds declining effect sizes of success factors compared to earlier meta-analyses. Thus, the authors call for "new and more comprehensive theoretical approaches to capture the underlying nature of NPD success factors" (Evanschitzky et al., 2012, p. 30). Table 5 gives an overview of the most relevant NPD success factors and their definition.

#### *2.2.3.2 NSD success factors*

Within the context of service innovation research, two recent meta-analyses have consolidated and synthesized prior research on NSD success factors (Kuester et al., 2013; Storey et al., 2016). Kuester et al. (2013, p. 535) identify 17 different success factors in four categories. By counting their prevalence in prior NSD success studies, the authors find that staff competence and market launch activities, synergy potential, service superiority, and customer orientation are the most cited success factors in the NSD literature. By analyzing the identified success factors within different service industries, Kuester et al. (2013, p. 540) show that the importance of certain success factors varies across different service industries and innovation types. Depending on the "adoption degree of externally developed innovations" and the "degree of individualization and usage of external innovation sources", the study classifies service firms into four clusters: efficient developers, innovative developers, interactive adopters, and standardized adopters. Innovative developers which include service industries such as R&D, consulting, data processing and business services, and which best relate to industrial services in

manufacturing industries, are found to strongly benefit from customer orientation, service superiority, integration of customers into the NSD process and a dominant innovation culture (Kuester et al., 2013, p. 541).

*Table 5: Top ten success factors of NSD and NPD (adapted from Storey et al.* (2016, p. 536) *and Evanschitzky et al.* (2012, pp. 25–26)*)*

| **NSD success factors** | **Definition** | **NPD success factors** | **Definition** |
|---|---|---|---|
| [1] Launch proficiency | Proficiency with which a firm launches and communicates the new service | [1] Product advantage | Superiority and/or differentiation over competitive offerings |
| [2] Absorptive capacity | The process through which a firm recognizes the value of new information, assimilates it, and applies it to performing development activities | [2] Market orientation | Degree of firm orientation to its internal, competitor, and customer environments |
| [3] Organizational design | Organizational design such as reward structure, job design | [3] Launch proficiency | Proficiency with which a firm launches the product |
| [4] Innovation strategy | Organization's openness to new ideas and propensity to change | [3] Dedicated human resources | Focused commitment of personnel resources to a new product initiative |
| [5] Efficiency of development process | Lower than expected development time and/or cost | [5] Predevelopment task proficiency | Proficiency with which a firm executes the prelaunch activities (e.g., idea generation/screening, market research, financial analysis) |
| [6] Service innovativeness | The degree of newness/ originality/ radicalness of the service offering | [6] Dedicated R&D resources | Focused commitment of R&D resources to a new product initiative |
| [7] Front-line staff involvement | The competence and extent of involvement of frontline staff during development | [6] Marketing task proficiency | Proficiency with which a firm conducts its marketing activities |
| [7] External relations | Coordination and cooperation between the firm and other organizations during development | [6] Organizational climate | The extent to which the day-to-day decisions are governed with organization/ group's shared values and norms |
| [9] Internal communication | Level of communication and knowledge dissemination among departments during development | [9] Strategic orientation | Strategic impetus, orientation, and focus of corporate strategy |
| [9] Formal/ structured development | Employment of explicit rules and formalized development procedures | [10] Internal communication | Level of communication and knowledge dissemination among departments during development |

[No.] Rank order of success factor

Most recently, Storey et al. (2016) conducted a very comprehensive quantitative meta-analysis to compare the antecedents service innovation and product innovation performance, as well as between different types of services. They apply the conceptual

framework, which has been proposed by Evanschitzky et al. (2012) to categorize success factors in NPD, to the context of NSD. Additionally, they add team-related success factors as a separate category of success factors. In total, the authors identify 37 success factors in six categories. The most important success factors of NSD are illustrated in Table 5, as well as compared with the most important NPD success factors identified by Evanschitzky et al. (2012).

Storey et al. (2016, p. 536) find significant differences in the success factors of NSD and NPD, as only two factors (launch proficiency and internal communication) are in the top ten for both NSD and NPD. Furthermore, their findings highlight the importance of customer integration, external relations, absorptive capacity, and knowledge integration mechanism in NSD. These factors play a crucial role in service innovation, as firms need to manage an extensive amount of tacit knowledge during the NSD process. Therefore, the authors conclude that service and product innovation are different and require distinct capabilities (Storey et al., 2016, pp. 541–542).

Besides the differences between the success factors of service and product innovation, they also find considerable differences regarding the type of service (Storey et al., 2016, p. 537). The authors differentiate between tacit and explicit services. Whereas tacit services are based on tacit knowledge and are delivered by interpersonal interactions, explicit services are based on explicit knowledge and are delivered with the aid of technology. Knowledge integration mechanisms, cross-functional integration, market orientation, proficient operations, and delivery systems, synergistic strategy, and environmental uncertainty have a larger effect for explicit services tan for tacit services. Accordingly, the study finds that explicit services, which best relate to data-driven services, “sit interstitial between tacit services on one side and products on the other side” (p. 543).

Research on success factors of innovation has provided various practical implications for the management and the practice of NSD and NPD (cf. Evanschitzky et al., 2012, p. 22). However, it has been criticized for its missing theoretical foundation, using ill-defined constructs (Brown & Eisenhardt, 1995, p. 353; Hauschildt et al., 2016, p. 72). Thus, many cross-sectional studies rather present an array of success factors without considering and analyzing the multidimensional and causal relationships (Ernst, 2002; Page & Schirr, 2008; Papastathopoulou & Hultink, 2012; Sammerl, 2006).

## 2.3 The context of medical technology firms

### 2.3.1 Medical technology industry

Medical technologies refer to products, devices, software, or procedures that are used for the prevention, diagnosis, treatment, or monitoring of diseases. In contrast to pharmaceuticals, which have a pharmacological, immunological, or metabolic effect, the intended principal effect of medical technologies is achieved primarily by physical or chemical means (BfArM, 2020). The European trade association MedTech Europe differentiates medical technologies into three main areas: (1) medical devices, (2) In vitro diagnostics (IVDs), and (3) digital health solutions (MedTech Europe, 2019, p. 4).

Medical technologies are highly regulated by laws that govern the safety and performance along the entire lifecycle. In Europe, medical technology firms have to demonstrate that their products are compliant to central regulations, which are monitored and controlled by a third-party, the so-called notified bodies. Accordingly, medical technology firms have to implement a quality management system that is certified according to the norm ISO 13485. The objective of the certified quality management system is to guarantee the safety and effectiveness of the marketed medical technology by ensuring the effectiveness of the applied corporate processes, such as the innovation process. Therefore, the innovation process needs to fulfill the requirements of ISO 13485, which makes the process very formalized and rigid.

In 2017 the market volume of the European medical technology industry was about 115 billion Euros, which is about 27% of the world market. The European medical technology industry consists of about 27’000 firms, whereas about 95% of these firms are small and medium-sized enterprises with less than 50 employees (MedTech Europe, 2019). In general, the medical technology industry is considered as highly innovative, as about one-third of the firms’ turnover is generated with products that are not older than three years (Schmid & Demuth, 2018, p. 2). According to Spectaris (2019), the average R&D expenses of German medical technology firms is about 9% of their turnover. Furthermore, the medical technology industry is the sector with the most patent applications in Europe (MedTech Europe, 2019, p. 13).

### 2.3.2 Servitization of medical technology firms

In the research field of servitization and product-service systems only limited in-depth research on service provision by medical technology firms exists, although several studies refer to the medical technology industry to highlight the relevance of servitization across

different industries (Lightfoot et al., 2013; Windahl et al., 2004). Schröter and Lay (2014) provide a review of three existing studies on servitization in the medical technology industry and find that due to the regulation and the complexity of the healthcare system, servitization follows specific patterns. First, regulatory requirements oblige medical technology firms to provide basic product-oriented services like maintenance and repair. Hence, these services are standard in the industry, and manufacturers are not able to differentiate by these services (Buschak et al., 2010, p. 9; Schröter & Lay, 2014, p. 168). To overcome the financial constraints of public hospitals and to increase the diffusions of innovative products, medical technology firms also provide advance service offerings like leasing or pay-per-use services. Operational services, where the manufacturer owns and operates the product, are limited in this sector as the application of medical technologies requires the employment of medical personnel and compliance to strict regulations. Therefore, the authors find that "the creation of added value through services plays a minor role compared to other sectors" and that the objectives of servitization are rather on increasing product sales than adding additional revenue streams (Schröter & Lay, 2014, p. 175).

Regarding digital servitization and digital services in the medical technology industry, literature rather describes anecdotal use cases of individual applications. Allmendinger and Lombreglia (2005), for example, refer to opportunities of smart services for medical diagnostic equipment and how GE Healthcare's connected MRI scanners opens up new opportunities for services and even entirely new business models. Similar, Porter and Heppelmann (2015, p. 19) highlight how smart medical devices like connected pacemakers will improve clinical decision making and induce new data-based services. Research from the domain of servitization and product-service systems finds that ICT-enabled services like remote maintenance services are gaining importance in the medical technology industry as they facilitate further customer integration and improve customer relationship management (Köbler et al., 2009; Paluch, 2014). However, comprehensive studies on the organizational implications of digital servitization on medical technology firms do not exist.

# 3 Conceptual background

This chapter provides the conceptual background of this dissertation. Chapter 3.1 introduce the organizational and dynamic capabilities theories which provide the theoretical lens of this research project. Based on these theories, a guiding research framework is developed, which is outlined in chapter 3.2. Finally, chapter 3.3 presents the results of a systematic literature review of prior research on organizational capabilities in the context of service innovation. Based on the findings of the literature review, the limitations of existing research are summarized and implications for this dissertation are derived (3.4).

## 3.1 Organizational capabilities

### 3.1.1 Origin and definition

Organizational capabilities are at the core of the resource-based view of the firm (RBV), which explains the source of firm's competitive advantages and superior performance from their internal resources and capabilities instead of a privileged product market position (Barney, 1991; Dierickx & Cool, 1989; Wernerfelt, 1984). The RBV originates from earlier works on how firms utilize resources more productively than its competitors, resulting in distinctive competencies (Penrose, 1959; Selznick, 1957).

Resources are firm-specific tangible or intangible assets that are owned, controlled, or accessed on a semi-permanent basis (Helfat & Peteraf, 2003; Wernerfelt, 1984). For generating a competitive advantage, these resources have to be valuable, rare, imperfectly imitable, and non-substitutable (Barney, 1991). Initially, Barney (1991, p. 101) defined resources very broadly as "all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc." However, scholars today rather distinguish between resources and capabilities (Schryogg & Kliesch-Eberl, 2007). Resources are firm specifics assets, whereas capabilities describe a firm's capacity to combine and deploy these resources (Amit & Schoemaker, 1993). According to Grant (1991, p. 119), "[…] resources are the source of a firm's capabilities, capabilities are the main source of its competitive advantage". Capabilities that are able to generate a competitive advantage are also called "Core Competencies" (Prahalad & Hamel, 1990). However, literature has used a variety of terms like organizational capabilities, collective skills, and best practices to refer to these capabilities (Schryogg & Kliesch-Eberl, 2007, p. 914). Table 6 provides an overview of selected definitions of organizational capabilities. This dissertation adopts the term organizational capabilities and follows the definition of Helfat and Peteraf (2003, p. 999):

organizational capabilities are "the ability of an organization to perform a coordinated set of tasks, utilizing organizational resources, for the purpose of achieving a particular end result."

The definitions of organizational capabilities highlight certain characteristics. First, their purpose is to solve organizational problems by combining and coordinating resources effectively, using organizational routines (Amit & Schoemaker, 1993; Helfat & Peteraf, 2003). Routines are conceptualized as repetitive and recognizable patterns of activities (Nelson & Winter, 1982) and are regarded as "building blocks" of organizational capabilities (Dosi et al., 2000, p. 4).

*Table 6: Overview of definitions of organizational capabilities*

| Definition | Source |
|---|---|
| *"[…] refer to a firm's capacity to deploy resources, usually in combination, using organizational processes, to effect a desired end."* | (Amit & Schoemaker, 1993, p. 35) |
| *"[…], this paper will define organizational capabilities as the socially complex routines that determine the efficiency with which firms physically transform inputs into output."* | (Collis, 1994, p. 145) |
| *"Integration of specialist knowledge to perform a discrete productive task is the essence of organizational capability, defined as a firm's ability to perform repeatedly a productive task which relates either directly or indirectly to a firm's capacity for creating value through effecting the transformation of inputs into outputs."* | (Grant, 1996, p. 377) |
| *"An organizational capability is a high-level routine (or collection of routines) that together with its implementing input flows, confers upon an organization's management a set of decision options for producing significant outputs of a particular type."* | (Winter, 2000, p. 983) |
| *"[T]he ability of an organization to perform a coordinated set of tasks, utilizing organizational resources, for the purpose of achieving a particular end result."* | (Helfat & Peteraf, 2003, p. 999) |

Furthermore, organizational capabilities are reliable (Helfat & Peteraf, 2003) and develop over time "through complex interactions among firm's resources" (Amit & Schoemaker, 1993, p. 35). They are information-based, integrating the knowledge of the firm's human resources (Amit & Schoemaker, 1993; Grant, 1996). Therefore, they are the result of a process of organizational learning (Schryogg & Kliesch-Eberl, 2007). Their time-dependent development and underlying complexity make them difficult to imitate by competitors, which make them a source of competitive advantage (Amit & Schoemaker, 1993; Schryogg & Kliesch-Eberl, 2007).

These underlying characteristics make them not only difficult to imitate by competitors, but also difficult to observe and investigate empirically (Kosanke, 2015). Therefore, this dissertation will focus on organizational routines and processes as building blocks of

organizational capabilities, whereas organizational routines are defined as "repetitive, recognizable patterns of interdependent actions of multiple actors" (Feldman & Pentland, 2003, p. 95). According to Feldman & Pentland (2003, p. 101), organizational routines consist of ostensive and performative aspects. The ostensive aspects describe the formalized and codified elements and can be interpreted as "standard operating procedures." Performative aspects describe the particular course of actions of specific people engaged in organizational routines (Feldman & Pentland, 2003, pp. 101–102).

### 3.1.2 Dynamic capabilities

#### *3.1.2.1 Definition*

As organizational capabilities are reliable and learned problem-solving routines and practices, they might also turn into rigidities that impede the organizational evolution in changing and volatile environments (Leonard-barton, 1992). Therefore, scholars have extended the RBV and the concept of organizational capabilities by introducing the concept of dynamic capabilities to explain how firms sustain competitive advantage over time and under dynamic conditions (Eisenhardt & Martin, 2000; Teece et al., 1997; Winter, 2003; Zollo & Winter, 2002). Whereas the RBV focuses on the current resource base and organizational capabilities of a firm, dynamic capabilities address how firms reconfigure and renew their resource base (Eisenhardt & Martin, 2000, p. 1107; Zahra et al., 2006, p. 921).

The term of dynamic capabilities was first introduced by Teece and Pisano (1994) and Teece et al. (1997) to provide a conceptual framework "to identify the foundations upon which distinctive and difficult-to-replicate advantages can be built, maintained, and enhanced" (Teece et al., 1997, p. 516). Accordingly, Teece et al. (1997, p. 516) define dynamic capabilities "as the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments." Table 7 provides an overview of prominent definitions of dynamic capabilities. These definitions highlight common features and different interpretations. Eisenhardt and Martin (2000) emphasize that dynamic capabilities are based on specific strategic and organizational processes, which allow a firm to "integrate, reconfigure, gain and release resources – to match and even create market change" (p. 1107). As an example, they refer to processes such as new product development, as well as alliances and acquisition processes to build new resources from external sources (Eisenhardt & Martin, 2000, pp. 1107–1108). Zollo and Winter's (2002) definition focuses on how dynamic capabilities are built. Thus, a dynamic capability is "a learned and stable pattern of collective activity" that aims to modify

operational routines (p. 340). Accordingly, the authors define dynamic capabilities as an outcome of organizational learning and implicitly differentiate them from operational capabilities (Helfat et al., 2007, p. 3), which are capabilities "that enable a firm to make a living in the present" (Helfat & Winter, 2011, p. 1244) and to maintain and leverage current operations (Schilke et al., 2018, p. 392). Winter (2003, p. 992) calls these capabilities zero-order capabilities in contrast to higher-order (dynamic) capabilities. Therefore, dynamic capabilities can be defined as a subset of organizational capabilities, sharing common characteristics. Despite differences in their purpose and underlying mechanism of action, dynamic capabilities are also embedded in organizational routines (Helfat & Peteraf, 2003, p. 999; Zollo & Winter, 2002, p. 341), which means that dynamic capabilities consist of patterned and practiced activities (Helfat et al., 2007, p. 5; Winter, 2003, pp. 992–993).

*Table 7: Overview of definitions of dynamic capabilities*

| Definition | Source |
|---|---|
| *"Dynamic capabilities are the subset of the competences/capabilities which allow the firm to create new products and processes, and respond to changing market circumstances."* | (Teece & Pisano, 1994, p. 541) |
| *"The firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments."* | (Teece et al., 1997, p. 516) |
| *"The firm's processes that use resources—specifically the processes to integrate, reconfigure, gain, and release resources—to match and even create market change; dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die."* | (Eisenhardt & Martin, 2000, p. 1107) |
| *"A dynamic capability is a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness."* | (Zollo & Winter, 2002, p. 340) |
| *"A dynamic capability is the capacity of an organization to purposefully create, extend, or modify its resource base."* | (Helfat et al., 2007, p. 1) |

#### *3.1.2.2 Underlying organizational processes*

The different definitions of dynamic capabilities show that these capabilities are strongly related to organizational and managerial routines and processes. Organizational and managerial processes are the underlying mechanism to develop and apply dynamic capabilities (Helfat et al., 2007, p. 30). Teece et al. (1997) refer to three main categories or dimensions of organizational and managerial processes in the context of dynamic capabilities: coordination and integration processes, learning processes, and reconfiguration processes (Teece et al., 1997, p. 518). These organizational processes are shaped by a firm's existing asset base and evolutionary path (Teece et al., 1997, p. 524).

Coordination and integration of internal and external activities is an important managerial task and organizational process. Teece et al. (1997) describe project management in the context of product development as such an internal coordination process. They find that "[…] differences in coordinative routines and capabilities seem to have a significant impact on such performance variables as development cost, development lead times, and quality" (Teece et al., 1997, p. 519). Similar Eisenhardt and Martin (2000, p. 1107), which denote product development as an integration process underlying dynamic capabilities. Besides internal coordination, both studies also highlight external coordination and integration processes such as the management of strategic alliances or the integration of suppliers (Eisenhardt & Martin, 2000, p. 1108; Teece et al., 1997, pp. 518–519).

Another important process that constitutes dynamic capabilities is learning: "a process by which repetition and experimentation enable tasks to be performed better and quicker" (Teece et al., 1997, p. 520). Organizational learning allows firms to build new knowledge, routines, and capabilities (Eisenhardt & Martin, 2000, p. 1108; Teece et al., 1997, p. 520). According to Teece et al. (1997, p. 520), learning emerges from joint problem-solving and requires "common codes of communication and coordinated search procedures." Research on organizational learning has identified three main learning sub-processes: (1) creating knowledge, (2) retaining knowledge, and (3) transferring knowledge (Argote, 2011, p. 441; Easterby-Smith & Prieto, 2008, p. 242). Besides internal learning, inter-organizational learning through collaborations and partnerships is also highlighted as an important process underlying dynamic capabilities. These external collaborations provide new knowledge to address "strategic blindspots" and "dysfunctional routines" (Teece et al., 1997, p. 520).

Reconfiguration refers to "the ability to scan the environment, to evaluate markets and competitors, and to quickly accomplish reconfiguration and transformation ahead of competition" (Teece et al., 1997, p. 521). More recently, this capability and underlying processes are referred to as sensing capabilities and processes (Pavlou & Sawy, 2011, pp. 243–244; Schilke et al., 2018, p. 402; Teece, 2007, p. 1322). In the context of new product development (NPD), Pavlou and Sawy (2011, p. 244) identify three main sub-processes: (1) "generating market intelligence", (2) "disseminating market intelligence", and (3) "responding to market intelligence". Accordingly, these processes enable firms to identify new market opportunities and respond to customer needs (Pavlou & Sawy, 2011, p. 244). Hence, reconfiguration processes deal with the strategic alignment of an organization towards the external environment (Sammerl, 2006, p. 175).

Several scholars on the underlying process of dynamic capabilities refer to a more recent conceptualization by Teece (2007). In this study, Teece (2007) describes three types of processes: (1) sensing new opportunities (and threats), (2) seizing these opportunities, and (3) transforming and reconfiguring the firm's resources, structures, and capabilities. However, Schilke et al. (2018, p. 402) find that despite different labels and ordering, both conceptualizations of the types of processes (coordination/integration, learning, and reconfiguration, as well as sensing, seizing and reconfiguring/transforming) share many similarities and overlaps and rather represent a different foci. Whereas Teece (2007) emphases the role of sensing opportunities and threats, Teece et al. (1997) pay more attention to coordination and learning. As this dissertation is concerned with the underlying processes and routines of service innovation, where the coordination of the innovation process, as well as the creation of new knowledge, are important aspects, this study follows the conceptualization of Teece et al. (1997).

#### *3.1.2.3 Antecedents*

*Resources:* As highlighted by Teece et al. (1997, p. 524), the organizational process as the main mechanism of dynamic capabilities, are shaped by a firm's evolutionary path and existing asset base. Accordingly, firm history and prior investments determine a firm's current tangible and intangible resources upon which dynamic capabilities operate (Helfat & Peteraf, 2009, p. 97). Thus, the existing resource base is an important antecedent of dynamic capabilities. Prior research on antecedents of dynamic capabilities has identified different types of resources that facilitate the development and exploitation of dynamic capabilities, such as financial and technological resources (Schilke et al., 2018, p. 404). Anand, Oriani, & Vassolo (2010, p. 1227) for example, find that existing technological resources might become so-called "competency traps" (Levitt & March, 1988, pp. 322–323), when new technologies are emerging. In this case, complementary resources such as capabilities to create and manage alliances, which provide access to emerging technologies, will help to overcome the deficiency within existing capabilities.

*Organizational Structure:* Another organizational antecedent of dynamic capabilities is the organizational structure (Schilke et al., 2018, p. 404; Teece et al., 1997, pp. 521–522). Teece et al. (1997, p. 521) already indicated that "the formal and informal structure of organizations and their external linkages have an important bearing on the rate and direction of innovation, and how competences and capabilities co-evolve". Felin and Powell (2016, pp. 83–84) suggest that under rapid technological change, firms have to foster decentralization and empowerment of individuals to identify and exploit emerging opportunities adequately. With regard to organizational learning as an important element

of dynamic capabilities, Van den Bosch, Volberda, & de Boer (1999, pp. 554–556) show that different organizational forms such as functional, divisional, or matrix forms, have different effects on how firms process knowledge. They find that matrix organizations enhance a firm's capability to identify, assimilate, and apply new knowledge due to their multiple cross-functional interfaces. Furthermore, organizational structures with a high formalization of work tend to hinder the use of new information (Deshpande & Zaltman, 1982, p. 18; Wilden et al., 2013, p. 76). Thus, the degree of centralization, organizational form, and formalization of work are relevant factors that need to be considered when studying dynamic capabilities.

*Organizational culture* refers to "the pattern shared values and beliefs" of a firm's employees (Deshpande & Webster, 1989, p. 4). According to Teece et al. (1997, p. 520), "culture can be a de factor governance system as it mediates the behavior of individuals." Thus, culture is considered as an important element of the informal structure of an organization, which also influences a firm's innovativeness (Bock et al., 2012, p. 282; Tellis et al., 2008, pp. 15–16). Tellis et al. (2008, p. 8) identify three different types of shared values ("attitudes") that influences a firm's innovativeness: willingness to cannibalize assets, future orientation, and tolerance for risk. Furthermore, in a meta-analysis on organizational culture and innovation, Büschgens, Bausch, & Balkin (2013, p. 763) find that an externally and flexibility oriented organizational culture fosters innovation, whereas an organizational culture that is internally and control-oriented might hinder innovation.

#### *3.1.2.4 Organizational outcomes*

Whereas zero-order capabilities focus on deploying and integrating existing resources, dynamic capabilities have the purpose of reconfiguring and renewing the resource base (Eisenhardt & Martin, 2000; Zahra et al., 2006). Referring to Helfat and Peteraf (2003, p. 999), dynamic capabilities "do not involve production of a good or provision of a marketable services." Dynamic capabilities do not create value directly but indirectly through their capacity to change operational capabilities (Helfat & Peteraf, 2003; Zahra et al., 2006). Thus, the effect of dynamic capabilities on organizational outcomes and firm performance is twofold (Kosanke, 2015, p. 75). By enabling firms to create and reconfigure resources and capabilities continuously, dynamic capabilities allow firms to adapt to changing market conditions, such as emerging, evolving, or dying markets (Eisenhardt & Martin, 2000, p. 1107). Accordingly, new product development and innovation have received much attention in the context of dynamic capabilities (see also Table 8), as the ability to develop new products, processes and or even markets is

considered as a dynamic capability (Danneels, 2008, p. 520; Helfat, 1997; Helfat & Raubitschek, 2018, p. 1397; Winter, 2003, p. 992). Therefore, *innovation outcomes* are a relevant organizational outcome of dynamic capabilities (cf. Schilke et al., 2018, p. 402).

*Table 8: Innovation capability as a dynamic capability*

| **References** | **Source** |
|---|---|
| *"[…] the capacity for problem solving that underlies effective product development is also the critical ingredient in dynamic capability more generally. Our interest in product development is motivated by a desire to understand the processes that govern dynamic capability and the sources of superior dynamic performance."* | (Iansiti & Clark, 1994, p. 566) |
| *"Dynamic capabilities enable firms to create new products and processes and respond to changing market conditions."* | (Helfat, 1997, p. 339) |
| *"[…] dynamic capabilities consist of specific strategic and organizational processes like product development, alliancing, and strategic decision making that create value for firms within dynamic markets by manipulating resources into new value-creating strategies."* | (Eisenhardt & Martin, 2000, p. 1106) |
| *"New product development, as practiced in many firms, is a prototypical example of a first-order 'dynamic capability'"* | (Winter, 2003, p. 992) |
| *"Second-order marketing and research and development (R&D) competences are particular manifestations of second-order competences [dynamic capabilities], reflecting the ability of a firm to explore new market and technological domains, respectively."* | (Danneels, 2008, p. 520) |
| *"Reconfiguring operational capabilities and deploying new ones to address turbulent environments is the ultimate goal of dynamic capabilities […]. Reconfiguration is markedly relevant in NPD where new products are the outcome of reconfigured operational capabilities."* | (Pavlou & Sawy, 2011, p. 243) |
| *"Next we examine what we see as three essential types of dynamic capabilities for the sensing, seizing, and transforming activities […]: 1) innovation capability, 2) environmental scanning and sensing capability, and 3) integrative capability. Innovation capabilities contribute to both seizing and reconfiguring by aiding firms in developing new innovations, and these capabilities may also help with sensing through the investigation of emerging technologies by research personnel* | (Helfat & Raubitschek, 2018, p. 1394) |

Besides providing firms with the ability to create new products and processes to match internal and external demands, dynamic capabilities are also seen as a source of competitive advantage and superior firm performance when their underlying learning mechanisms continuously create path-dependent and difficult to imitate resources and capabilities as described by the RBV (Kosanke, 2015, p. 75; Zahra et al., 2006, p. 923; Zollo & Winter, 2002, p. 340). Thus, dynamic capabilities influence firm performance only indirectly, by providing firms with the ability to reconfigure its resource base (Eisenhardt & Martin, 2000, p. 1116; Schilke et al., 2018, p. 406; Zott & Amit, 2013, p. 98). Eisenhardt and Martin (2000, p. 1116) conclude that the "[…] value for competitive advantage lies in the resource configurations that they create, not in the capabilities

themselves. Dynamic capabilities are necessary, but not sufficient, conditions for competitive advantage."

## 3.2 Guiding research framework

To guide theory development and to structure the empirical investigation, a research framework is developed. The research framework illustrates the research scope, important variables, and their interaction (M. B. Miles et al., 2014, p. 20). It is a graphical representation of relevant theoretical constructs and their relationships (Wolf, 2010, p. 37). Kubicek (1977, p. 18) differentiates heuristic frameworks that formulate questions from conceptual frameworks that are a system of hypotheses. Accordingly, heuristic research frameworks do not fulfill the strict requirements with regard to logical consistency and operationalization that hypothetical frameworks have to fulfill. Heuristic research frameworks are seen as a preliminary explanatory model that steers the research process, as well as provide guidance in solving a practical problem (Kubicek, 1977, p. 18). Throughout the research process, the guiding research framework is further refined and critically reflected (Tomczack, 1992, p. 84). Furthermore, the research framework helps to systemize and organize relevant empirical findings on cause and effect, as well as facilitates the communication of the research process and results (Wolf, 2010, p. 37).

A guiding research framework can be illustrated as a figure consisting of checkboxes and arrows. Checkboxes represent the "conceptual categories" or "units of analysis", which are derived from existing theoretical constructs, whereas arrows indicate assumed relationships of these constructs. Additionally, conceptual categories consist of multiple dimensions, which enable the comparative analysis of the empirical findings (Kubicek, 1977, p. 18). According to Wolf (2010, pp. 38–39), conceptual research frameworks typically have a three-part structure. Thus, the author differentiates between (1) design-related, (2) context-related, and (3) performance- and outcome-related variables and constructs. Design-related variables are the center of the empirical investigation, and it is assumed that their manifestation can be influenced by decision-makers (e.g., managers). The manifestation of design-related variables might be directly or indirectly influenced by context-related variables, which cannot directly be controlled by decision-makers. Performance-related variables are the dependent variables. It is assumed that their manifestation is considerably influenced by the manifestation of design-related variables and the interplay of design- and context-related variables.

The starting point of the development of a conceptual framework is a general phenomenon, which is, according to the researcher, only insufficiently understood. (Kubicek, 1977, p.

17). In the context of this thesis, the starting point for the development of a guiding research framework is the limited understanding of the organizational requirements to develop digital services successfully. To investigate such an empirical phenomenon, the researcher requires a theoretical perspective, which allows him to frame and describe the theoretical problem and formulate adequate research questions and hypotheses (Kosanke, 2015, p. 104; Kubicek, 1977, p. 17). Therefore, the theoretical perspective underlying the guiding research framework is derived from a comprehensive review of prior research on service innovation (cf. 2.2) and organizational capabilities (cf. 3.1). Figure 4 consolidates the review and the derived insights on key constructs, their dimensions, and assumed relationships into a guiding research framework.

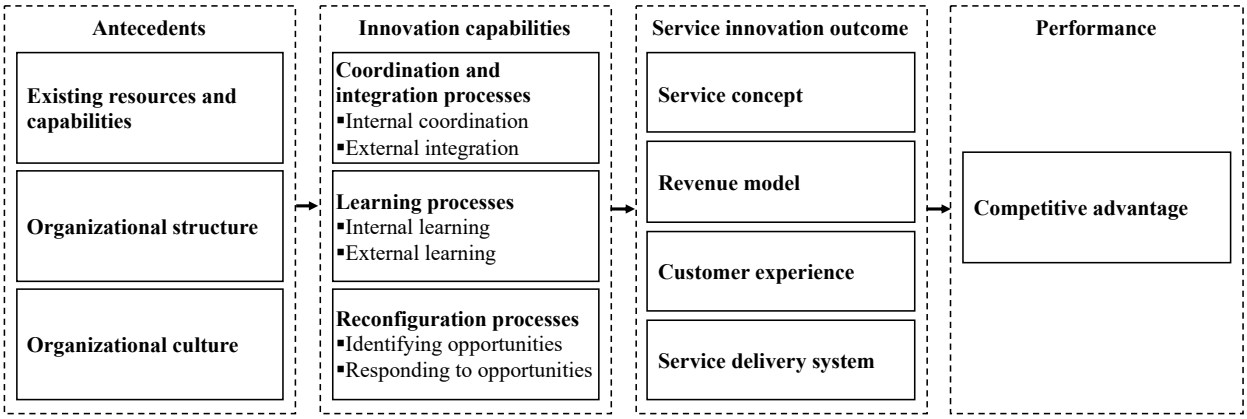



*Figure 4: Guiding research framework*

The guiding research framework consists of the following key constructs and underlying dimensions:

- *Innovation capabilities:* Organizational capabilities are defined as "the ability of an organization to perform a coordinated set of tasks, utilizing organizational resources, for the purpose of achieving a particular end results" (Helfat & Peteraf, 2003, p. 999). Organizational routines and processes are regarded as "building blocks" of organizational capabilities (Dosi et al., 2000, p. 4). To sustain competitive advantage over time, firms require dynamic capabilities, which are defined "as the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments" (Teece et al., 1997, p. 516). Additionally, dynamic capabilities are defined as high-order capabilities (Winter, 2003, p. 992). Thus, as a subset of organizational capabilities, dynamic capabilities are also embedded in organizational routines and processes (Helfat & Peteraf, 2003, p. 999). Teece et al. (1997) identify three main dimensions of organizational processes of dynamic

capabilities: (1) coordination and integration processes, (2) learning processes, and (3) reconfiguration processes. In line with research on innovation capabilities, this thesis defines the ability to develop new digital services as a dynamic capability (cf. chapter 3.1.2).

- *Antecedents:* Factors and elements that "facilitate or hinder the development, maintenance, and usage of dynamic capabilities" can be described as antecedents of dynamic capabilities (Schilke et al., 2018, p. 404). On the organizational level, the following three main antecedents affect dynamic capabilities: (1) existing resources and capabilities, (2) the organizational structure, and (3) the organizational culture. Thus, to develop a detailed understanding of what facilitates and hinders innovation capabilities for digital services, these factors have to be considered in the empirical analysis (cf. 3.1.2.3).
- *Service innovation outcome:* Innovation outcomes are considered as relevant organizational outcomes of dynamic capabilities (Schilke et al., 2018, p. 402). Service innovation is defined as an intangible offer not previously available to the firm's customers. Service innovation can emerge in one of the following constituting dimensions: (1) a new service concept, (2) a new revenue model, (3) a new customer experience, and (3) a new service delivery system. The dimensions of service innovation are interrelated. Thus, innovation in one dimension might trigger changes in the others (cf. 2.2.2.)
- *Firm Performance*: Dynamic capabilities are seen as a source of competitive advantage, as their underlying learning mechanisms continuously create path-dependent and difficult to imitate resources and capabilities (Kosanke, 2015, p. 75; Zahra et al., 2006, p. 923; Zollo & Winter, 2002, p. 340). However, dynamic capabilities influence firm performance only indirectly by providing firms with the ability to reconfigure their resource base and to create new products, services, and processes (Schilke et al., 2018, p. 406).

The following chapter reviews the existing conceptual and empirical research on organizational capabilities in the context of service innovation. Therefore, the review provides further insights into the underlying constructs and variables of the guiding research framework, as well as their relationships.

## 3.3 Reviewing the knowledge base on service innovation capabilities

The previous chapter introduced the conceptual background and defined the guiding research framework of this thesis. This chapter is based on a systematic literature review

process and follows the approach proposed by David and Han (2004) and Newbert (2007). The goal of the systematic literature review is to provide an analysis and synthesis of prior research on organizational capabilities in the context of service innovation.

### 3.3.1 Systematic literature review process

In order to ensure a systematic identification and selection of relevant literature, an adapted version of the approach, as described by David and Han (2004, pp. 42–44) and Newbert (2007, pp. 124–126), is applied. The approach consists of the following steps and is adapted from Newbert (2007, p. 125).

1. To ensure the quality of the selected journals, only "scholarly" and peer-reviewed journals have been searched.
2. Journals were searched from the databases *Web of Science*, *EBSCOhost (Business Source Ultimate), and ProQuest (ABI/INFORM).*
3. To ensure substantive relevance, selected articles are required to contain at least one of the primary keywords – "*service innovation", "new service", "NSD", "service develop*"* – in the *title* of the article.
4. To ensure substantive relevance with regard to organizational capabilities, selected articles are required to contain the additional subject matter keyword – *"capabilit*"* – in the *title*, *abstract* or *subject terms* of the article.
5. All abstracts of articles identified by the database search are read. To ensure substantive relevance, articles with limited reference to the research topic are eliminated.
6. Finally, all remaining articles are read in their entirety for substantive context, and articles with limited connection to the research topic or insufficient depth (e.g., using the term capability rather generally without referring to the core concept) are eliminated.

The systematic search of the selected databases was conducted in January 2019 and resulted in 206 articles (109 without duplicates), which were fulfilling the requirements of steps 1 to 4. Reading the abstracts and eliminating duplicates found in several databases resulted in a sample of 50 articles. Reading all remaining articles in their entirely resulted in a final sample of 27 relevant journal articles published between 2009 and 2018, which are covering the topic of organizational capabilities in the context of service innovation. Out of the final sample, the 11 articles were published in the last three years, with six articles in 2018. This shows that the topic of organizational capabilities in the context of service innovation recently gained much scholarly attention. However, the rising number

of publications indicates that the research topic is still in its infancy and that no conclusion on the topic has been achieved.

Further information on the search results and identified articles are provided in Appendix A.

### 3.3.2 Results and synthesis

As already indicated by Gebauer et al. (2017, p. 158) in their review of organizational capabilities in the broader context of servitization, studies on service capabilities discuss multiple organizational capabilities on various hierarchical levels that are linked to different organizational routines and functions. Out of the 27 identified journal articles, 15 articles refer to dynamic capabilities as the main conceptual foundation to study service innovation capabilities. Nine articles are based on the more general resource-based view, whereas three articles refer to the competence-based or knowledge-based view. However, within the most recent studies, the dynamic capability view is the predominant conceptual foundation.

The review of the articles resulted in a comprehensive list of capabilities. However, many of the discussed capabilities refer to similar routines and activities using only different vocabulary. Therefore, the identified capabilities are clustered according to the underlying routine and categorized according to the dimensions of the guiding research framework (cf. 3.2). Capabilities or routines that refer to antecedents of service innovation capabilities are clustered accordingly and are discussed separately. The synthesis of the capabilities discussed in the literature on service innovation resulted in five capabilities and four antecedents. Furthermore, 16 categories of routines have been identified and assigned to the respective capability. Table 9 and Table 10 provide an overview of organizational capabilities, routines, and antecedents that are discussed in the context of service innovation. In the following, each service innovation capability is introduced and discussed.

#### *3.3.2.1 Internal coordination*

The first relevant routines relate to *formalized service design and development*. Kindström and Kowalkowski (2014, p. 102) find that firms need to implement dedicated new service development processes, which are compared to product development processes more flexible and iterative with extensive customer involvement. Similar, den Hertog et al. (2010, pp. 500–501) highlight that due to the intangible nature of services, the development process is different from the development process of physical products. Therefore, it requires a dedicated process, as well as a multidisciplinary project team to

conceptualize, design, and prototype new services. Jin et al. (2014, pp. 93–94) indicate that for a formalized NSD process, firms have to implement standardized and formal rules, use adequate tools such as service blueprinting, as well as document their design and development activities. Furthermore, firms have to define dedicated functions and responsibilities for their NSD activities. Firms that have implemented dedicated resources and processes for new service development are found to have a superior NSD performance (Storey & Hughes, 2013, p. 846).

*Table 9: Overview of service innovation capabilities and underlying routines*

| Capabilities | Routines | Authors |
|---|---|---|
| Internal coordination | Formalized service design and development | (Bhatnagar & Gopalaswamy, 2017; den Hertog et al., 2010; Jin et al., 2014; Parida et al., 2015; Storey & Hughes, 2013) |
| | Cross-functional collaboration | (Mennens et al., 2018; Ordanini & Parasuraman, 2011; Sharma et al., 2014) |
| | Modularization and standardization | (den Hertog et al., 2010; Kindström & Kowalkowski, 2014) |
| | Scale and roll-out | (den Hertog et al., 2010; Janssen et al., 2016) |
| External coordination | Building relationships with customers | (Agarwal & Selen, 2009, 2013; Chen et al., 2016; Jin et al., 2014; Kindström & Kowalkowski, 2014; Sharma et al., 2014; Weng & Huang, 2012) |
| | Building relationships with suppliers and external partners | (Agarwal & Selen, 2013; Bhatnagar & Gopalaswamy, 2017; Chen et al., 2016; den Hertog et al., 2010; Giannopoulou et al., 2014; Witell et al., 2017) |
| | Orchestrating of external relationships | (Ghoshal et al., 2018; Janssen et al., 2016; Kindström & Kowalkowski, 2014; Liu & Huang, 2018; Ordanini & Parasuraman, 2011; Sharma et al., 2014; Thanasopon et al., 2016) |
| Internal learning | Experimental learning | (den Hertog et al., 2010; Janssen et al., 2016) |
| | Continuous learning | (den Hertog et al., 2010; Salunke et al., 2019; Tsou & Cheng, 2018) |
| | Knowledge management | (Jin et al., 2014; Ordanini & Parasuraman, 2011; Shang et al., 2009; Sharma et al., 2014; Tang et al., 2013) |
| External learning | Customer co-development | (Giannopoulou et al., 2014; Kindström & Kowalkowski, 2014; Liu & Huang, 2018; Parida et al., 2015; Randhawa et al., 2018; Salunke et al., 2019; Tsou & Cheng, 2018) |

| Capabilities | Routines | Authors |
|---|---|---|
| | Open innovation | (Agarwal & Selen, 2013; Giannopoulou et al., 2014; Randhawa et al., 2018; Thanasopon et al., 2016; Tsou & Cheng, 2018) |
| Reconfiguration | Identifying customer needs and market opportunities | (Agarwal & Selen, 2009; Cantaleano et al., 2018; den Hertog et al., 2010; Ghoshal et al., 2018; Janssen et al., 2016; Kindström et al., 2013; Thanasopon et al., 2016; Tsai & Wang, 2017) |
| | Identifying technological opportunities | (den Hertog et al., 2010; Janssen et al., 2016; Kindström et al., 2013; Tsai & Wang, 2017) |
| | Portfolio management | (Jin et al., 2014; Kindström et al., 2013; Kindström & Kowalkowski, 2014) |

For an effective development of new services, routines and practices relating to *cross-functional collaboration* are considered as crucial. These routines and practices foster knowledge exchange between employees involved in the development activities, as well as those employees with relevant external knowledge (Ordanini & Parasuraman, 2011, p. 7). Employees with direct customer contact provide relevant external knowledge on customer problems and requirements, which can lead to new service innovations (Mennens et al., 2018, pp. 504–505; Ordanini & Parasuraman, 2011, p. 7). In addition, the relevance of processes and routines that facilitate cross-functional collaboration is further increased, as service innovation requires multidisciplinary project teams (den Hertog et al., 2010, p. 501).

Another set of routines that relate to the internal coordination of service innovation and new service development activities relates to the *standardization and modularization* of service components. As many service innovations are new configurations of existing service components, routines and processes that allow an effective bundling and unbundling of service components enable service innovation (den Hertog et al., 2010, pp. 501–502). Furthermore, as many services are developed locally in direct customer interactions, firms need to implement routines to standardize global service offerings (Kindström & Kowalkowski, 2014, p. 103).

Finally, processes and routines to scale and roll-out service innovations firm-wide and globally are also found to be an important element of internal coordination capabilities (den Hertog et al., 2010, p. 503; Janssen et al., 2016, pp. 805–806). Accordingly, firms need to implement routines to codify intangible service innovations to be able to transfer

new service concepts within the firm. Being able to scale and roll-out new services will help to provide a consistent service and brand experience (den Hertog et al., 2010, p. 503).

#### *3.3.2.2 External coordination*

Besides the capability to coordinate internal service innovation activities, external coordination with customers, suppliers, and external partners is another important service innovation capability. Especially customers and users play an important role in the service innovation process as they participate in the development and design of new services, provide relevant information on needs and requirements, and are potential users of prototypes during testing (Agarwal & Selen, 2009, p. 436). Therefore firms need to establish routines and processes that help to *build relationships to customers* and engage lead user during entire service innovation process (Chen et al., 2016, p. 58; Jin et al., 2014, pp. 94–95; Kindström & Kowalkowski, 2014, p. 103).

As many services are provided by a network of partners, firms also need to implement routines and processes to engage with external stakeholders and *build relationships with suppliers and external partners* (Chen et al., 2016, p. 58; den Hertog et al., 2010, p. 502). Additionally, external suppliers and partners provide access to relevant resources and capabilities not available to the focal firm. However, integrating suppliers and external partners might also increase the complexity of the development project (Witell et al., 2017, pp. 295–296).

To fully benefit from external relationships with customers, suppliers, and partners, firms do not only need to build relationships and engage with external stakeholders but also require routines and processes to manage and *orchestrate these external relationships* to build temporary partnerships and alliance (den Hertog et al., 2010, p. 502; Kindström & Kowalkowski, 2014, p. 104), as well as to coordinate boundary-spanning activities of the network of partners (Liu & Huang, 2018, pp. 468–469).

#### *3.3.2.3 Internal learning*

Organizational learning is an important dimension of dynamic capabilities, such as service innovation capabilities. With regard to internal learning, three different routines and processes have been identified in the literature on service innovation. Den Hertog et al. (2010, p. 501) highlights the importance of experimenting with new services and testing prototypes in practice, as intangible services cannot be tested in a lab-like setting. Accordingly, prototyping new services helps firms to capture customer feedback and learn from first-hand experiences (Bhatnagar & Gopalaswamy, 2017, pp. 385–386). Thus, routines and processes to *learn from experimentation* and prototyping foster efficiency and

effectivity of service innovation (Bhatnagar & Gopalaswamy, 2017, p. 385; den Hertog et al., 2010, p. 505). Another dimension of the internal learning capability relates to *continuous learning routines*, which allow firms to learn from past innovation projects and pilots (den Hertog et al., 2010, p. 504; Ghoshal et al., 2018, p. 140; Salunke et al., 2019, p. 146), as well as by incorporating employee suggestions into the innovation process (Tsou & Cheng, 2018, p. 987).

Finally, *knowledge management processes and routines* to manage and integrate distributed knowledge, which is required to develop new services, is another important element of the service innovation capability (cf. Jin et al., 2014, p. 94; Salunke et al., 2019, p. 147). According to Parida et al. (2015, p. 40), service innovation requires effective management of widely distributed knowledge on service offerings, customer requirements, and delivery processes. Thus, firms need to establish "formal processes and structures that facilitate the capture, analysis and synthesis of various types knowledge and the dissemination of that knowledge among different function units" (Ordanini & Parasuraman, 2011, p. 8). To foster knowledge sharing firms should codify relevant knowledge such as best practices and make it accessible, for example, via online platforms (Parida et al., 2015, p. 40). For intangible knowledge firms should facilitate employee and cross-functional collaboration (Ordanini & Parasuraman, 2011, p. 7; Tang et al., 2013, pp. 100–101) for example by integrating front-line employees into the service development process, as these employees can provide relevant knowledge on customer requirements (Ordanini & Parasuraman, 2011, p. 7).

#### *3.3.2.4 External learning*

External learning arises from joint problem solving with customers, suppliers, and partners (Tsou & Cheng, 2018). Therefore, external learning processes and routines can be categorized into two groups: *customer co-development*, as well as *supplier and partner co-development*. Learning from customers is found to be an important capability for service innovation and superior value creation (Salunke et al., 2019, p. 147). Developing new services requires a deep understanding of the customer's processes (Liu & Huang, 2018, p. 468). Accordingly, Parida et al. (2015, p. 38) indicate that "deep insights into customers' operations help to promote better customer understanding and stimulate new ideas for service innovation." Therefore, firms should foster direct and indirect customer interactions and joint innovation projects (Giannopoulou et al., 2014, p. 35; Liu & Huang, 2018, p. 468; Salunke et al., 2019, p. 147) for example by working together with lead users and early adopters (Kindström & Kowalkowski, 2014, p. 102; Parida et al., 2015, p. 38).

Liu and Huang (2018, p. 473) find that joint innovation projects of firms and their customers especially contribute to "explorative innovation."

Regarding *open innovation processes and routines*, scholars find that service innovation is often the result of external collaboration (Giannopoulou et al., 2014, p. 34) and strongly depends "on access to external information sources" (Thanasopon et al., 2016, p. 35). Therefore, firms need to establish organizational processes to promote open innovation, which supports external knowledge exchange and intellectual resource sourcing (Giannopoulou et al., 2014, p. 34). Open innovation routines are especially important during the early stages of innovation projects where the information need and the uncertainty are highest. Therefore, the early involvement of external partners is crucial for successful service innovation (Thanasopon et al., 2016, p. 35).

#### *3.3.2.5 Reconfiguration*

The reconfiguration capability deals with the strategic alignment of the organization towards the external environment (cf. 3.1.2.2). Three different sub-processes and routines have been identified during the literature review of service innovation capabilities. First, firms need *to identify customer needs and market opportunities* by implementing processes to generate customer and market intelligence systematically (den Hertog et al., 2010, p. 499; Janssen et al., 2016, p. 802; Kindström et al., 2013, p. 1067; Tsai & Wang, 2017, p. 736). Therefore, dedicated functions or roles are required (Kindström et al., 2013, p. 1067), which are most likely located in marketing, new business development, or innovation management (den Hertog et al., 2010, p. 499). By establishing such processes and functions, firms are able to identify changing market conditions and customer needs, as well as new service opportunities well in advance (den Hertog et al., 2010, pp. 499–500). Kindström et al. (2013, p. 1067) find that these insights often derive from customer co-development activities and therefore are closely related to external learning processes.

Besides identifying customer needs and market opportunities, firms also need to *identify technological opportunities* for service innovation. Especially information and communication technologies (ICT) provide opportunities to develop innovative service delivery systems, as well as new ways of interacting with customers (den Hertog et al., 2010, p. 499; Kindström et al., 2013, p. 1068). Hence, firms required dedicated functions, which are responsible for scanning technological opportunities, as well as engaging with external technology providers (den Hertog et al., 2010, p. 499).

To disseminate customer-, market- and technology-related insights and to initiate service innovation activities, firms require a strategy and *portfolio management process* (Jin et al.,

2014, p. 93; Kindström & Kowalkowski, 2014, p. 100). This process involves the definition and communication of the service innovation strategy, the selection of target markets, as well as the allocation of necessary resources (Jin et al., 2014, p. 93). Accordingly, Kindström and Kowalkowski (2014, p. 100) find that firms need to develop a portfolio management capability, which enables them to define what services to offer, as well as to develop a coherent service portfolio.

#### *3.3.2.6 Antecedents of service innovation capabilities*

This section discusses the antecedents of service innovation capabilities that have been identified in the literature review. Many scholars do not classify these organizational routines and characteristics as antecedents but describe them as part of the service innovation capabilities. However, based on the dynamic capability perspective, organizational routines, and characteristics that refer to the resource base, the organizational structure, or culture are classified as antecedents of service innovation capabilities. Table 10 provides an overview of the identified antecedents. In the following, each antecedent is introduced and discussed.sca

*Table 10: Overview of antecedents of service innovation capabilities*

| Antecedents | Routines and characteristics | Authors |
|---|---|---|
| Marketing capabilities | Customer insights and market knowledge | (Kindström & Kowalkowski, 2014; Parida et al., 2015; Randhawa et al., 2018) |
| Technological capabilities | General technological capability | (Bhatnagar & Gopalaswamy, 2017; Randhawa et al., 2018) |
| | IT capability | (Kroh et al., 2018; Thanasopon et al., 2016; Tsou & Cheng, 2018) |
| | Digitalization capability | (Parida et al., 2015) |
| Organizational culture | Entrepreneurial culture | (Cantaleano et al., 2018; Salunke et al., 2019; Storey & Hughes, 2013; Tsou & Cheng, 2018) |
| | Customer orientation | (Grawe et al., 2009; Ordanini & Parasuraman, 2011) |
| | Leadership | (Bhatnagar & Gopalaswamy, 2017; Kindström & Kowalkowski, 2014; Sharma et al., 2014) |

Dynamic capabilities operate upon the firm's existing tangible and intangible resources (Helfat & Peteraf, 2009, p. 97). In the literature review, marketing and technological capabilities are identified as two antecedents of service innovation capabilities, which refer

to the existing resource base. With regard to *marketing capabilities*, firms require comprehensive knowledge about customer-specific processes and customer needs to develop new services (Kindström & Kowalkowski, 2014, p. 101; Parida et al., 2015, pp. 37–38). Parida et al. (2015, p. 38) indicate that "deep insights into customers' operations help promote better customer understanding and stimulate new ideas for service innovation."

The literature on *technological capabilities* for service innovation mainly refers to three sub-capabilities: (1) general technological capability, (2) IT capability, and (3) digitalization capability. The general technological capability describes the "firm's technological expertise and its ability to put it to effective use for developing services innovations" (Bhatnagar & Gopalaswamy, 2017, p. 392). Technological knowledge is particularly important for developing adequate service delivery systems (cf. Randhawa et al., 2018, p. 823). A more specific sub-technological capability refers to the use of information technology in service innovation. Kroh et al. (2018, p. 720) find that the intensive use of IT fosters internal and external information exchange, which increases market knowledge and innovation performance. Thus, an IT capability enhances the processing of relevant internal and external information, which has a positive effect on service innovation (Tsou & Cheng, 2018, p. 987). Finally, digitalization capability refers to the use of "smart and connected physical products" to promote service innovation. Product condition and customer usage data, as well as real-time data analytics, provide extensive opportunities for developing new services (Parida et al., 2015, pp. 41–42).

Several scholars analyze and discuss the role of the *organizational culture* in the context of service innovation. Organizational culture describes shared values and beliefs of firms employees (Deshpande & Webster, 1989, p. 4). Salunke et al. (2019, pp. 151–152) show that an entrepreneurial culture positively affects internal and external organizational learning and is an important driver of service innovation. They operationalize entrepreneurial culture in terms of innovativeness, proactiveness, risk-taking, and adaptiveness (Salunke et al., 2019, p. 146). Storey and Hughes (2013, p. 836) differentiate between externally-oriented entrepreneurial culture and internally-oriented learning culture. The authors show that entrepreneurial culture drives the quantity of NSD (Storey & Hughes, 2013, p. 846). Tsou and Cheng (2018, p. 988) indicate that an entrepreneurial culture (they term it entrepreneurial alertness) facilitates a firm's ability to identify and explore market opportunities for service innovation. Similar to the externally-oriented entrepreneurial culture, customer orientation as a form of organizational culture is another driver of service innovation (Grawe et al., 2009, p. 285). Ordanini and Parasuraman (2011, p. 17) find evidence that customer orientation fosters radical innovation; however, it is not

associated with the extent of innovation activities. Finally, leadership is important to establish and facilitate an entrepreneurial and service-oriented culture (Bhatnagar & Gopalaswamy, 2017, p. 388; Kindström & Kowalkowski, 2014, p. 105). Furthermore, it is required to drive organizational change and to establish an adequate organizational setting for service innovation (Kindström & Kowalkowski, 2014, p. 105).

## 3.4 Summary and implications

The understanding of the organizational antecedents of service innovation outcomes is still limited (Janssen et al., 2016, p. 808; Ostrom et al., 2010, p. 15). Therefore, research has started to examine organizational routines, processes, and structures of the service innovation process by adopting an organizational capability perspective (Ghoshal et al., 2018, pp. 129–130). The previous section has provided a systematic review of this research. It has revealed that existing literature on service innovation discusses various capabilities and routines across different organizational functions and hierarchical levels. Thus, the firm's service innovation capability can be considered as a higher-level and multi-dimensional capability, which integrates lower-level capabilities and routines (cf. Grant, 1996, p. 378; cf. Menor & Roth, 2007, pp. 826–827) Furthermore, the review indicates that these capabilities and routines can be associated with the underlying three core processes as conceptualized and described by the guiding research framework. Accordingly, it is found that the dynamic capability view provides an adequate theoretical perspective to investigate organizational antecedents of service innovation (cf. Janssen et al., 2016, p. 798) and to understand better what enables the successful development of new services.

Additionally, the review provides first insights into relevant routines and processes that constitute the multi-dimensional service innovation capability. It indicates that service innovation requires adequate processes and structures to manage and coordinate internal and external collaborations between cross-functional teams, customers and partners, to acquire and share customer- and market-related knowledge, as well as to identify, leverage, and respond to strategic opportunities for service innovation. Furthermore, the capacity to develop new services is affected positively by firms' existing technological and marketing-related capabilities, as well as by an entrepreneurial and customer-oriented organizational culture.

Despite providing relevant insights and direction to examine the specific manifestation of organizational routines and practices for digital service innovation, existing research has several limitations and shortcomings. Most scholars rather focus on specific dimensions

and sub-capabilities such as organizational learning and knowledge management (Carbonell & Rodriguez-Escudero, 2014; Mennens et al., 2018; Salunke et al., 2019; Tsou & Cheng, 2018), or external coordination and integration (Agarwal & Selen, 2009; Liu & Huang, 2018; Ordanini & Parasuraman, 2011). However, only a limited number of studies offer a holistic perspective on service innovation capabilities and their interrelations (Bhatnagar & Gopalaswamy, 2017; den Hertog et al., 2010; Jin et al., 2014; Kindström & Kowalkowski, 2014), while den Hertog et al. (2010) and Jin et al. (2014) develop a conceptual framework and do not derive their findings from empirical evidence.

With regard to the research approach, it is found that the majority of studies are based on surveys and quantitative research methods. 16 articles are based on quantitative approaches, eight articles follow a case study approach, and three articles develop a conceptual model. A recent systematic literature review on the topic of service innovation and new service development (NSD) finds that due to the strong reliance on quantitative research approaches, the research field has failed to provide consistent insights on "how to most effectively manage the NSD process" (Biemans et al., 2016, p. 382). Accordingly, the authors state that "the NSD domain would benefit from a shift in research approaches from the ubiquitous quantitative, large-sample survey to more exploratory, fine-grained qualitative research approach, such as in-depth cases research […]" (Biemans et al., 2016, pp. 395–396).

Furthermore, it is found that the majority of articles focus on pure service industries such as financial, telecommunication, or healthcare services. Only a limited number of articles deal with service innovation capabilities in the context of servitization and manufacturing industries, while none of the reviewed articles refers to service innovation in the medical technology industry. In general, service innovation research has strongly relied on insights from financial services (Salunke et al., 2019, p. 144). Therefore, recent research has called for broadening the empirical context of service innovation to other industries (Biemans et al., 2016, p. 395).

Finally, none of the reviewed studies examines organizational capabilities for digital and data-driven service innovation. However, organizational capabilities might differ regarding the type of service (Ulaga & Reinartz, 2011, p. 6). Accordingly, Mennens et al. (2018, p. 514) state that "it is possible that drivers of service innovation performance are not identical across different types of service innovation, a point that warrants further investigation."

Thus, current research does not provide a holistic and in-depth perspective on service innovation capabilities, their underlying routines, and processes, as well as their

interrelations. This dissertation intends to address the identified research gap by studying organizational routines, processes, and structures of medical technology firms in the context of digital and data-driven service innovation. Therefore, this study applies an inductive, multiple case study approach, which is guided and structured according to the guiding research framework. In addition, the results of the literature review provide a first understanding of the research topic, which helps to structure and direct the research process. Nevertheless, these results are not tested in terms of hypotheses, as the thesis aims to uncover empirical insights, as well as interdependencies of relevant variables and constructs that are not described in the literature yet. Furthermore, by focusing on organizational routines, processes, and structures, the study will provide managerial and organizational levers to manage digital service innovation. Accordingly, it aims to address Biemans et al. (2016, p. 382) finding that current research "fails to provide managers with consistent answers to basic questions about how to most effectively manage NSD processes."

# 4 Empirical research

The previous chapter has introduced the conceptual background and guiding research framework of this research project. To better understand how medical technology firms can foster their innovation capabilities for digital services, the manifestation and interplay of various organizational antecedents and processes have to be investigated. As digital services are an emerging topic with a limited knowledge-base, as well as due to the complex nature of organizational capabilities, a multiple in-depth case study approach is adopted. The following chapters present the empirical findings of the thesis. Chapter 4.1 introduces the research design and methodology, including data collection and analysis, as well as the applied measures to ensure the reliability and validity of the case study approach. Chapter 4.2 to 4.5 provide the within-case analyses of four medical technology firms. The cross-case analysis will be presented in the following chapter 5.

## 4.1 Case study methodology

The selection of an adequate research methodology is crucial for sound empirical research (Eisenhardt & Graebner, 2007, p. 26). According to Yin (2018, p. 9), the type of research questions to be answered, as well as the state of research, are two important factors that determine the suitability of a research method. Empirical research that aims to answer "how" and "why" research questions on a contemporary and unexplored topic are most suitable for case study research (Eisenhardt & Graebner, 2007, p. 26; Yin, 2018, p. 13). Thus, Eisenhardt (1989, p. 548) highlights that "case study research is most appropriate in the early stages of research on a topic." Furthermore, research on contemporary topics that are in an emergent stage of knowledge development calls for an inductive research approach that builds theory from the interpretation of individual observations (Tomczack, 1992, p. 77). Therefore, an inductive case study approach allows deriving a "relatively full understanding of the nature and complexity of the complete phenomenon" (Voss et al., 2002, p. 197). Yin (2018, p. 9) differentiates between descriptive, explanatory, and explorative case studies. While descriptive case studies focus on a detailed description of the phenomenon, explanatory studies investigate the causal relationships between variables (Saunders et al., 2007, p. 134). However, explorative case studies are valuable for emerging topics with limited prior knowledge and have the objective "to develop pertinent hypotheses and propositions for further inquiry" (Yin, 2018, p. 10). Following Yin (2018, pp. 10–11), the form of research question calls for different types of case studies. Exploratory case studies rather aim to answer "what", whereas as explanatory studies are more suitable to answer "how" questions.

The literature review and identified research gaps have illustrated that current research does not provide an adequate understanding of how the hybrid nature of digital services affects the innovation and development practices of medical technology firms. Additionally, digital service innovation is an emerging research topic, and little is known about the organizational prerequisite for developing digital services. Therefore, an inductive and exploratory case study approach is seen as a suitable research methodology to answer the research questions of this thesis. However, this research does not only intend to provide propositions for further research but also aims to analyze the relationship and underlying mechanism of identified organizational routines to identify managerial and organizational levers to facilitate digital services innovation. Thus, this research also involves explanatory elements.

This research project follows the case study methodology as proposed and described by Yin (2018). Accordingly, it adopts a theory-guided case study approach. Compared to Eisenhardt (1989, p. 536), who state that "theory-building research is begun as close as possible to the ideal of no theory under consideration and no hypotheses to test", Yin (2018, p. 15) finds that case studies "benefit from the prior development of theoretical propositions to guide design, data collection and analysis […]". These theoretical propositions can be found in the guiding research framework (cf. 3.2) which synthesizes relevant theoretical propositions derived from prior research on organizational capabilities and service innovation.

### 4.1.1 Case selection

Eisenhardt (1989, p. 537) suggests that theoretical considerations instead of statistical criteria should drive case selection. Therefore, this dissertation follows an information-oriented and theoretical sampling strategy to identify capabilities and antecedents of digital service innovation in medical technology firms. According to Eisenhardt and Graebner (2007, p. 27), theoretical sampling means "that cases are selected because they are particularly suitable for illuminating and extending relationships and logic among constructs." Therefore, theoretical sampling has not the ambition to select samples that represent a certain population. The objective is rather to choose cases that provided the required insights to extend and replicate emergent theory (Eisenhardt, 1989, p. 527). A relevant approach of theoretical sampling is the selection of so-called "polar types", where substantial variations in the cases (e.g., low and high performing firms) allow the identification and explanation of underlying patterns and relationships (Eisenhardt & Graebner, 2007, p. 27). Finally, Eisenhardt (1989, p. 545) suggests that four to ten cases should be selected to derive sufficient empirical insights and build theory. With less than

four cases, the empirical grounding might be weak, while above ten cases, it might be difficult to manage the volume and complexity of the collected data.

The selected cases vary across multiple dimensions and constructs. First, the selected firms develop and manufacture medical technologies that address different market segments. Furthermore, they follow different service strategies, which results in the development of different types of digital services. Moreover, the case firms use different organizational structures and processes to develop digital services. Accordingly, it can be assumed that differences in the organizational characteristics will facilitate the identification of capabilities and antecedents that enable digital service innovation.

In total, four medical technology firms have been selected. The firms are all headquartered in Germany and Switzerland, which reduces extraneous effects due to cultural differences, which might influence the innovation routine and practices of the firms. Additionally, by focusing on a single industry, the internal validity of the research findings is increased. Table 11 provides an overview of the selected cases.

*Table 11: Case overview*

| | **Alpha** | **Beta** | **Gamma** | **Delta** |
|---|---|---|---|---|
| **Segment** | Drug delivery devices | Medical consumables | Respiratory equipment | Ophthalmic systems |
| **Type of digital service** | E-health and digital health services | Digital supply chain solutions | Product enabling and augmenting digital services | Product enabling and augmenting digital services |
| **Target groups** | Healthcare professionals and patients | Healthcare professionals | Healthcare professionals | Healthcare professionals |
| **Unit of analysis** | Business unit | Company | Company | Company |
| **Employees** | > 100 | > 350 | > 350 | > 250 |

### 4.1.2 Data collection

To increase the validity and substantiation of the constructs, the data collection for case study research followed the principle of triangulation (Eisenhardt, 1989, p. 537). Therefore, multiple data sources were used to gain comprehensive insights into the routines and processes for developing digital services, as well as the organizational setup of the case companies. The primary data sources of the case studies are semi-structured

interviews with senior managers that are directly involved in the firm's innovation activities. To limit the bias from individual impressions and retrospective sensemaking, Eisenhardt and Graebner (Eisenhardt & Graebner, 2007, p. 28) suggest involving multiple informants across hierarchical levels and functional units that are able to provide multiple perspectives on the focal topic. Therefore, the case studies involved interview partners from research and development, product management, marketing, digital solutions, and top management. Furthermore, the insights generated by the interviews were triangulated by additional internal and external information. First, case company Alpha, Gamma, and Delta participated in a consortia research project on digital service innovation that took place between November 2017 and December 2018. The research project involved multiple workshops and interviews with various organizational members. Second, all case companies participated in a quantitative industry study that was conducted between January and May 2019 and published together with the strategy consultancy Roland Berger (cf. Friedli et al., 2019). Finally, publicly available information on the internet and company reports were reviewed. Accordingly, this internal and external information extended the insights generated by personal interviews.

The data collection for each case study was based on semi-structured interviews. To enable a structured and comprehensive data collection, as well as to ensure a consistent data collection, an interview guideline was developed (see Appendix B). The interview guideline was structured according to the guiding research framework (cf. 3.2). It was made sure that for each dimension of the research framework, at least one question was included in the interview guideline. Accordingly, the guideline was structured into nine sections: (1) provide a short introduction to the research project, (2) understand the strategic relevance of digital services, (3) and the organizational structure to develop digital services, (4) gain insights into existing capabilities and resources that are leveraged for digital service innovation, and (5) new capabilities and resources that had to be acquired, (6) understand the innovation process for developing digital services, (7) as well as the strategy process to initiate innovation activities, (8) reflect the role of the organizational culture, (9) understand organizational barriers that constraint digital services innovation. The interview guideline and additional information on the purpose of the research project were sent to the interview partners beforehand.

The eight interviews took place between March and April 2019 and were conducted mainly in-person and on-site, as well as lasting between 45 and 90 minutes. Each interview was recorded and afterward transcribed for in-depth analysis. Table 12 provides an overview of the interview partners, their function, as well as further details.

*Table 12: Overview of interview partners*

| Case | Function | Code | Duration (in min) | Type of interview | Interview transcript |
|---|---|---|---|---|---|
| Alpha | Director Digital Solutions | A1 | 90 | Personal | yes |
| Alpha | Head of Digital Healthcare | A2 | 77 | Personal | yes |
| Beta | CEO | B1 | 51 | Personal | yes |
| Beta | Head of Digital Services | B2 | 45 | Phone | yes |
| Gamma | Director of Research and Development | C1 | 59 | Personal | yes |
| Gamma | Head of Product Management | C2 | 53 | Personal | yes |
| Delta | Head of Marketing and Sales | D1 | 71 | Personal | yes |
| Delta | Head of Research and Development | D2 | 59 | Personal | yes |

### 4.1.3 Data analysis

This dissertation applied a qualitative content analysis according to Mayring (2010a). The qualitative content analysis enables a theory-guided analysis of rich-information and large volume content. Accordingly, it allows a structured analysis and condensation of complex information (Mayring, 2010b, p. 601). Central to the qualitative content analysis, as proposed by Mayring (2010a), is the development of a categorization system, which is used to identify and highlight relevant text passages. Categorization systems can be developed inductively or deductively depending on the type and objective of the research study (Kosanke, 2015, p. 151). As this study follows and theory-guided case study approach (cf. 4.1), the categorization system for the content analysis was derived deductively and is based on the guiding research framework. Therefore, the first-order categories represent the dimensions of the guiding research framework. However, second-order categories were derived inductively using a thematic coding approach, which "is a form of pattern recognition within the data, where emerging themes become the categories of analysis" (Fereday & Muir-Cochrane, 2006, p. 82). Accordingly, this study used a hybrid approach of data analysis that combines a "deductive thematic analysis while allowing themes to emerge direct from the data using inductive coding" (Fereday & Muir-Cochrane, 2006, p. 83). To analyze the transcripts of the interviews and to extract relevant themes, patterns, and relationships, the software Atlas.ti was used.

The data were analyzed following Eisenhardt (1989) using a two-step approach of within-case analyses and cross-case analysis. First, a within-case analysis enables researchers to become familiar with each case and to identify individual patterns before these are

generalized across cases (Eisenhardt, 1989, p. 540). Therefore, for each case study, an individual case report was written (see 4.2-4.5). The case reports are structured according to the main dimensions of the guiding research framework. Accordingly, they provide relevant (1) background information and illustrate the strategic relevance of digital services for the company, (2) discuss the underlying routines and practices of innovation capabilities, (3) as well as organizational antecedents of digital service innovation. (4) Finally, the findings of each case report are summarized in a table, which provides an overview of the identified routines and practices for digital service innovation.

Second, to identify patterns across individual cases, a cross-case analysis was conducted (see chapter 5). The cross-case analysis examines similarities and differences across cases in order to deepen the understanding and explanation of the emerging themes (M. B. Miles et al., 2014). To provide supporting evidence for the emerging themes, both within-case and cross-case analysis display direct quotes from the interview partners (cf. Eisenhardt & Graebner, 2007, p. 29). The direct quotations from the interview partners have been translated and are referenced by a code and the corresponding number of the quote. For example, “A1, 89” refers to the quote 89 of the first interview partner of case A (for all codes of the interview partners, see Table 12).

### 4.1.4 Validity and reliability

Case studies provide rich insights into real-life settings where the context of the study cannot be controlled entirely and where “many more variables of interest than data points” are available (Yin, 2009, p. 18). Accordingly, case studies are often criticized for their limited rigor (Gibbert & Ruigrok, 2010, p. 710). In order to demonstrate rigor and credibility, case studies have to meet certain reliability and validity standards. In general, four criteria are suggested to enable rigor case study research: (1) construct validity, (2) internal validity, (3) external validity, and (4) reliability (Gibbert & Ruigrok, 2010, p. 712; Yin, 2009, p. 24).

First, construct validity refers “to the extent to which a procedure leads to an accurate observation of reality” (Gibbert & Ruigrok, 2010, p. 712). Yin (2009) suggest to use different sources of evidence and to establish a chain of evidence. Accordingly, the insights should be derived from various data sources, and the data collection and analysis procedures should be made transparent. The insights of this study were derived from interviewing multiple informants, as well as using different internal and external information, which enables triangulation of the generated findings. According to Gibbert and Ruigrok (2010, p. 713), triangulation is the most important measure to ensure construct validity in case study research.

Second, internal validity describes "the presence of causal relationships between variables and results" (Gibbert & Ruigrok, 2010, p. 713). Internally validity is supported by using a guiding research framework that is derived from the literature and which demonstrates theoretically valid relationships between the variables investigated (Gibbert & Ruigrok, 2010, p. 713). Therefore, this study followed a theory-guided case study approach, which was based on a guiding research framework (cf. 3.2). Moreover, the internal validity of the findings is further increased by focusing on a single industry (cf. Simpson & Kohers, 2002, p. 99).

Third, external validity in the context of case study research refers to the generalizability of research findings (Yin, 2009, pp. 43–44). Eisenhardt (1989, p. 545) suggests conducting multiple cases to generate sufficient empirical evidence to generalize the research findings and to build theory. Additionally, researchers should make the case selection transparent and provide sufficient information on the context of the case companies to enable the reader to comprehend the sampling (Gibbert & Ruigrok, 2010, p. 715). Therefore, chapter 4.1.1 provides the rationales of the case selection, as well as relevant context information of the case companies.

Finally, reliability refers to the replicability of a study. Therefore, it is suggested to provide detailed documentation of the case study and the underlying protocol (Yin, 2009, p. 45). Researchers should record and transcribe personal interviews, as well as organize the data in a case study database to enables other researchers to replicate the findings (Gibbert & Ruigrok, 2010, p. 715). As described in chapter 4.1.2 and 4.1.3, all interviews have been recorded and transcribed, as well as stored in a case study database using Atlas.ti. In order to further increase the reliability of the study, the case study reports also include direct quotations that underline key findings (cf. Gibbert & Ruigrok, 2010, p. 715).

## 4.2 Case Alpha

### 4.2.1 Background information

Alpha is the medical device unit of a global technology and healthcare company and is located in Switzerland. The unit has about 100 employees, who are responsible for the development, deployment, and customer support of drug delivery devices and accompanying services. Alpha is a sub-unit of the pharmaceutical business unit (BU) and provides automated self-medication devices and related digital services to different therapeutic areas, which are organized in so-called Global Business Franchises (GBF). Thus, it acts as an internal service provider to enable the different GBFs to provide comprehensive treatment solutions in combination with their pharmaceutical drugs. The

drug delivery devices of Alpha are mainly used by patients with chronic conditions, whereas the provided digital services also address healthcare providers and health insurances that aim to monitor and improve patient adherence and compliance.

#### *4.2.1.1 Strategic relevance of digital services*

Connected drug delivery devices and related digital services have already gained considerable strategic importance for Alpha, as standard *"drug delivery and injection monitoring products are almost commodities"* (A1, 1). Furthermore, Alpha's direct customers, the therapeutic areas, are increasingly demanding connected devices and digital services, as they want to differentiate their pharmaceutical drugs with value-adding services. Thus, to stay competitive and respond to the increasing demand for digital services, Alpha has built "digital capabilities" into their products, which allow the collection of patient-related injection data. Accordingly, Alpha provides digital services mainly to differentiate their products from competitors and to increase customer retention. Generating additional revenue streams by digital services is currently not seen as a strategic priority.

Alpha expects that the strategic importance of digital service will further increase in the future, as the therapeutic areas are increasingly demanding more complex and comprehensive digital services. The increasing complexity will result in the need to enter into strategic partnerships with providers of digital platforms, which enables access to relevant capabilities. Accordingly, the interview partner assumes that in future, *"the entire digital value creation will not be created by the medical technology unit itself, but rather provided in an ecosystem [of strategic partners]"* (A1, 7).

### 4.2.2 Innovation capabilities

#### *4.2.2.1 Reconfiguration routines and practices*

Ideas for new digital services are either identified by Alpha or by the GBFs. Alpha and the GBFs do not follow a pre-defined and structured process for identifying new opportunities in the field of digital services. However, some GBFs have created dedicated functions that are responsible for identifying new opportunities and formulating the digital service strategy. By creating such a function, the respective GBFs have been able to put more focus on the topic, which resulted in a better understanding of future opportunities: *"In our case, there is a respective person in the steering committee, which takes care of the topic. […] We have a real pipeline actually. I would not call it a roadmap, because it is not really clear when we will develop what. Nevertheless, we have an overview of all*

*digital services, which will become relevant in our specific therapeutic area within the next five years"* (A1, 89). Additionally, there have been first initiatives to create an overarching function, which stimulates and drives service innovation for all therapeutic areas. Nevertheless, it is found that this dedicated function requires a deep customer and market knowledge to be able to identify new opportunities: *"It is my observation that one needs deep customer and market insights of a therapeutic area to be able to make reasonable propositions how such a portfolio, or how such digital services could look like"* (A1, 91).

Another challenge besides missing customer and market knowledge for scouting and identifying new opportunities relates to a missing relevance of digital services for today's business activities. In the short- and midterm, medical device-related digital services will not be able to contribute relevant revenues compared to the pharmaceutical drugs. Therefore, only limited attention is paid to a systematic scouting of digital services: *"[…] it [digital services] will stay peripheral and maybe only has positive effects indirectly on the profitability of the portfolio. That is why there is currently no continuous scouting for doing new things"* (A1, 87).

As the identification of new digital services is mainly driven by personal initiative of certain employees, but not anchored in the corporate strategy and the strategic principles of the therapeutic areas, Alpha and the GBFs struggled to turn ideas and opportunities into actual development roadmaps: *"Even when ideas were existing. They were at a far too high level and have never been broken down into roadmaps"* (A2, 75). Thus, due to missing routines and processes, the transition from the fuzzy front-end of the innovation process into actual development projects is perceived as very vague: *"And before this development process starts and the early scouting, there is a relatively vague transition"* (A1, 82). However, transferring ideas and opportunities into pipelines and development roadmaps is seen as an important factor for the strategic management of digital service innovation: *"One tried various things [to identify ideas]. However, this was not connected to a longer-term pipeline. There was no long-term pipeline. […] besides on a high-level, it was not clear how things should develop"* (A2, 74).

#### *4.2.2.2 Coordination routines and practices*

***Internal coordination***

A major challenge for Alpha as an internal solution provider is that the unit has no direct access to the end-users of the services. Accordingly, Alpha has only limited knowledge about service-specific user needs and requirements. Relevant knowledge regarding user needs is located within the GBFs and the sales organizations, as well as within other units

of the pharmaceutical BU, such as medical affairs. To improve the internal communication and coordination during development projects, Alpha has established so-called Global Project Teams, which include all relevant stakeholders from product management, engineering, and the Global Business Franchise. These GPTs help to facilitate internal communication and coordination. Furthermore, a well-structured Stage-Gate process with defined gate reviews was introduced to review earlier and more regularly the progress and fulfillment of project objectives. By introducing a structured Stage-Gate process and having defined gate reviews with all relevant project stakeholders, Alpha was able to improve internal communication and coordination further: *"As a result, there was an improvement that they do not develop certain things for two years, and in the end, the customer [the GBF] says: 'No, I do not need that. […] I will also not use it'"* (A1, 35).

Drug delivery devices and digital services are developed according to a linear and sequential waterfall model. This process is compliant with common medical device regulations and medical device quality management systems such as ISO 13485. Due to the strict regulatory requirements of medical devices, Alpha has established only one development process for hardware and software components. Accordingly, no dedicated development process for digital services is applied. As a result, the development of new digital services mainly focuses on the technical components. Service components such as the service concept or the user experience are not regarded as a distinct "design object": "*That we think about the service as a 'Design Object' - this is missing, and this results in various challenges. First of all, with regard to the development process, but furthermore, that the market does not accept the service, as it has not been sufficiently specified and tested"* (A1, 115).

Today, Alpha develops services only indirectly within the software and hardware development: *"Services are not developed as services, respectively are not thought as services from the beginning. With the vague idea of the services, it is asked, 'what do I need to develop such a service' – that is a software and hardware which is required. However, the service itself is developed in parallel to the development process. Somehow alongside to development of the technical components – the software and hardware – it is started to think about the services and to discuss it with 'key though leaders' and 'pilot customers'* (A1, 84).

Nevertheless, it is found that service components have a direct impact on the technical components. Defining or changing specifications of service components during later stages of the development process, will require changes in the technical components, which will result in increased development costs and prolonged development cycles: *"[…]*

*with regard to the 'injection platform' you have the question: 'which data should I display to the patient and which data should I actually display to the physician?'. And instead of thinking about this prior to the development, as it influences the technical system, one starts to think about it during the development. However, when it is done that late, it will create further requests to change the specifications, which will slow down the process and increase costs"* (A1, 85).

Due to the interdependencies between service design, software, and hardware engineering, Alpha sees the necessity to develop service, software, and hardware as an integrated system. However, integrating these design and development activities is challenging, as the development cycles are substantially different: *"[...] hardware and software development are very, very different, work very, very differently. [...] For hardware, you have completely different development cycles compared to software. It is the way how fast you can build a prototype and test something, which is much more difficult for hardware compared to software"* (A2, 10). Accordingly, Alpha still struggles to integrate hardware and software engineering for the development of digital services. Software and hardware are currently developed in two streams with separate responsibilities and incentives. However, the integration of hardware and software engineering is not only difficult, due to functional principles, but also due to missing responsibilities for the integrated development: *"I believe it is indeed the lack of a function or someone who integrates. [...] They got objectives to focus on their particular tasks, but the task to consider the system had nobody. Insofar it is an organizational question: 'who is responsible for the integral system?'"* (A1, 1:27).

Furthermore, Alpha has also realized that the linear and sequential waterfall model is only of limited applicability for digital services: *"Because you have to be much more responsive. You launch the first version and realize that all your good ideas do not work, but something else works. Thus, you turn completely. However, that does not work with the [existing] process. Here you have to go back multiple steps to the beginning"* (A2, 67). However, due to the regulatory requirements regarding the traceability of requirements, as well as the strict design controls of medical devices, Alpha has failed to introduce an iterative and incremental development process: *"Well, there was an attempt to do it in 'agile'. However, it was not successful in shifting the development to 'agile'. [...] But what is now missing is the continuous testing of prototypes"* (A1, 81).

***External coordination***

Alpha develops substantial parts of their medical devices and digital services in collaboration with external suppliers. To be able to integrate the different hardware and

software components into a comprehensive digital service, Alpha had to build up relevant knowledge on these technical components internally. Without relevant knowledge of the different software and hardware components, managing and integrating external suppliers is found to be difficult: *"In the past, this was the main problem, that even when we let do something [externally], we had internally not the competencies to evaluate if it is OK what they have done"* (A1, 117).

In the context of digital services, a new model for collaboration with external partners emerged. Traditionally external partners were mainly service providers who delivered a software component according to the specification of Alpha. Recently, the firm started to collaborate with external partners, who provide substantial elements of the digital services as "Software as a Service" or "Platform as a Service". Therefore, these solutions are already existing and are only customized and extended to the specific needs of Alpha. With the new collaboration model, external suppliers become increasingly strategic partners, as the dependencies increase: *"That is quite a close partnership, as one designs the platform collaboratively. Furthermore, one is tied to the platform provider during operations, because one cannot easily transfer it […] to other platforms"* (A1, 69).

Due to the increasing delivery risks and dependencies to external partners, Alpha realized that working intensively with external partners requires adequate processes for selecting and steering these partners: *"If you work with many externals you need someone, who is able to steer all the externals partners, […] else they will steer you"* (A2, 55). Therefore, Alpha sees the need to establish a kind of organizational function, which goes beyond a procurement function that only manages the request for proposal and the operative aspects of the partnership and service provision. With the increasing relevance of strategic partnerships, as well as increasing dependencies regarding the development and operation of digital services, firms need to establish a strategic management of these partnerships and assess future scenarios on the value creation and their role within the ecosystem: *"You have to consider how the ecosystem will look alike. […] Who is required to join in, and which part of the value creation, you as Alpha want to keep internally, and which part is provided by others"* (A2, 52).

#### *4.2.2.3 Learning routines and practices*

***External learning***

Alpha has mainly built technological knowledge to develop digital services by hiring engineers, such as system architects and user experience engineers. These engineers came mainly from outside the medical technology and healthcare industry. Hence, relevant customer and market knowledge were not systematically built up: *"Regarding customer*

*insights, especially Alpha has built barely anything"* (A1, 56). Accordingly, missing customer knowledge and insights are a major barrier for developing digital services successfully: *"We are consistently missing sufficient knowledge and insights, what the customer really needs, respectively how the customer would actually use certain things. As a result, one has a vague specification, also partly for the technical system"* (A1, 114).

The missing customer knowledge results in a certain degree of uncertainty and ambiguity about the customer needs and the design problem. To build relevant customer insights, Alpha considers prototyping and user tests as an important instrument to generate relevant knowledge: *"How can I better get to the customer value or generate a better understanding of customers? […] that is that the engineers of the product speak more frequently with customers, conduct more frequent user tests. Thus, are testing prototypes beyond human factor studies, which are required to get the regulatory approval"* (A1, 36). Currently, Alpha mainly tests prototypes and early versions of the digital service during human factor studies and pilot phases, shortly before introduction to the market. However, at this stage, comprehensive changes are not possible or very expensive. Therefore, early tests, e.g., by paper or visual prototypes, are seen as appropriate tools to decrease ambiguity and uncertainty about the customer needs: *"How does an injection procedure works when I combine software [digital service] and hardware? And instead of doing this very early, maybe also by paper prototypes, it was combined fare to late during a later stage, and of course resulted in many surprises"* (A1, 24).

Additionally, it is also highlighted that prototyping is not only important to validate design outputs, but also to generate design inputs and user requirements: *"You have to do requirement engineering with them [the customers]. You also have to provide them with prototypes very early […] and then listen to them what they have to say"* (A2, 57).

However, testing prototypes early and continuously during the development of digital services is more difficult when following a linear and sequential development process, such as a waterfall model. Therefore, an iterative and incremental design approach is considered as more appropriate for developing digital services, as it allows continuous deployment of prototypes and early product versions, which facilitates the generation of customer insights and external learning. When Alpha was developing a search engine for medical publications, it was following an iterative and incremental approach: *"They did short sprints, they always launched something new. […] the first version was crude – looked nice, but the second version was able to do more, and the third version again more. This was mainly below the surface, but you did see what is used"* (A2, 70).

Besides testing prototypes and using an iterative and incremental development process, external learning is also facilitated by integrating key customers and users into the development process. Integration of customer can be done either by directly visiting and discussing strategic aspects with "Key Accounts" and "Thought Leaders", or by setting up "Advisory Boards" or "Focus Groups". So far, joint development or co-development of digital services with key customers was not conducted by Alpha. However, it is considered as a relevant approach to generate customer and user insights: *"I think you have to work with people [customers] relatively early in certain 'beta programs' – maybe even collaborate with a hospitals, so that you say: 'let us develop something together that really helps you, that really helps you as physician but also the patients'"* (A2, 58).

***Internal learning***

Testing prototypes does not only facilitate external learning but is also found to be important for internal learning. Customer knowledge is often implicit and resides within certain team members, which makes it difficult to transfer. However, by systematically testing prototypes and by documenting these tests and its results, customer knowledge becomes explicit and codified: *"However, when I am not testing prototypes, […] then obviously nothing is documented how respective customers are reacting on certain things. Thus, many things stay vague and in the minds of certain employees who took care of a project for some time"* (A1, 44). Accordingly, testing prototypes promotes knowledge management, which enables internal learning. Besides, fostering codification and knowledge management, prototyping also helps to make intangible service concepts more tangible and easier to evaluate at an early stage: *"How does an injection procedure works when I combine software [digital service] and hardware? And instead of doing this very early, maybe also by paper prototypes, it was combined fare to late during a later stage, and of course resulted in many surprises"* (A1, 24).

Furthermore, the experiences of Alpha also indicate that internal learning is not only facilitated by prototyping new digital services, but also by regularly reviewing development activities and results internally. By introducing a strict Stage-Gate Process, Alpha was able to improve internal learning: *"Well, what was done, […] was the introduction of a strict Stage-Gate process to evaluate much earlier and more frequently that one is on the right path to developing a product with customer value"* (A1, 34).

Another aspect that relates to internal learning is the sharing of distributed information and knowledge within the firm. Due to the organizational setup of Alpha as an internal solution provider with only limited access to end-users, access to relevant customer information is complicated. Accordingly, missing communication channels are considered as a major

barrier for transferring relevant information to the development team: *"It would be so important that they [Medical Affairs and Sales] feed things [information] back. However, it is not envisaged. There are no channels that this happens more or less automatically or when passing by"* (A1, 51). Additionally, organizational distance is another aspect, which complicates the exchange of relevant knowledge, as well as internal learning: *"There is a knowledge within the Franchises. However, it is easily possible that due to certain staff rotations, the knowledge is still somewhere in the organization but not where you need it for a specific project. […] it is still there, but the knowledge dilutes more and more and becomes very vague until it is not practically usable"* (A1, 42).

### 4.2.3 Organizational antecedents

#### *4.2.3.1 Organizational structure*

Alpha acts as a service provider for the development and operation of medical devices and accompanying services to the pharmaceutical business unit. It is organized as a separate legal entity which is owned by the pharmaceutical BU. Medical devices and digital services are developed on behalf of the different therapeutic areas (GBFs), who combine these digital services with the pharmaceutical treatments to offer comprehensive treatment solutions. Therefore, certain GBFs have started to create dedicated functions, who are responsible for digital solutions. Within Alpha, the business development unit is responsible for managing the cross-functional collaboration with the GBFs. Device related digital services are developed in collaboration between hardware and software engineering, which mainly focus on requirements engineering and regulatory compliance, whereas external suppliers do the actual development. Furthermore, software engineering is not only responsible for the development of software platforms and mobile applications of digital services, but also for the embedded software of the devices (see Figure 5).

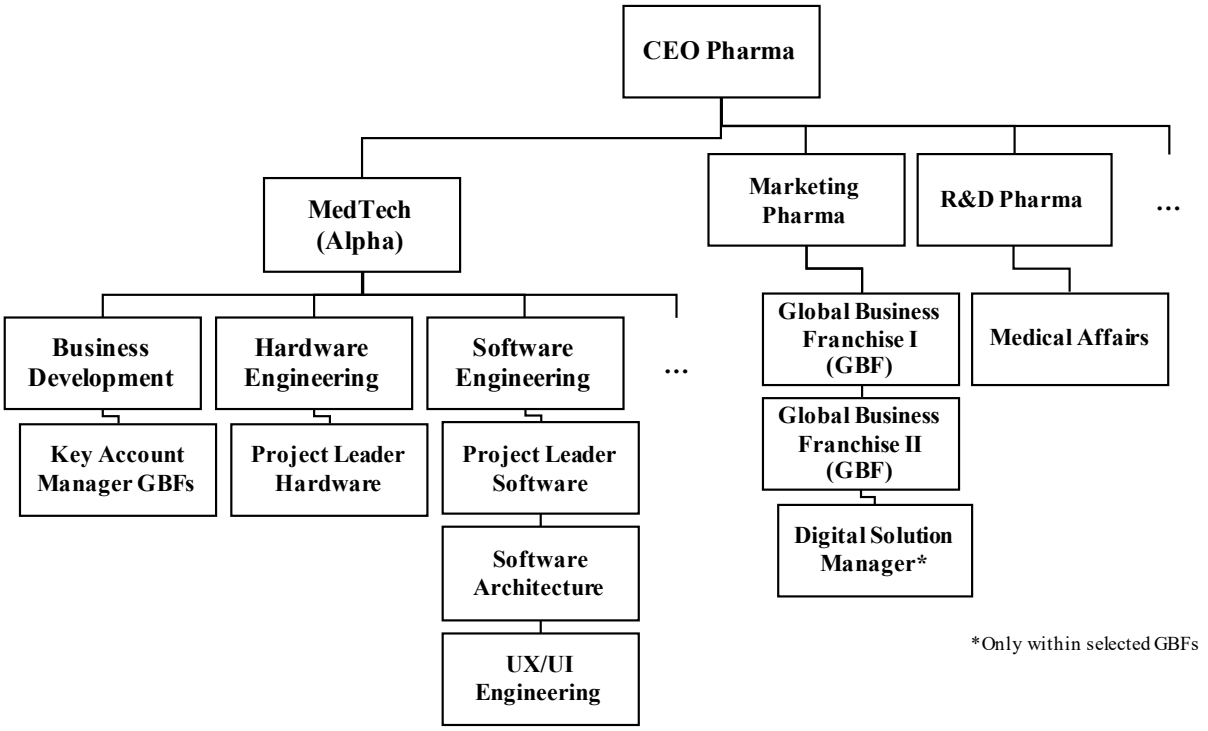



*Figure 5: Organizational setup of Alpha*

The organizational structure of Alpha is found to have several implications on the digital service innovation capability. As described earlier, relevant customer and market knowledge for digital services reside within the GBFs and medical affairs departments. However, due to organizational distance and missing communication channels, engineering teams within Alpha have only limited access to relevant customer and market knowledge: *"The challenge is that the customer knowledge […] is only indirectly known, and when one has to make design decisions, one has to ask via various stages what kind of implications that would have for the customer. Thus, the strong decoupling of those who are doing the [technical] development […], and those who know what the customer actually needs, is a big challenge"* (A1, 21).

Another implication of the organizational structure that affects digital service innovation relates to dedicated organizational functions. Establishing dedicated organizational functions responsible for digital services is found to facilitate the strategic management digital service innovation, as these functions enhance internal visibility and importance for the topic, as well as help to accelerate the development of relevant knowledge: *"That would be not a complete structural change, but a shift in the priorities and an enhancement of the topic. […] Such a digital service role, which would be coupled with the data strategy of the GBF, […] which decidedly takes care of digital services within the respective therapeutic area"* (A1, 111). However, these functions should be established

decentralized within the therapeutic areas, as they required comprehensive customer and market knowledge.

Finally, Alpha found that the organizational model influences the adequate alignment of incentives and targets for digital service innovation. For example, the medical affairs department possesses relevant customer knowledge and accordingly is an important contributor to the development of digital services. However, due to their role within the organization, they have different incentives and targets, which hinders cross-functional collaboration during the development of digital services: *"They [medical affairs] are not in a managerial hierarchy. They are also not incentivized on the same targets. […] And therefore, at least in a given case, it is difficult to motivate them to directly contribute with their knowledge"* (A1, 49).

#### *4.2.3.2 Organizational culture*

The organizational culture of Alpha is found to influence digital service innovation in various aspects. First, the pharmaceutical BU has initiated an internal campaign to create a strong patient orientation, which also influences the behavior of Alpha's employees: *"it shall bring all employees to mind that all that we are doing should ultimately serve patients"* (A1, 102). Therefore, a strong patient orientation is seen as a cultural aspect that contributes to digital service innovation: *"And of course, this is a supporting lodestar, when thinking about digital services. […] The orientation on the medical and clinical benefit, respectively, the patient experience as a soft factor"* (A1, 119). Furthermore, Alpha's digital service innovation activities benefit from top management support, as well as their willingness to support experimentation: *"But basically, the management supports and promotes the exploration and development of such things [digital services]"* (A1, 103)

However, certain aspects of the organizational culture of Alpha also hinder digital service innovation. As the company operates in a highly regulated environment, Alpha tends to be rather risk-averse, which influences the development of digital services negatively: *"[…] there is a certain risk aversion, and it can hinder things basically, that things are not introduced to the market, respectively, that functionalities are restricted due to risk aspects. And this reduces the value of the digital services until it loses its total value"* (A1, 106).

#### *4.2.3.3 Existing resources and capabilities*

Alpha was among the first medical device companies that developed a connected drug delivery device. Therefore, the business unit was able to build relevant competencies regarding the digital infrastructure, as well as the regulatory and legal requirements:

*"Technically, our company introduced one of the first IoT-devices to the market. More than ten years ago. […] Thus, the fundamental knowledge of how to manage such data streams is available, maybe not on the latest state-of-the-art, but basically, how I can do it, that is available, and the experience what kind of external suppliers are required"* (A1, 39). Furthermore, as Alpha is part of a pharmaceutical company, relevant knowledge about medical needs relating to digital services is available. However, as the knowledge resides within the GBFs, it is rather vague and not directly applicable to the development of digital services: *"Indirectly the organization, initially via the franchises, brings a basic understanding of what, in essence, are the famous 'unmet needs'. They are available. However, they are simply not available in such detail. Thus, it is difficult to test, if what is developed is also corresponding [to the needs]"* (A1, 38).

### 4.2.4 Summary

Based on the case study of Alpha, several routines and practices relating to digital service innovation have been identified. These routines have been clustered according to the guiding research framework (cf. 3.2). In total, 14 routines have been identified, which can relate to multiple innovation capabilities. Additionally, first insights regarding structural and cultural antecedents that drive and affect the innovation capabilities have been gained. Therefore, the case study of Alpha provides a first indication of how the identified routines interrelate and enable digital service innovation. Table 13 summarizes the findings of the case of Alpha regarding the identified innovation capabilities.

*Table 13: Findings case Alpha*

| | Routines and practices | Findings |
|---|---|---|
| **Reconfiguration** | Establishing a dedicated organizational function | A dedicated organizational function responsible for digital service innovation fosters the systematic scouting and identification of opportunities |
| | | The dedicated organizational function responsible for digital service innovation requires comprehensive customer and market knowledge |
| | Structured and formalized strategy process | Procedural anchoring of digital services within the corporate strategy and strategy review process promotes the systematic identification of opportunities |
| | Portfolio management | Creation of innovation pipelines and roadmaps for digital services facilitates the systematic innovation portfolio management |
| **Internal coordination** | Structured development process | A structured development process with regular review meetings facilitates internal coordination and communication. |
| | Service development process | Without a dedicated service development process, service concepts and user experience tend to be developed only indirectly within hardware and software development |
| | Integrated development process | Strong interdependencies between service design, software and hardware engineering require an integrated development of digital services |
| | | Integrated development of digital services is hindered by different cycle times of hardware and software engineering |
| | | Missing responsibilities for an integrated development hinder the successful development of digital services |
| | Iterative and incremental development model | Due to high ambiguity and uncertainty of customer needs, digital service development benefits from an iterative and incremental development model |
| **External coordination** | Coordinating external partners | For coordinating and managing external partners, sufficient knowledge of the respective subject has to be developed internally |
| | | For steering and managing external partners, clear responsibilities have to be defined |
| | Selecting external partners | If key components of digital services are obtained from external partners, adequate processes for selecting external partners are required, as dependencies and delivery risks might emerge |
| | Managing strategic partners | If digital services are developed and operated jointly with strategic partners, strategic management of these partnerships is required, as the partnership can affect the value creation and the role within the ecosystem |
| **External learning** | Prototyping | Prototyping facilitates external learning by generating customer feedback and insights. Therefore, prototyping helps to reduce ambiguity and uncertainty of intangible service concepts |
| | | Prototyping during early stages of the development generates design inputs and customer requirements |
| | Iterative and incremental development model | Linear and sequential development approaches complicate frequent testing of prototypes, whereas iterative and incremental development models facilitate prototyping |
| | Integrating customers | Integrating customers into early phases of the development process via advisory boards, focus groups and direct visits fosters the generation of customer insights |
| | Co-developing digital services | Joint development projects with selected key customers facilitate access to and generation of relevant customer insights |
| **Internal learning** | Prototyping | Prototyping digital services facilitates the codification of customer insights and promotes knowledge management |
| | | Prototyping digital services increases the tangibility of digital services which facilitates the evaluation of intangible service concepts |
| | Structured development process | A structured development process with regular gate reviews facilitates internal learning by sharing and documenting past experiences |
| | Knowledge management | Missing communication channels and cross-functional collaboration hinders the exchange of information and knowledge |
| | | The organizational distance of stakeholders complicates the exchange of information and knowledge |

## 4.3 Case Beta

### 4.3.1 Background information

Beta is a leading supplier of medical consumables to hospitals, nursing homes, and physicians. The company is headquartered in Switzerland and is owned by a global medical technology company. With about 350 employees, Beta develops, manufactures, and distributes medical consumables for areas such as wound and incontinence management, as well as supplies for the operating room. Beta develops and manufactures about 20 % of the assortment by itself, while 80 % are obtained from other group companies or external suppliers. As part of a global medical technology group, Beta serves only Swiss customers directly. Within the Swiss market, the company does not only compete against other manufacturers but also against pure distributors of medical consumables and supplies. Therefore, controlling the "last mile" to the customer is seen as an important strategic pillar and also regarded as a core competence of Beta: *"core competence is to provide B2B customers a high service level. Thus, to provide the highest possible availability of our products"* (B1, 55). Accordingly, in recent years, Beta has turned from a pure manufacturer of medical technologies to a solution provider that develops and provides comprehensive supply chain and logistics solutions to its customers. Therefore, Beta has developed a digital procurement and supply chain platform that allows customers to manage the resupply of consumables, as well as to decrease associated process costs.

#### *4.3.1.1 Strategic relevance of digital services*

As a manufacturer and supplier of medical consumables, Beta has only a limited number of products with a unique selling proposition (USP), and most products are seen as commodities. Therefore, digital supply chain solutions are seen as an important factor in differentiating physical products from competitors: *"They [digital solutions] are already today a USP. We are increasingly in competition, not only with manufacturers but distributors. Solutions that safe process costs for the customer are a USP"* (B1, 7). However, Beta does not only develop digital services and solutions to differentiate their offering from competitors but, more importantly, to secure the customer interface and increase customer retention by creating a lock-in effect. Currently, Beta is not able to price its digital solutions independently. Nevertheless, within the respective market segment, digital supply chain solutions already contribute indirectly to revenue growth.

Within the next five years, Beta assumes that their digital solutions will gain further strategic relevance as the company expects further distributors, and low-cost suppliers to

enter the Swiss market. Therefore, the role and importance of digital services to differentiate the offering and retain customers will further increase: *"I expect that more distributor organizations and low-cost suppliers will push into the commodity market and as a result differentiation by services will increase"* (B1, 9).

### 4.3.2 Innovation capabilities

#### *4.3.2.1 Reconfiguration routines and practices*

Beta follows a formalized and cascaded strategy process to identify and execute new opportunities for digital services. The yearly strategy process starts in the group company and is forwarded to the country organizations such as Beta. Therefore, at least once a year, Beta is reviewing its opportunities for new digital services. Within the strategy process, Beta identifies new market requirements, which are translated into strategic initiatives that form the basis for new development projects: *"We always start with the strategy. It is not that we come up with something completely new, but rather that we continuously review, at least once a year, which results in new requirements. Then we break it down into initiatives, […] which is, in the end, a business plan with a rough description of the basic functionalities we want to have, and then we start a project"* (B1, 33). Accordingly, following a structured and formalized strategy process enables Beta to continuously review, identify, and execute new opportunities for digital services innovation.

Moreover, Beta and the group company have created a so-called *"steering board"* for the evaluation and execution of new digital service initiatives. Within the steering board, the CEO acts as the sponsor of these initiatives: *"We will have a steering board. […] I will be the sponsor in Switzerland, and also in the group, the CEO will be the sponsor of digital. That means the business cases move to the steering board, and the board makes two decisions. First, 'yes' or 'no', as well as the second decision, on which platform we will create the 'MVPs'"* (B1, 3). Consequently, by appointing top-management sponsors and by evaluating new opportunities in steering boards, Beta is able to drive the execution of new digital service opportunities.

The insights of Beta illustrate that the identification and execution of new digital service opportunities benefit from a structured and formalized strategy process that rather follows a waterfall-model. However, as one of the informant highlights, only the strategy process of Beta is formalized, while the implementation and actual development of new digital services follow a market-driven and adaptive process, which is much less formalized than the strategy process: *"Well, the strategy process is completely formalized, organized and sequenced. However, what we push into releases is completely market-oriented without a*

*formalized process"* (B2, 42). Accordingly, the strategic planning of future development project is not driven by well-defined roadmaps, but rather by the vision and strategic priorities that guide the implementation and development of new digital service: *"Of course, we have a planning for the next three years, but I rather call it visionary. It is not written down, which feature will come by which release, but its already more than a pipeline. Therefore, we have strategic cornerstones. […] as an example that we want to move to a subscription model […]"* (B2, 39). Therefore, having a clear vision and strategic priorities enable Beta to transfer digital service initiatives from a well-defined and formalized strategy process into a less-formalized and market-driven development process. Thus, the iterative and incremental development process is not driven by well-defined development roadmaps but rather by a vision and defined strategic priorities.

#### *4.3.2.2 Coordination routines and practices*

***Internal coordination***

The digital supply chain solutions of Beta are not classified as medical devices. Therefore, Beta has been able to establish a dedicated development process for developing digital services, which is different from the development process for developing medical devices: *"For medical products, we have a very rigid Stage-Gate process, which is very robust but also very slow. In IT, we develop not a hundred percent according to scrum but in fast cycles, which is completely different from the product development process"* (B1, 29). Accordingly, the development of digital services follows an iterative and incremental development model: *"Well, we write concepts, screen ideas, and then realize these ideas mostly in a 'light version', and further implement it incrementally. […] We try to get out a release every two weeks"* (B2, 28).

Beta's development process for digital services starts with a comprehensive assessment of customer needs. However, due to the uncertainty and ambiguity regarding customer needs resulting from the complexity of healthcare, Beta finds it difficult to define customer requirements ex-ante: *"We always start with the assessment of the customer needs, which is not that easy in healthcare. On the one hand, it [the healthcare system] is very slow. On the other hand, there is legislation and the interpretation of the legislation, as well as what the market players are actually doing. Thus, we try to have a midterm strategy where we want to go. I would say hypothesis-driven. And then we take these hypotheses – not written down, but in the form of prototypes and ideas – to the customer and reflect them"* (B2, 25). Consequently, the assessment of customer needs results in the definition of hypotheses instead of the specification of definite customer requirements. These hypotheses are tested and adapted throughout the development process. Therefore, Beta's

development of digital services follows rather a hypothesis- instead of a requirements-driven development approach: *"We have a vision. Then we decide to go into this direction, and when we realize that it works, we go further, but if it is not working, we are adapting. Thus, it is a kind of an iterative and adaptive approach*" (B2, 31).

Beta did not only adapt its development approach for developing digital services but also adapted the organizational setup to facilitate internal coordination and collaboration. Therefore, Beta established autonomous and independent development teams that possess the most required competencies to develop digital services. By combining relevant competencies such as project management, software engineering, marketing, and logistics into an integrated team, Beta is able to facilitate internal coordination and to reduce the need for complex cross-functional collaboration: *"We try to keep the digital solution team a completely autonomous unit with the required capabilities to act. […] It is my endeavor to establish a team without matrix assignments and preferably with a line-management responsibility. This releases me specifically from any coordination stuff"* (B2, 9).

Additionally, Beta is developing digital services in constant digital solution teams and not in a temporary project organization, as the temporary nature of project organizations do not fulfill the requirements of digital services, which require a continuous development and deployment approach: *"Digital as a project is already lost, as a project ends, whereas digital solutions continuously develop further. After the project, people are tied in the next project, mainly other projects. Thus, I have to establish constant digital teams"* (B2, 43).

In general, Beta found that the organizational setup is an important lever to foster digital services innovation. Following an iterative and incremental development approach requires a short decision-making process and an adaptive organization. However, Beta realized that such an organizational setup is difficult to implement in a global matrix organization of group companies: *"The decision-making processes that group companies have, or most group companies have – specialized departments, matrix organization, distributed responsibilities – with those you cannot survive the digital competition. Not a chance"* (B2, 5).

***External coordination***

In the context of digital service innovation, Beta tries to develop and build-up required competencies internally. Only for selected topics such as user experience (UX) and user interfaces (UI), the firm collaborates with external suppliers. According to the informant, Beta develops about 80 % of their solutions internally: *"I would say 80/20. We want to master this by ourselves"* (B1, 20). Furthermore, Beta also tries to build up relevant resources mostly internally, as coordinating external suppliers is complex due to the

different objectives and goals of internal and external development teams: *"It works mediocre. Externals are always willing as they earn money with it. […] But it always flattens, such as a relationship. In the beginning, the relationship is still passionate, but when they are involved for a couple of months, they are typically again tied to other projects. A then the problem of the resource allocation and utilization emerges"* (B2, 20).

Especially in the case of offshoring, Beta finds it difficult to integrate geographically distributed development teams. Besides misaligned objectives and goals, also geographical and cultural distance hinders successful collaboration and coordination of external suppliers: *"They have absolutely not a clue, which is evident. There is a team which is in a different culture, different time zone, they operate five applications in parallel, in five different programming languages. They are just not able to know my application"* (B2, 55).

Additionally, Beta observed that working with external suppliers without having required competencies and knowledge in-house, increases dependencies from external partners: *"The greatest difficulty I see with externals, are my core competencies, as I start building competences externally. The engineer knows how the product works. It is like developing a pacemaker. The product engineer knows how the thing works, but he is external. Then you are completely dependent on him"* (B2, 21).

Accordingly, Beta highlights that having the most important competencies for developing digital services in-house is a prerequisite for digital service innovation: *"When I want to be competitive in 'digital', I have to have the required core competencies in my digital unit. Thus, I will try to build up those competencies internally"* (B2, 54).

#### *4.3.2.3 Learning routines and practices*

***External Learning***

As mentioned earlier, due to the complexity of healthcare with its various stakeholders, Beta finds it difficult to assess and define customer needs ex-ante. Dealing with uncertain and ambiguous customer needs requires adequate practices and processes do generate relevant customer insights. Central to Beta's development approach is a close collaboration with key customers. By frequently visiting and discussing potential solutions with customers, the company is able to generate relevant insights: *"There are many discussions and customer visits. […] And we show certain screens or prototypes to the customer. The exchange with the customer is extremely close"* (B1, 24). Additionally, Beta follows a lead user approach with selected customers. These lead users provide relevant information and data and, in return, receive certain compensations: *"The first customer*

*[lead users], […] get such systems for free, but have to provide data and time to us"* (B1, 25).

Beta does not only generate customer insights by integrating customers into the development process, but also by demonstrating and validating wireframes, prototypes, and minimal viable products. However, wireframes and prototypes are mainly used during the early phases of service development. Thus, these approaches are used to validate promising new ideas. During later phases of the innovation process, Beta follows a minimal viable product approach to foster external learning about possible solutions: *"By using the minimal viable product approach, you have to test and understand if it works, before you go into standardization"* (B1, 2).

Furthermore, Beta facilitates external learning by using a hypothesis-driven development approach. Beta highlights that compared to a static requirements-driven development approach, a hypothesis-driven approach is dynamic and fosters experimentation and learning: *"We document quite a lot. However, the documents are living. It is not like with medical products, where you have the requirements, and two years later, you compare those [against the design output]. They are variable. I start with a hypothesis and during the course of the process one realizes that the hypothesis has to be adapted"* (B1, 35)

Beta combines the hypothesis-driven development approach with an iterative and incremental development model. By following a *"trial and error approach"* (B2, 58), Beta is able to generate relevant customer insights and to learn about the feasibility and desirability of their digital services: *"We have a vision. Then we decide to go into this direction and when we realize that it works, we go further, but if it is not working, we are adapting. Thus, it is a kind of an iterative and adaptive approach*" (B2, 31)

***Internal Learning***

In the case of Beta, three different practices and routines to facilitate internal learning have been identified. First, the team that is responsible for developing digital services collaborates closely with customer-facing employees from sales. By integrating customer-facing employees into the development process, Beta is able to foster knowledge exchange from the sales organization into the development team: *"We are directly assigned to the sales organization. […] we are part of the sales organization and the head of sales channels are my peers"* (B2, 7). Furthermore, Beta tests and prioritizes new ideas in close collaboration with sales: *"We are exploring new ideas and first provide them to sales. Some ideas are seized by sales, but there are many ideas, where sales say: 'No, that is nonsense, it is no use, that will not work for this and that reasons.' Thus, it is a joint discussion, and sometimes we abandon the idea"* (B2, 32).

Besides collaborating with customer-facing employees from sales during the development of digital services, Beta also fosters internal information and knowledge sharing by building cross-functional development teams with members from software engineering, sales, marketing, logistics, and finance: *"We always try to build the team with someone from sales. […] who has already been for some years in the company and in a line function, who knows the colleagues from the sales force and back office, who knows how the customer work. […] And we always have at least a Product Owner and Engineering, and usually someone from logistics, marketing, and to some extent from finance for accounting"* (B2, 57)

Finally, internal learning about intangible service ideas is supported by using prototypes: *"We build prototypes, that is more tangible"* (B2, 33). By Prototyping new digital services, Beta is able to evaluate and discuss the feasibility of new ideas during the very early stage of the development process.

### 4.3.3 Organizational antecedents

#### *4.3.3.1 Organizational structure*

When Beta started to develop and provide digital supply chain solutions, it formed a dedicated department that is responsible for the development and maintenance of digital services. The employees of the new department have formerly been part of the IT department and had already some experience in developing customer-specific solutions. Additionally, the new "digital unit" is not only separated from the IT department but now also part of the sales organization, which is headed in personal union by the CEO of Beta. Thus, the head of the digital unit directly reports to the CEO and closely collaborates with the managers of the different sales channels. Within the digital unit, the development of digital services is organized in autonomous and independent development teams, so-called value-seeking teams. These value-seeking teams have about four to eight team members and are composed as a multi-disciplinary team consisting out of software engineering, marketing, and logistics, as well as if necessary, sales and finance. As highlighted by the informant, Beta tries to have all required competencies to develop digital services directly within the team and in a line responsibility, as opposed to a matrix-oriented project organization: *"We try to keep the digital solution team a completely autonomous unit with the required capabilities to act. […] It is my endeavor to establish a team without matrix assignments and preferably within a line responsibility"* (B2, 9).

The organizational structure of Beta has several implications on the capabilities to develop digital services. First, building small, autonomous and independent development teams

within a separated digital unit improves internal coordination and enables an "agile" (iterative and incremental) development model by accelerating the decision-making process: *"it has to be small teams between four and eight persons, which are able to act fast upon demand, act less-formalized, are able to make decisions fast, thus decoupled from any corporate processes. But responsible for the result. They have to be measured on the business case, so to say require a kind of P&L [profit and lost] responsibility. Have entrepreneurial setup"* (B1, 6).

Additionally, the previous quote also highlights that Beta has implemented a result-oriented incentive system, which was possible due to the separation and integration into the sales organization. The strong result orientation of the development team is found to strengthen the project ownership and entrepreneurial mindset, which facilitates an iterative and incremental development model.

Furthermore, by integrating the digital unit within the sales organization rather than into a centralized IT department, Beta is able to increases customer orientation and intimacy of the development team, which facilitates internal learning from customer-facing employees, as well as external learning from customers: *"Well, we are close to the customers, we are going out to customers, we are prioritizing with the colleagues [from sales]."* (B2, 11)

Finally, as the head of the digital unit directly reports to the CEO, and the CEO is the main sponsor of new digital service initiatives, digital service innovation gains much visibility and top-management support. Accordingly, having comprehensive visibility and top-management support enables Beta to drive strategic initiates and manage the organizational change required for successfully developing digital services: *"It requires a champion who drives the topic"* (B1, 40).

#### *4.3.3.2 Organizational culture*

Beta highlights that organizational culture is a relevant factor that affects service innovation. Developing digital services according to an iterative and incremental development model requires a culture, which is different from the culture of a large corporation: *"Acting fast and adapting, again and again, that does not fit the culture and organizational structure of a group company. It would say that this is the biggest challenge we have"* (B1, 37). According to the informant, digital service innovation requires an entrepreneurial or startup culture: *"A startup culture. It is mainly about speed. However, topics, like being close to the customer, and achieving objectives, are similarly important. Because for a startup, it is essential for survival that it is close to the customer and that it*

*achieves its goals, else it runs short of money. However, speed is something I would add [to our culture]"* (B1, 51). Summarizing, service innovation is found to benefit from an entrepreneurial culture that fosters customer- and result-orientation, as well as a speed-orientation.

Thus, Beta beliefs that its existing organizational culture provides a good starting point for digital services innovation. Accordingly, the informant describes Beta as results- and customer-oriented: *"Results-oriented and customer-oriented that are both strengths. We are extremely goal-oriented"* (B1, 49). Nevertheless, despite the strong result- and customer-orientation, the limited adaptability and flexibility of the organization are found to hinder digital service innovation: *"Our adaptability is limited"* (B1, 48).

Therefore, to promote the required cultural change and to implement an entrepreneurial culture that fosters digital service innovation, Beta has separated the development of digital supply chain solutions and transferred it from the IT department to a newly founded "digital unit" that is part of the sales organization: *"From the cultural perspective, this is a completely different thinking that you have to get into the organizational culture. […] It requires a cultural change that you have to promote"* (B1, 28).

#### *4.3.3.3 Existing resources and capabilities*

Beta is developing customer-specific digital solutions on a small scale for quite some while. Thus, the company had already built relevant technological resources and capabilities within the IT department, when the management decided to focus on digital supply chain solutions: *"We did develop solutions for many years. These were isolated applications for customer-specific issues. Thus, three years ago we had already a small team that was at this time part of the IT, which took care of the programming of interfaces, and patient management solutions"* (B1, 13)

Besides having relevant technological resources and capabilities, Beta benefited from having a well-established customer interface with direct access to end-users to derive relevant insights about customer needs and requirements: *"Compared to other companies of our group, we have a three- to four times higher market share. Thus, we are very close to the customer. Having extremely good channel organizations. It is one of our strengths that we realize very early what they [the customer] really want"* (B1, 12).

Accordingly, having direct access to customers and owning and controlling the customer interface, as well as having all relevant technological competencies, are found to be important resources and capabilities required for digital services innovation: *"We have to*

*understand what the customer actually wants, and we have to implement it as fast as possible, which is much easier when you are programming by yourself"* (B1, 54).

### 4.3.4 Summary

The case of Beta has provided insights into 14 different routines and practices that can be related to multiple innovation capabilities. Furthermore, various antecedents that affect the innovation capabilities for digital services have been identified. Table 14 summarizes the findings regarding the identified innovation capabilities.

*Table 14: Findings case Beta*

| | Routines and practices | Findings |
|---|---|---|
| **Reconfiguration** | Structured and formalized strategy process | A structured and formalized strategy process enables review and identification of new opportunities |
| | Creating a steering committee | Creating a steering committee responsible for selecting new digital service initiatives fosters the execution of new digital service opportunities |
| | Appointing top-management sponsors | Appointing a project sponsor from the top-management team fosters the execution of new digital service opportunities |
| | Defining strategic priorities | Well-defined strategic priorities guide the less-formalized iterative and incremental development approach and ensure the fit to the corporate strategy |
| **Internal coordination** | Dedicated development process | As the digital services of Beta are not classified as medical devices, Beta is able to follow a dedicated development approach for digital services |
| | Iterative and incremental development model | An iterative and incremental development process is found to be more suitable for the development of digital services as it facilitates continuous testing of new service features |
| | | Due to complex decision-making processes, an iterative and incremental development approach is difficult to implement in a global matrix organization with distributed responsibilities |
| | Hypothesis-driven development process | When customer requirements are uncertain and ambiguous, a hypothesis- instead of a requirements-driven development approach is found to be more suitable |
| | Establishing autonomous development teams | Autonomous and independent development teams that are possessing relevant capabilities facilitate internal coordination and collaboration |
| **External coordination** | Coordinating external partners | For coordinating and managing external partners, sufficient knowledge of the respective subject has to be developed internally |
| | | Coordination and integration of external development teams require an adequate alignment of objectives and goals of internal and external development teams |
| | | Geographical and cultural distance complicate coordination and integration of external suppliers |
| **External learning** | Integrating customers | Customer visits and close collaborations with lead users facilitate the generation of relevant customer insights |
| | Prototyping | During the early phases of digital service development, prototyping enables external learning by validating new features and ideas |
| | Developing minimal viable products | During later phases of the digital service development, developing minimal viable products fosters external learning about possible solutions |
| | Hypothesis-driven development process | A requirements-driven development approach is static, while a hypothesis-driven is dynamic and fosters experimentation. Thus, a hypothesis-driven development approach facilitates external learning |
| | Iterative and incremental development model | An iterative and incremental development model facilitates the generation of customer needs by continuous testing of new digital services |
| **Internal learning** | Integrating customer-facing employees | Integrating and collaborating with customer-facing employees during the development of digital services facilitates internal learning about desirability and feasibility of new ideas |
| | Building multi-disciplinary development teams | Building multi-disciplinary development teams foster knowledge exchange between team members of different functional expertise |
| | Prototyping | Prototyping digital services increases the tangibility of digital services which facilitates the assessment of intangible service ideas |

## 4.4 Case Gamma

### 4.4.1 Background information

Gamma is a leading manufacturer of medical devices and consumables for critically ill patients that are used mainly in intensive care medicine. The family-owned firm is headquartered in Switzerland and has about 350 employees who work in R&D, manufacturing, marketing, and sales. Gamma sells and distributes its medical devices globally, but primarily via a network of exclusive dealers. Only in selected key markets, Gamma also operates subsidiaries and sells directly to end-users. Today, Gamma generates its revenue mainly by selling medical devices and related consumables. Thus, at present, services do not play a major role in the business model of Gamma. Nevertheless, the company believes that digital services will become more relevant in the future, and recently has started to develop a first digital service that shall be used in combination with their medical devices. The IoT-enabled digital service will enable medical professionals to monitor the device and patient condition remotely. Currently, the development activities of Gamma mainly focus on the technical components of the digital service, such as the connectivity of the medical devices, as well as the mobile software application to display corresponding device and patient data.

#### *4.4.1.1 Strategic relevance of digital services*

At present, the strategic relevance of digital services is rather limited, and digital services are only anchored to a limited extent in the corporate strategy, as well as the organization: *"Strategically, it is small today. Today, we have zero digital services. […] And strategically, it is actually also very weakly anchored"* (C2, 1). Nevertheless, the company has started to develop a first digital service, as well as to implement connectivity features into the devices, as it believes that digital services will become more relevant in the future: *"I believe it will have a very great impact. I am convinced of that"* (C1, 59). Currently, the firm is not able to describe in detail how digital services will impact their business model in the future. Various scenarios have been discussed, from the increasing importance of data-driven value creation to the loss of the direct customer interface. However, as these scenarios are still very vague, they play only a minor role in the strategic considerations of Gamma. Therefore, current development activities are rather driven by market and customer requirements to provide medical device connectivity. Gamma aims to increase product differentiation and customer retention by providing digital services while generating additional revenues is not considered as a strategic priority. Besides generating additional customer value, Gamma also aims to gain access to relevant device

data that provide additional insights about customers, as well as product usage: *"One chance is that we know more about what our customers are doing with our devices. That we know where they are and how they work with them. This information is certainly important for us"* (C1, 67). Due to the dealer network, Gamma has only limited access to end-users. Accordingly, generating additional customer insights by providing digital services is considered as strategically important.

### 4.4.2 Innovation capabilities

#### *4.4.2.1 Reconfiguration routines and practices*

Gamma has not implemented a formalized and structured strategy process for identifying and executing new opportunities for digital services: *"[…] there is no formal process that we follow at the moment, which ensures that we get into services. Instead, there are such ideas in the room. However, we do not have a strategy process to manage it. Nevertheless, we need it. [...] I think you have to approach it more formally"* (C1, 42). Accordingly, the informant highlights that a formalized and structured strategy process drives the targeted identification and execution of new digital service opportunities.

Despite a missing strategy process, Gamma has established a steering board that is responsible for assessing and executing new ideas for development projects: *"The only thing is, there is a certain steering committee that pushes ideas forward. By submitting ideas [to the board] and making decisions, which ideas should be elaborated further in order to enable a decision about their realization. However, we have not implemented a more systematic approach"* (C2, 35). Thus, a steering board facilitates the transition from the fuzzy front-end to the development phase.

Besides adequate processes and practices, also the organizational structure is found to affect the identification and execution of new ideas. Recently, Gamma has established a dedicated unit that is responsible for developing digital services. Furthermore, the company is currently recruiting a product manager for digital services. According to the informants, establishing a dedicated organizational function and defining clear responsibilities will foster the identification of new ideas and the execution of digital service initiatives: *"We have just advertised the position – product manager digital services – that will actually be one of his topics [developing the strategy][...] At the moment that does not exist yet, that will be a new position"* (C2, 36).

Moreover, the identification and execution of new digital service ideas are not only hindered due to missing organizational processes or functions but also due to the time horizon of the corporate strategy. Gamma rather operates on a two- to three-year time

horizon: *"We always only have a two- to three-year perspective. We do a lot in this area. We make decisions here at relatively short notice"* (C2, 39). As digital services currently do not play a major role within the market segments of Gamma, identifying new opportunities for digital services that become relevant beyond the next two to three years is found to be difficult. Accordingly, identifying new opportunities for digital services requires an adequate time horizon and rather a mid- and long-term orientation of the corporate strategy.

Furthermore, the short-term orientation of Gamma is further influenced by a strong market- and customer-orientation: *"[We are] very market-driven – 'what can I sell today.' Digitalization only came onto the scene seriously when the competition more or less forced us to do so"* (C2, 41). As highlighted by the informant, digital service innovation can be rather considered as a technology-push approach to innovation where classical market research is less suitable: *"I am also convinced that when I ask customers that I do not get a clear answer there either. I do not see anything in the near future that the customer sees as added value and is willing to pay for it"* (C1, 60). Accordingly, a strong market-orientation of a company can hinder the identification of new opportunities for digital services, as the existing innovation activities tend to focus on explicit and articulated customer needs and requirements.

#### *4.4.2.2 Coordination routines and practices*

***Internal coordination***

Currently, Gamma is developing digital services that are classified as medical devices. Accordingly, the firm has to follow a development process that is compliant to existing industry regulations and applies strict design controls, especially regarding traceability of design inputs and outputs. Therefore, Gamma follows the same development process for digital service that is also used for medical devices. Hence, until now, Gamma has not implemented a dedicated development process for digital services: *"Theoretically, they still have to follow the [existing] innovation process. […], but we do not have a dedicated process that we have adapted for that [digital services], but it will be for sure necessary"* (C1, 35). Accordingly, the informant highlights that the existing medical device development process is not fully suitable for developing digital services.

The different development settings of hardware and digital service development projects are perceived as a challenge. While hardware development projects mostly have a defined start and endpoint, digital services rather follow a continuous deployment and delivery approach, which is more in line with an iterative and incremental development model: *"Another challenge is – how is it called – the agile setting, where you have every three*

*months a new operating system. How do you solve the ongoing refreshing?"* (C2, 12). However, organizational inertia that is partly induced by industry regulations is perceived as a barrier to such approaches: *"Today, the barrier is that we are too inertially, if self-chosen or not self-chosen in our regulatory environment"* (C2, 25). One reason for the organizational inertia can be found in the requirements-driven development approach of medical devices, where due to safety considerations, much time is spent on specifying requirements: *"Making decisions and implementing, instead of producing only paper. […] there you can spend much time in discussions, instead of just getting started"* (C2, 26).

Another challenge relates to the integrated development of the hardware and software components of IoT-based digital services. Gamma's IoT-based digital services will be used in multiple market segments and for multiple medical devices. Therefore, the hardware of multiple devices has to fulfill the requirements of the mobile software applications of the digital service. However, currently, the hardware development of medical devices is organized in independent development projects for each device. Accordingly, implementing an integrated development of hardware and software components is considered as a major challenge in organizing the development of digital services: *"And the same problem do we have with the app development, […] which should work as an app for multiple products. However, of course, the [hardware] product are not released at the same time. Now, do I put it into the specifications of all products and how decidedly? Moreover, when does a project start, and when is it finished. Thus, the demarcation, as it is central for all products. That is something where we struggle"* (C1, 38). Thus, in the case of Gamma, the question remains, if the different components of the digital services are developed in an integrated project of hardware and software engineering, or if the different components are developed in separate projects, and if separated, how are the different independencies managed.

Currently, the development of digital services mainly focuses on technical components, such as the connectivity of medical devices, as well as mobile software applications. However, a dedicated development process for developing the service components, such as the service concept or business models, is missing. Nevertheless, Gamma recognizes the need to build corresponding competencies for developing the service components: *"Knowing how to price [digital services], as well as what is the problem for the customer that we want to solve by the digital service, but also, how we implement it within the organization. Thus, we have to understand the problem of the customer – these competencies we need in-house. Moreover, of course, we have to be able to calculate [a business case for] digital services"* (C1, 66).

To build such competencies and to establish the development of the service components, Gamma is currently recruiting a dedicated product manager for digital services. Thus, a dedicated organizational function responsible for digital services is considered to foster the targeted development of service components, such as the service concept and business model: *"And what we do not have yet and what does not fit into it at all, is to develop a business model out of it. […] We are now recruiting a person, who can think about the building blocks of how any added value can be generated – but we are not there yet"* (C1, 40).

***External coordination***

Gamma has just started to develop digital services and thus has only limited competencies on topics such as mobile software applications and cybersecurity. Therefore, Gamma collaborates for the development of digital services substantially with external suppliers. To manage these external suppliers and to internalize relevant knowledge, Gamma has established a dedicated development team that is responsible for the specification of the requirements, as well as the coordination of the external suppliers. Thus, the actual development of digital services is currently mainly outsourced: *"We are currently having it developed externally. We have commissioned it. However, at the end of the day, we want to have it in-house"* (C1, 7). Therefore, Gamma currently collaborates with external suppliers to gain access to relevant technological competencies more quickly, as compared to an internal development of the corresponding competencies.

Nevertheless, the previous quote also highlights that Gamma is considering the outsourcing of major development activities only as temporarily suitable. In the midterm, Gamma aims to build required resources and capabilities internally to decrease dependencies from external suppliers: *"But we also want to have the competence in-house, in order to understand what the [external suppliers] are actually doing, and if they talk about something, we even understand what it is, that they do not develop an app or large platforms that you cannot even use. Thus, we want to be able to have a say, too"* (C1, 10). Accordingly, for selecting and coordinating external suppliers, relevant competencies on the topic have to be developed internally.

Besides building relevant competencies to manage and coordinate external suppliers, Gamma also believes that these competencies will become strategically relevant as well as an integral part of the development of medical devices: *"The reason is that we think it will become an integral part of the product. We are following the strategy that something which is essential for the product is something we want to have internally"* (C1, 8). Furthermore, as digital services rather follow an iterative and incremental development

approach, outsourcing of the entire development activities is considered as less adequate*: "The stuff changes quickly and with an app, you have to book resources again and again. However, when something happens, you have to be able to react quickly […]"* (C1, 68). Thus, being able to react to customer and market requirements quickly requires sufficient resources and capabilities internally. Nevertheless, collaborating with external suppliers will help to manage capacity fluctuations, as well as to gain access to additional development resources for major projects: *"We believe that at some point it will be worth having a small team in the house. Then you can always outsource major tasks if you have corresponding projects"* (C1, 9).

#### *4.4.2.3 Learning routines and practices*

***External Learning***

For generating relevant customer insights about customer needs and requirements, Gamma integrates selected customers into the development process by demonstrating prototypes, observing customer behavior and operations, as well as by asking for feedback: *"I still have to hold it under someone's nose and ask them what they think. […] Ask the customers, show them something, observe them, let them give feedback. It is still state-of-the-art, even in the app development"* (C2, 24).

Besides integrating customers into the development process and asking for feedback on new ideas, prototyping is found to be an important practice for generating relevant insights about customer requirements. Gamma uses prototyping, particularly for validating user interfaces: *"I mean rapid prototyping, […] that is what we are already doing today with the device interfaces. For an app, you have to do it as well"* (C2, 33). Accordingly, prototyping is especially used to gain knowledge about the customer experience by demonstrating the interface design. Consequently, integrating customers into the development process and validating prototypes facilitates external learning about customer needs.

To gain knowledge and learn about technological components of digital services, Gamma collaborates with external suppliers and service providers: *"[Cyber] Security; we got an external company to consult us, where we send internal [employees] for training. We now have a team that does nothing else. […]. However, we buy this know-how. With the expectation that at some point, we will have the know-how in-house."* (C1, 70). Thus, collaborating with external partners fosters external learning on technological capabilities by enabling knowledge exchange between subject matter experts and the development team.

***Internal Learning***

To promote the development of relevant technological capabilities on digital services, Gamma has created a dedicated development unit. The team members of the newly established unit have been mainly recruited internally. Furthermore, Gamma has established the new digital service unit within the existing R&D department to facilitate the knowledge exchange between the different engineering departments and the new unit for digital services: *"But the role is simply that we have recruited them from internal resources and that we continue to have a strong exchange. [...] otherwise, we have them bundled within an independent department. So, we took them out of software engineering and put them there. But of course, still under the same roof."* (C1, 71). Accordingly, the quote points out that a limited organizational distance promotes internal knowledge exchange and facilitates internal learning.

### 4.4.3 Organizational antecedents

#### *4.4.3.1 Organizational structure*

Recently, Gamma has established a dedicated digital service unit within the R&D department. For establishing the unit, Gamma separated the software engineering of digital services from the embedded software engineering of medical devices. Thus, the team members of the digital service unit were mainly recruited from the existing embedded software engineering team. Moreover, Gamma is currently building up additional competencies on mobile software applications and cybersecurity by recruiting new employees from outside. Besides software engineering, the new unit also consists of a dedicated project manager, as well as engineers responsible for the connectivity of the medical devices. Accordingly, the goal is to establish a mostly independent and autonomous team for developing digital services. Currently, the digital service unit is concentrating on developing the technical components of digital services such as device connectivity and mobile software applications for displaying device data. Commercial aspects, such as product management and marketing, are not integrated into the new unit but are still part of the already existing functional departments.

To strengthen the commercial and service-specific aspects of digital services, Gamma is currently recruiting a product manager for digital services who will belong to the product management of the medical devices. However, in the future, Gamma plans to combine technical and commercial aspects into an integrated digital service unit: *"Now digital services is a separate department, consisting of software and hardware engineering. [in the future], I would bundle everything that has do with digital services in such a*

*department. Thus, not only the technology but also commercial – everything"* (C1, 25). Figure 6 shows the organizational setup of Gamma.

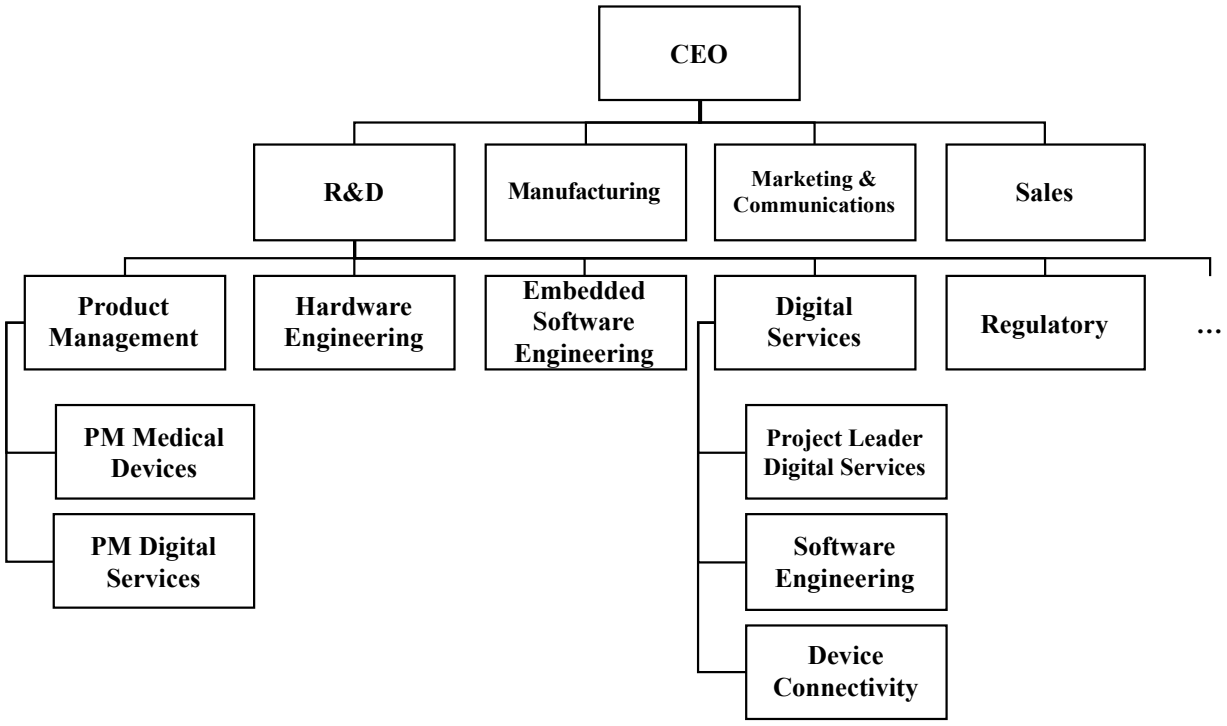



*Figure 6: Organizational setup of Gamma*

Several aspects motivated the separation of the digital service unit from other engineering departments. First, by establishing a dedicated digital service unit within the R&D department, Gamma is able to create more visibility and awareness for the topic within the organization. In the past, Gamma faced difficulties to create the required urgency and importance to strategically and operationally address the topic, as digital services had only a limited relevance for the business activities and market segments: *"So that the area of digital services, which we are now organizationally forming, becomes visually recognizable on the organization chart. So that everyone who looks at it can see that there are digitalization activities, and several people are working on it. [...] And that they are directly subordinated to me – I manage them directly myself. So that everyone can see that this is important now"* (C1, 54).

Moreover, by creating dedicated organizational functions and by defining responsibilities, Gamma is able to foster the targeted identification and development of digital services: *"Someone has to be able to take care of it. […] Who takes the responsibility and gets started with it. […] You have to have one to two persons who are responsible and get started"* (C2, 34). Furthermore, the experiences of Gamma also highlight that not only

dedicated engineering resources are required but also service-specific and commercial resources that are responsible for developing the service concept and business model of digital services: *"Thus, a person [is missing] that we are recruiting now, who can think about the building blocks and how we can generate any added value. However, we are not there yet"* (C1, 40).

Nonetheless, the new organizational setup also creates some new challenges. Especially the demarcation between the development of medical devices and IoT-enabled digital services can be challenging. Gamma has integrated the development of connectivity and IoT-solutions into the digital service unit to foster an integrated development of digital services. However, these IoT-solutions are strongly related to the device hardware and must be considered in device development projects. Thus, the organizational setup affects the coordination between device hardware and digital service development projects: *"But there are also other topics: Where are the basic requirements specifications?; Where is the demarcation?; Do we only develop it for two devices, or all, as all [devices] will have connectivity?; Will the [connectivity] project serve all of the devices?; However, not all of them at the same time? Thus, it is mainly an organizational issue. One major issue is the demarcation to other [development] projects"* (C1, 63).

#### *4.4.3.2 Organizational culture*

As already described in the context of the reconfiguration routines and processes, Gamma has a strong market- and customer-oriented organizational culture. Thus, this culture fosters the generation of market- and customer-related insights. However, due to the market- and customer-oriented culture, Gamma rather focuses on exploitative innovation within existing market segments and for existing customer demands: *"Part of our corporate culture is that we do many things. We have resources at our disposal. We feel like doing many things. In other words, digitalization was always secondary compared to the devices – out of focus. We always have a two to three years perspective. […] Very market-driven, what can I sell today"* (C2, 40). Accordingly, a market- and customer-oriented culture can also hinder the exploration of new technologies and market segments, as in the case of digital service innovation, which is often not driven by explicit customer demands (cf. 4.4.2.1).

Another aspect of Gamma's organizational culture that hinders digital service innovation is the risk-averse approach to the development of medical devices. Thus, in medical device companies, employees are encouraged to focus on medical device safety. However, as the informant highlights, such an approach can hinder the exploration of new technologies as risk assessments might be difficult ex-ante: *"I am in medical technologies and not in a*

*Berlin app development startup. That is the topic for me. You can always become safer. […] That is where I see the risk that we will not make any progress, that we miss the opportunity" (C2, 28).*

Furthermore, another informant of Gamma highlights that missing top management support could hinder digital service innovation as well. However, the top management of Gamma considers digital service innovation as important and supports corresponding activities: *"Internally, the challenge is to recognize the importance of these activities - I think that is given in the management, [...]the understanding that it is important and that it is the future that is given in our management"* (C1, 29).

#### *4.4.3.3 Resources and capabilities*

Within the market segment, Gamma is one of the leading medical device companies and has developed in-depth knowledge about the application of its medical devices and the corresponding medical field: *"Certainly, the opportunities are that we have an expert knowledge, if we manage to demonstrate it in digital services, in […] intensive care medicine, that would be the opportunity"* (C2, 6). Accordingly, this knowledge is considered as an important existing resource that will facilitate the development of digital services: *"What we can use […] is the applicatory competence, and that we know how the devices are used"* (C1, 1). Furthermore, the market position of Gamma also provides systematic access to customers and medical advisors, which is perceived as another important resource that facilitates the development of digital services: *"The access to the customers, that would be something we have in our backpack – systematic access to customers"* (C2, 7).

Since the development of Gamma's medical devices involves a large part of software engineering, Gamma has already established state-of-the-art software engineering methodologies, such as Scrum: "*it [digital services] is essentially software engineering. Regarding software engineering, we are state-of-the-art with Scrum and everything, that is something we will be able to use"* (C1, 37). Thus, existing software engineering capabilities and methodologies will facilitate digital service innovation.

### 4.4.4 Summary

The case of Gamma has provided insights into 12 different routines and practices that can be related to multiple innovation capabilities. Furthermore, various antecedents that drive digital service innovation have been identified. Table 15 summarizes the findings regarding the identified innovation capabilities.

*Table 15: Findings case Gamma*

| | Routines and practices | Findings |
|---|---|---|
| **Reconfiguration** | Structured and formalized strategy process | A structured and formalized strategy process drives the targeted identification and execution of new opportunities for digital services |
| | Establishing a steering board | Establishing a steering board facilitates the transition from the fuzzy front-end to the development phase |
| | Establishing a dedicated organizational function | A dedicated organizational function responsible for digital service innovation fosters the systematic identification and execution of digital service development projects |
| **Internal coordination** | Medical device development process | The existing requirements-driven medical device development process is not fully suitable for developing digital services, as for digital services it is difficult to define the endpoint of the development process |
| | Iterative and incremental development model | The development process of digital services rather follows an iterative and incremental development model |
| | Integrated development process | Integrating hardware and software engineering facilitates the integrated development of IoT-enabled digital services |
| | | An integrated development process of IoT-enabled digital services can be hindered by strong interdependencies between hardware and digital service development |
| | Developing service components | A dedicated organizational function responsible for digital service innovation fosters the systematic development of service concepts and business models |
| **External coordination** | Collaborating with external partners | Collaborating with external partners provides access to relevant technological competencies more quickly compared to an internal development |
| | | Collaborating with external partners facilitates the management of capacity fluctuations of R&D resources |
| | Selecting and coordinating external partners | For selecting and coordinating external partners, relevant competencies on the topics of the collaboration have to be built internally |
| **External learning** | Integrating customers | Integrating customers into the development process facilitates external learning about customer needs and requirements |
| | Prototyping | Prototyping interface designs facilitates external learning about the customer experience of digital services |
| | Collaborating with external partners | Collaborating with external partners fosters external learning on technological components of digital services by enabling knowledge exchange between external subject matter experts and the development team |
| **Internal learning** | Knowledge management | Cross-functional collaboration between R&D departments facilitates internal learning on technological components of digital services |
| | | Limited organizational distance between development teams fosters knowledge exchange and facilitates internal learning |

## 4.5 Case Delta

### 4.5.1 Background information

Delta's parent company is an international management holding that is mainly engaged in medical technologies. Delta develops and manufactures medical devices in the area of ophthalmology. The firm is headquartered in Switzerland and employs about 250 employees. Delta serves multiple customer segments, such as hospitals, private practices, and optometrists. The medical devices are sold globally via a network of distributors. In selected market, the parent company operates subsidiaries that sell the devices directly to end-users. As Delta has only limited access to end-users, the firm has not established a considerable service business. Currently, the service business consists of second-level support, repair, and spare parts. Consequently, Delta's present business model is mainly drive by device sales. Despite the dominant role of the medical devices, over the past, also software solutions to control and operate the devices have gained much relevance. These on-premise software solutions are sold as part of the medical device and are not generating independent revenues. However, Delta has recently started to develop cloud-based software solutions that enable service-driven business models and revenues. Thus, to a limited extent, Delta already provides specific functionalities of its software solutions online and device independently. Besides cloud-based software solutions, Delta also aims to strengthen its after-sales business in the future by developing and providing smart and remote services to distributors and end-users. However, these digital services are still in a pre-development phase and are currently assessed strategically.

#### *4.5.1.1 Strategic relevance of digital services*

Digital services are currently not anchored in the corporate strategy of Delta and do not receive major strategic focus: *"[…] but specifically in the strategy it is not yet anchored in such a way that we could say it has really a great importance"* [D1, 1]. According to an informant, the limited strategic relevance is caused by the difficulty to determine the business value of digital services: *"I think the strategic importance is very small at the moment because people did not calculate the business case or do not see it, so they do not understand where to make money with it"* (D2, 1). Thus, generating additional revenues by digital services is not considered as a strategic priority. Delta rather aims to provide digital services to differentiate their products from competitors, as well as to enable distributors to increase device sales: *"It [digital services] can have great importance when it comes to enabling our customer, i.e., our distributors, to sell our products better, but of*

*course, also to promote the preference for our products by offering good services. But revenue streams, I am still having some trouble seeing them."* (D1, 2).

Despite the limited importance of digital services for Delta's current business, the informant believes that in the future, cloud-based software solutions and service-driven business models will become highly relevant for Delta*: "I believe that the product and the application of the product are becoming strongly digitalized […]. Thus, I assume that the software world will further impact the hardware world and that we have to identify digital services to earn money at all"* (D2, 5).

### 4.5.2 Innovation capabilities

#### *4.5.2.1 Reconfiguration routines and practices*

Delta has not implemented a dedicated strategy process for identifying and executing digital service opportunities: *"We do not have one, it is none existent. As said, we have one that works for classic products, but it works differently"* (D1, 57). However, according to the informant, the existing strategy process for identifying and executing innovation projects is not suitable for digital services: *"If I simply take the criteria that we have, then such projects would fail because they do not generate any revenue, they do not generate the required revenue, and because they may not be so describable as a product"* (D1, 59). First, the assessment and evaluation of innovation projects are based on measures and key performance indicators (KPIs) that work for physical products but not for digital services.

Secondly, the process fosters innovation projects with a well-defined business case. However, Delta find it difficult to define and describe the underlying business model and business case of digital services: *"Every time we bid such a topic against a classic one, it loses, because with the classic topic the business model is clear and with the digital one the business case is not clear, therefore it loses"* (D2, 2).

Finally, the existing strategy process mainly focuses on identifying product ideas that are driven by explicit customer needs or opportunities to improve existing technological approaches: Thus, the existing strategy process and its underlying steering mechanism mainly focus on exploitative innovation, while digital service innovation is rather considered as explorative innovation: *"That is something I have realized that you probably have to be much more agile. However, in our case, we are always focused on revenue. We usually do not do projects to evolve ourselves further, but it [digital service innovation] is going into this direction. […] However, our process does not take that into account"* (D1, 59).

Furthermore, Delta considers the organizational structure as another factor that affects the capability to identify and execute corresponding innovation projects. Currently, the firm is missing a dedicated function that drives the identification and execution of new opportunities for digital services: *"I think we need someone who is even more strategic about how ecosystems are transforming in the digital world. [...] So on the side between market and strategy, a lot is missing. There we have nobody who works strategically on those topics"* (D2, 25). Additionally, the missing organizational function goes hand in hand with a lack of accountability for the topic. Therefore, currently, it is not clearly defined who is responsible for driving digital service innovation: *"Currently, it is not defined. That is something that the organizational structure would need to provide, that it is clearly defined who is responsible"* (D1, 62).

Besides organizational processes and structure, the strategic orientation of Delta has been identified as an additional determinant that influences the capability to identify and execute digital service initiatives. The informants describe Delta's culture as rather short-term oriented that results in a strong focus on exploiting existing market segments: *"[...] we are not that strategic and conceptual. We are much more operational and profit-oriented, rather focused on the daily and short-term business"* (D1, 70). However, due to the strong short-term and exploitation focus, digital service innovation is not fully reflected in the strategy process: *"But it is probably also because we cannot pull a fixed strategy for the next ten years out of our pocket. In our company, that is always a bit of a problem. […] We are too short-term oriented to emphasize that"* (D2, 3).

#### *4.5.2.2 Coordination routines and practices*

***Internal coordination***

Delta has not implemented a dedicated process for developing digital services. Digital services and software solutions are developed according to the existing development process for medical devices that is compliant with existing industry regulations. The medical device development process follows a waterfall and requirements-driven development methodology. However, the informants indicate that a requirements-driven development methodology is less suitable for digital services and that digital services required a dedicated development process: *"I believe that this [a waterfall and requirements-driven development methodology] is no longer possible for digital services which are mainly focused on customer processes. I have to collaborate with the customer on this part and try it out. Thus, it has to become much more iterative, which is better reflected by the software world […]"* (D2, 46). Accordingly, the development of digital services deals with the mapping of customer processes, which are often heterogeneous and

difficult to capture in advance. Thus, a dedicated development process for digital services should follow an iterative and incremental development methodology, as well as integrate customers much further: *"Ideally, it would be much more of a trial and error approach, testing at the customer site. Thus, having a development model that makes it possible to install and test certain things and, if they are valid, to roll them out as a product"* (D1, 47).

However, according to the informant, aligning an iterative and incremental development process with existing industry regulations is perceived as a major barrier to the implementation of a corresponding process: *"But if it is a medical device, we find it difficult, extremely difficult as you cannot go there and say 'trial and error' and just give it a trial. Because you always have the entire release process"* (D1, 48).

Moreover, the informant highlights that the development of digital services consists of two elements. On the one hand, the development of the service components, including the mapping and modeling of the customer process and, on the other hand, the development of the software application. Furthermore, the development of the service components precedes and encompasses software engineering: *"I would say it is very much upstream, but also very much accompanying. So, you cannot stop at the moment you start with engineering. I think it is coming together, and that is why it requires agility"* (D2, 47)

While Delta has already established the development of software applications, the dedicated development of the service components is still missing. Therefore, for the future, Delta sees the need to establish a dedicated function that is responsible for developing digital services: *"As said, I think we need someone who specifically takes care of digital services, who also integrates the required knowledge here internally. […] As I said, we have the product managers, who know the application, but for services, we still have to build up the knowledge. There we need people who gather it, condense it, and draw the right conclusions"* (D1, 19).

***External coordination***

Currently, Delta collaborates only for selected technological aspects such as the software and cloud architecture with external suppliers and service providers. These collaborations provide Delta access to relevant technological competencies much faster compared to internal development or external recruiting: *"We are already buying external consulting services on topics such as the [software] architecture, as we are not able to get the specialists as quickly"* (D2, 32). However, the informant highlights that sourcing external competencies requires sufficient internal knowledge on the topic in order to be able to identify and select external suppliers et all: *"And it affects the entire technical*

*architecture, not just the software architecture, but the entire cloud architecture that we need to build in the near future, where we have to understand which partnerships we will need. However, that is a competence we are missing"* (D2, 27). Thus, a complete outsourcing of R&D resources is not possible, as companies require relevant internal knowledge to identify, select, and manage external collaborations.

In general, Delta considers external collaborations with suppliers and service providers to be particularly relevant for sourcing technological competencies and components of digital services, while service-related competencies are considered as core competencies that need to be developed internally or within strategic partnerships. Therefore, Delta believes that strategic partnerships for digital services will become much more important, as small and medium-sized enterprises (SME) will not be able to manage the complexity of customer process-oriented services that integrate multiple data sources: *"And I believe that the collaborative approach is much more important for this topic as it has been until now. So far, we require only very view collaborations to develop a medical device. […] But can we create an ecosystem of digital services and with everything that goes with it? I do not think that is possible per se. So, we will become dependent on strategic partnerships whether they are technology partners or even equal partners"* (D2, 10). Accordingly, strategic partnerships do provide not only access to technological competencies but also address service- and customer-related competencies that are critical for developing customer process-oriented services.

As strategic partnerships are becoming more relevant in the future and will play a crucial role in developing and providing customer process-oriented digital services, Delta believes that adequate organizational processes and structures are required to manage these partnerships. According to the informant, the identification and management of strategic partnerships should be rather centralized within a management function of the parent company. A centralized management function gives the opportunity to develop an ecosystem perspective beyond the focal development project: *"Because that is really a cross-group topic. So, the correct way would be to anchor it within the group management. […] Thus, it would require a strategic marketing or business development function within the holding. That would be the correct anchoring. It does not exist at the moment, but there are tendencies in this direction"* (D1, 43). Consequently, identifying, establishing, and managing strategic partnerships requires adequate managerial functions and processes.

#### *4.5.2.3 Learning routines and practices*

***External learning***

Delta has realized that developing digital services requires deep insights into customer processes. However, at present, the firm lacks relevant insights into certain customer processes, as the current development activities mainly focus on medical devices, their physical functions, as well as their usability: *"And even there, I do not think we have all the expertise. Instead, you first have to see how the customer works exactly. Does he want such services? When do they want them, and how do they want to integrate them into their processes? There we still think too product-oriented and not so much in the processes"* (D1, 22). Accordingly, the informant indicates that customer knowledge, which is required for developing digital services, is different compared to medical devices.

As digital services require deep insights into customer processes, Delta considers an approach that integrates customers into the development processes as highly important: *"I believe that this [a waterfall and requirements-driven development methodology] is no longer possible for digital services which are mainly focused on customer processes. I have to collaborate with the customer on this part and try it out"* (D2, 46). Thus, integrating customers into the development process and testing prototypes fosters external learning about customer processes. The importance of testing prototypes is also underscored by another informant who adds that the development of digital services benefits from an iterative and incremental development model that fosters the testing of prototypes: *"Ideally, it would be much more of a trial and error approach, testing at the customer site. Thus, having a development model that makes it possible to install and test certain things and, if they are valid, to roll them out as a product"* (D1, 47).

Moreover, Delta is considering not only gaining customer insights by testing prototypes, but also through direct customer collaborations and co-development activities. According to the informant, customer co-development activities especially foster the generation of insights into customer processes: *"I think it is gonna turn a lot more into process modeling. In the sense that a product manager and someone who maps the process will develop the processes together with the customer"* (D2, 43)".

To facilitate access to relevant technological know-how and to foster external learning, Delta collaborates with external service providers: *"When it comes to the [software] architecture topic, it is definitely the case, that we are already collaborating with companies that already have 20 years of digital experience. Pure software companies"* (D2, 34). However, external collaborations with service providers are found to be mainly relevant to access technological knowledge but of limited importance regarding the market

and customer-related knowledge: *"I do not think you can buy it [customer knowledge] from consultancies, but maybe I am mistaken. […] Finally, I think you have to work directly with the customers"* (D1, 26).

***Internal learning***

According to the informant, internal learning is facilitated by establishing a dedicated organizational role or function that is responsible for developing digital services. Having defined responsibilities promote the acquisition, building, and sharing of corresponding knowledge within the organization: *"Basically you have to establish it organizationally so that you either bring in external people or make them internally responsible or promote them to a position where they then build up the knowledge or acquire the knowledge beforehand and then get into the position. So, this is the pure structure and also the organizational alignment. However, not only by one or more persons of this team but to carry the whole topic into different areas"* (D1, 24).

Furthermore, a dedicated organizational role acts as a kind of gatekeeper that gathers and prioritizes relevant knowledge before it is shared and assimilated by the organization: *"And there has to be someone who brings this knowledge together and ultimately also evaluates and prioritizes it, whether these are important issues that we want to implement or not. However, we do not have that yet. As I said, we have the product manager, who knows a lot about the [clinical] application, but for services, we still have to build up the knowledge. There we need people who gather, consolidate and condense the knowledge, as well as draw the right conclusions"* (D1, 21). However, such a role is still missing. Therefore, Delta faces difficulties to acquire and assimilate relevant knowledge that is required for developing digital services.

### 4.5.3 Organizational antecedents

#### *4.5.3.1 Organizational Structure*

Delta has implemented a functional organization with three dedicated areas: marketing and sales, research and development (R&D), as well as manufacturing. A dedicate unit for digital service innovation is not existing. Currently, digital service innovation is mainly driven by the product management and software engineering departments. However, within these departments, there are no dedicated roles that are responsible for managing digital service innovation. Thus, digital service innovation is rather implemented as a cross-sectional topic that is driven on an ad-hoc basis and by opportunities. Currently, the product managers of the different market segments and corresponding medical devices are responsible for the identification and initiation of product and service innovation projects.

In the case of digital service innovation, software applications are developed by the software engineering department, which also develops embedded device software. Consequently, at present, there are no dedicated responsibilities for the strategic and operative management of digital services innovation. Accordingly, the informant highlights that digital service innovation is currently not visible and anchored within the organizational structure of Delta: *"It is not anchored today"* (D1, 65).

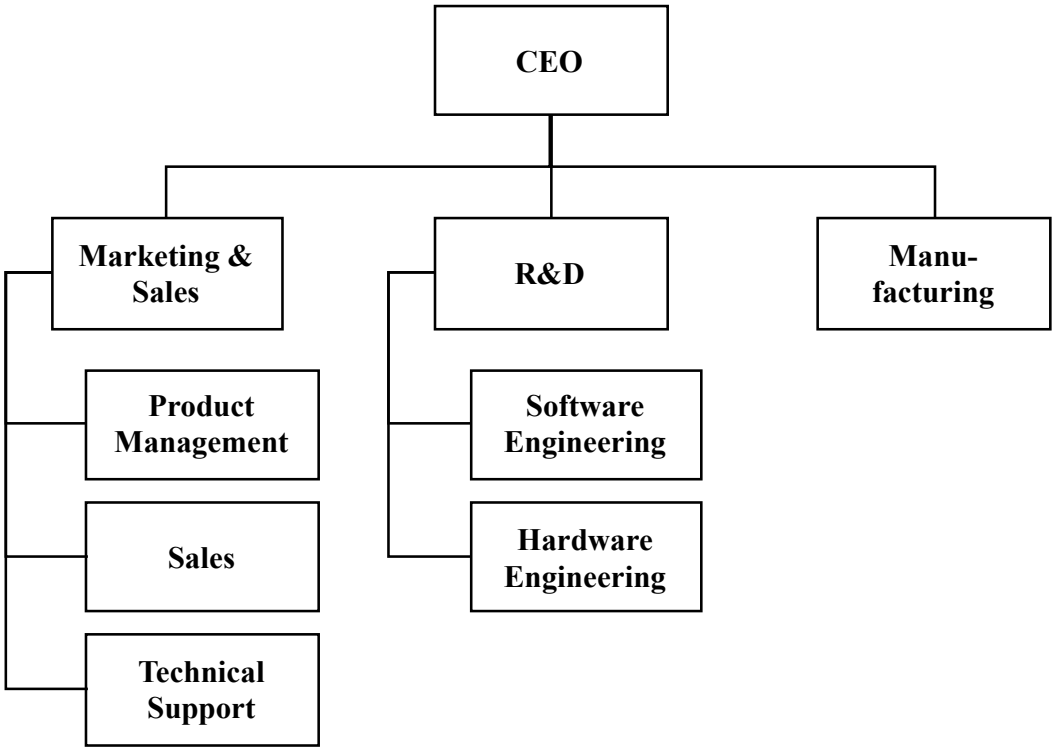



*Figure 7: Organizational setup of Delta*

In the near future, Delta plans to improve the organizational anchoring and visibility of digital service innovation through several measures. Therefore, the firm plans to establish dedicated organizational roles that are responsible for driving digital service innovation. For the strategic management of digital services innovation, Delta is considering recruiting a business development manager, who directly reports to the CEO and who will be responsible for identifying and coordinating corresponding innovation activities. The informant of Delta believes that establishing a staff position will increase visibility and strategic attention within the organization. Additionally, he highlights that a service-oriented mindset is required, which is difficult to establish within the existing departments: *"I just think it requires a different way of thinking for these digital services and that it gets lost if you just give the departments the job to take care of it. Therefore, I think it requires*

*a superordinate organization that does not do everything itself but at least puts the brackets around the different organizational units"* (D1, 28)

Moreover, to drive the operational management of digital service innovation, Delta is considering hiring a dedicated product manager for digital services who will be part of the existing product management department and who will be responsible for building detailed knowledge on relevant customer processes: *"And there has to be someone who brings this knowledge together and ultimately also evaluates and prioritizes it. Whether these are important issues that we want to implement or not"* (D1, 21).

Besides these minor adaptations to the organizational setup, another informant believes that in the mid-term, software solutions and digital services will become much more important within the markets of Delta. Accordingly, digital services will become an independent product segment: *"I think software products will gain importance, and it will slowly be established as an independent product segment"* (D2, 58). To adequately reflecting the importance of software solutions and digital services, he believes that a dedicated and independent organizational unit is required. Without establishing a dedicated unit, digital service innovation will remain a secondary topic with limited impact: *"As we have the product segments today, such as the product segment [anonymized], where we know that it earns as much money and is a major contributor to sales. […] I think you have to establish digital services as exactly such a segment. If you do not do that, then it always has a shadowy existence and nothing more"* (D2, 51).

#### *4.5.3.2 Organizational culture*

Delta has a long heritage in developing high-quality ophthalmic equipment. Within selected market segments, Delta is known for its technological sophistication. This external brand perception is also reflected in the organizational culture that is driven by a strong technology- and quality-orientation: *"Currently, I would say we are strongly technology-oriented"* (D1, 66). Furthermore, the informants consider the short-term orientation as another element of the organizational culture of Delta: *"We are much more operational and profit-oriented, rather focused on the daily and short-term business"* (D1, 70). Accordingly, the organizational culture of Delta rather fosters exploitative innovation within existing market segments and for explicit customer demands.

With regard to digital service innovation, the informants find that Delta misses a kind of start-up and entrepreneurial culture that would facilitate experimentation and agile development approaches: *"I think there is a little bit of a start-up culture missing, in the*

*sense that you are keen to experiment, as well as to be agile. I think that is missing"* (D2, 57).

Moreover, Delta has a strong product-oriented culture and mindset. Therefore, the organization faces difficulties in identifying and understanding service-oriented business models: *"Perhaps we also need to gain more competences from a fundamental service thinking. So, we are still at a point where we are surprised that we could earn money with services. We still have the feeling that you make money with the product; you do not make money with services. That is fixed in our minds"* (D2, 23). Thus, the missing service-oriented mindset hinders digital service innovation.

#### *4.5.3.3 Resources and capabilities*

Delta has a well-established network of dealers that provides systematic access to customers. Having access to deals and end-users is considered as an important resource for generating relevant customer insights and for developing digital services: *"We are actually already in intensive and close contact with our distributors, and I think you can use that [relationship]. This cooperation is not just a supplier-dealer contact. You can use the relationship to more accurately identify and develop such services"* (D1, 10).

Furthermore, as Delta has a long tradition in developing ophthalmic medical equipment, the company has gained a comprehensive knowledge of the clinical application of its devices, as well as the medical field of ophthalmology. This clinical- and market-related knowledge is considered as another important resource that facilitates digital service innovation: *"But I think nevertheless we know the business of ophthalmology, of diagnostics, of our customers. I think that is the strength"* (D2, 13).

Finally, as a leading manufacturer of ophthalmic medical devices, Delta has developed comprehensive technological competencies on the acquisition and processing of biomedical data. Therefore, the company has established software engineering resources and capabilities that enable the development of digital services. However, these capabilities are not considered as major assets as the lifecycle of these capabilities is very short: *"I would say that we could profit from the technological side, I mean the discipline of software and digital is still relatively young in the company, even though we now have 20 people who develop software – now saying that we are well-positioned on a topic that reaches its half-life every five years – I do not think that is the big asset"* (D2, 16). Accordingly, it is the customer- and market-related resources and capabilities that differentiate Delta from pure software companies with superior software engineering capabilities: *"But I do not think it is the key resource that we have in the company. So, I*

*believe a big software company would do it probably much faster and also has the technologies to make the foundation. They just do not have the knowledge about our customers and all the players that are acting in the market"* (D2, 18).

### 4.5.4 Summary

The case study of Delta has provided insights into 12 different routines and practices. These routines and practices partly relate to multiple innovation capabilities. Furthermore, various antecedents that drive digital service innovation have been identified. Table 16 summarizes the findings regarding the identified innovation capabilities.

*Table 16: Findings case Delta*

| | Routines and practices | Findings |
|---|---|---|
| **Reconfiguration** | Establishing adequate performance indicators and steering mechanisms | Existing product-oriented performance indicators and steering mechanism are not suitable for selecting and executing digital service development projects |
| | Establishing dedicated organizational functions and roles | A dedicated organizational function responsible for digital service innovation fosters the systematic identification and execution of digital service development projects |
| **Internal coordination** | Medical device development process | The existing requirements-driven medical device development process is not fully suitable for developing digital services, as it limits the integration of customers and the testing of prototypes |
| | Iterative and incremental development model | A digital service development process rather follows an iterative and incremental development methodology |
| | Customer process mapping | Systematic mapping and modeling of customer processes facilitate the development of digital services |
| | Developing service components | The development of service components precedes and encompasses the software development activities |
| | | Dedicated organizational functions and roles responsible for developing digital services foster the systematic development of service components |
| **External coordination** | Collaborating with external partners | Collaborating with external partners provides access to relevant technological competencies much faster compared to internal development |
| | Identifying and selecting external partners | For identifying and selecting external partners, comprehensive competencies on the topics have to be built internally |
| | Establishing and managing strategic partnerships | While external partners and suppliers mainly provide access to technological competencies, strategic partnerships provide access to service- and customer-related competencies that foster the development of digital services |
| | | For establishing and managing strategic partnerships, adequate managerial functions and processes have to be established |
| **External learning** | Integrating customers | Integrating customers into development process fosters external learning about customer processes |
| | Prototyping | Prototyping digital services foster external learning about customer processes |
| | Iterative and incremental development model | An iterative and incremental development model facilitates the testing of prototypes which fosters external learning about customer processes |
| | Co-development activities | Customer co-development activities foster external learning about customer processes |
| | Collaborating with external service providers | Collaborating with external partners fosters external learning on technological components of digital services by enabling knowledge exchange between external subject matter experts and the development team |
| **Internal learning** | Establishing dedicated organizational functions and roles | Establishing dedicated organizational functions and roles promote the acquisition, assimilation, and sharing of digital service-related knowledge, which foster internal learning |

# 5 Cross-case analysis

The previous chapter has provided an in-depth case analysis of how different medical technology firms manage and organize digital service innovation. By exploring different routines and practices as well as antecedents of digital service innovation, chapter 4 provides the foundation for the cross-case analysis. According to Miles et al. (2014), a cross-case analysis aims to deepen the "understanding and explanation" by examining similarities and differences across cases. Furthermore, a cross-case analysis enhances the generalizability of the findings, as well as their transferability to other contexts (M. B. Miles et al., 2014, p. 101). Therefore, the following chapter systematically compares the findings of the in-depth case studies along the dimensions of the guiding research framework (c.f. Figure 4) to provide generalizable findings regarding SRQ 1 and 2.

## 5.1 Barriers to digital service innovation

The exploratory case studies revealed several factors that influence a firm's ability to develop digital service innovations successfully. In the following, these factors or constraints are called *barriers* to digital service innovation. According to Mirow, Hölzle and Gemünden et al. (2007, p. 105), innovation barriers are factors that influence the innovation process of a firm by hindering, delaying, or transforming the innovation. Accordingly, overcoming innovation barriers is considered as a necessary, but not sufficient condition for successful innovation (Hadjimanolis, 2003, p. 559; Mirow et al., 2007, p. 103). Furthermore, organizational barriers to innovation are rather considered as the rule instead of an exception (Bannon & Grudin, 1990). Thus, understanding organizational factors that hinder digital service innovation is an important first step to identify organizational and managerial levers to overcome these barriers.

In general, innovation barriers can be analyzed on various levels, such as the individual, group, firm, or inter-organizational level (King, 1990). Additionally, research on innovation barriers distinguishes between external and internal barriers. External barriers originate from the external environment of the firm and cannot be influenced, while internal barriers can be influenced by the firm (Hadjimanolis, 2003, p. 560). As this thesis investigates organizational capabilities, the analysis of innovation barriers will focus on internal barriers at the firm level. However, while mainly focusing on organizational barriers, also characteristics of digital services that are found to impede existing innovation processes and activities are taken into account. Hadjimanolis (2003, p. 565) highlights that the "characteristics of innovation and its complexity determine to some extent the difficulties that the firm finds producing or adapting innovation to its needs."

### 5.1.1 Identified innovation barriers

The cross-case analysis resulted in the identification of 18 different factors that hinder or constraint the successful development of digital services. These 18 barriers are grouped into six different categories. Hadjimonolis (2003, p. 561) suggests classifying internal barriers into the sub-categories of people-related, structure-related, and strategy-related innovation barriers. Referring to him, Goepel (2013, p. 59) offers a more fine-grained classification. Accordingly, internal innovation barriers are classified into cultural, structural, strategic, resource-related, and employee-related. This thesis adopts the classification of Goepel (2013) and adds the categories of barriers related to the type of innovation and the innovation governance system. However, employee-related barriers are not considered, as the focus is on organizational barriers. Thus, the 18 identified innovation barriers are grouped into six different categories of innovation barriers. In the following, the findings of each category are discussed in detail. Table 17 provides an overview of the identified innovation barriers and their relevance within the case studies.

#### *5.1.1.1 Innovation type-related barriers*

As highlighted by Hadjimonolis (2003), certain characteristics of the innovation type might create specific barriers to innovation. The cross-case analysis revealed two specific characteristics of digital services that are found to impede existing innovation processes. First, the *heterogeneity of customer and market requirements* regarding digital service is highlighted as a barrier to developing scalable solutions. As digital services are information-intensive services and are developed to provide valuable information to support and enable customer processes, a detailed understanding of the underlying customer processes is required. However, the process and IT landscape of customers vary strongly. Additionally, digital services often have to comply with local legislation and regulation, resulting in varying market requirements. Therefore, medical technology companies find it difficult to identify and specify overarching customer requirements for digital services.

Finally, the cross-case analysis indicates that digital service innovation has to be considered as a type of innovation that is induced by a *technology-push*. The goal of a technology-push approach of innovation is to make commercial use of new technological capabilities, while market-pull innovation addresses existing customer needs and is often related to incremental innovation (Brem & Voigt, 2009, p. 355). However, the cross-case analysis showed that the innovation processes of medical technology firms are oriented towards innovation projects that address explicit customer needs and are driven by a market-pull. Thus, conventional market research methods such as customer surveys or

focus groups provide only limited insights regarding digital services and related customer requirements, as these methods mainly uncover existing customer needs (cf. Herstatt & Lettl, 2006, p. 153). Additionally, Herstatt and Lettl (2006, pp. 156–157) highlight that the source of innovation, technology, or market, also has implications for the innovation process. While waterfall model-based innovation processes such as the Stage-Gate process are well suited for market-pull innovation, technology-push innovation rather benefits from an iterative "probe and learn" approach. However, Alpha, Gamma, and Delta develop digital services according to the existing medical device development process, which follows a waterfall model. Thus, the technology-push nature of digital service innovation can be considered as a barrier to the existing innovation approach of medical technology firms.

*Table 17: Barriers to digital service innovation*

| Barriers | Alpha | Beta | Gamma | Delta |
|---|---|---|---|---|
| ***Innovation type-related*** | | | | |
| Heterogeneity of customer and market requirements | + | + | + | + |
| Technology-push driven innovation | + | + | ++ | ++ |
| ***Culture-related*** | | | | |
| Short-term orientation | + | | ++ | ++ |
| Unbalanced customer orientation | | | ++ | + |
| Product-centric mindset | + | + | + | ++ |
| Risk aversion | + | | + | + |
| ***Strategy-related*** | | | | |
| Missing digital service strategy | ++ | | ++ | ++ |
| Unclear business model | + | | + | + |
| Missing business case | ++ | | + | ++ |
| ***Structure-related*** | | | | |
| Lack of organizational anchoring | ++ | + | + | ++ |
| Missing service development | ++ | | ++ | + |
| Integrating hardware and software development | + | | + | |
| ***Resources-related*** | | | | |
| Lack of qualified human resources | + | + | + | + |
| Lack of customer process knowledge | ++ | + | ++ | ++ |
| Lack of technological knowledge | + | | + | + |
| ***Innovation governance-related*** | | | | |
| Missing leadership and senior management support | + | | + | ++ |
| Misaligned incentives | + | + | + | + |
| Inadequate portfolio decision criteria | + | | | ++ |

++ = significant barrier; + = barrier

### *5.1.1.2 Culture-related barriers*

Several culture-related factors are found to influence the digital service innovation capability of medical technology firms. First, a strong *short-term orientation* is found to

impede digital service innovation, as it rather fosters incremental product innovation. Short-term orientation describes a corporate culture that focuses on "goals and objectives in the near future at the cost of those that build sustainable competitive advantage" (Voss & Blackmon, 1998, p. 147). Thus, managers tend to focus on short-term opportunities within existing market segments while missing investments in the long-run (Laverty, 1996, p. 826). The case studies indicate that especially Gamma and Delta faces challenges to foster digital service innovation due to a strong focus on short-term objectives and goals. Furthermore, the case studies indicate that a strong customer orientation further reinforces the short-term orientation. While a strong focus on customer needs is often considered as a key success factor for developing and commercializing technological innovations, it might also inhibit radical or disruptive innovations, as incumbents only focus on existing customer segments, as well articulated and explicit customer needs (Slater & Mohr, 2006, p. 30). Slater and Narver (1998, p. 1002) indicate that a "customer-led philosophy […] is reactive and short term in focus, and generally leads to adaptive rather than generative learning". The cross-case analysis confirms these findings, as Gamma and Delta's innovation projects tend to focus on incremental product innovation that meets articulated customer needs and pays off immediately. Accordingly, the informant of Gamma states that the culture of the company is *"very market-driven – what can I sell today"* (C2, 41).

Besides a strong focus on explicit customer needs within existing market segments, the product-centric mindset of medical technology firms might also hinder the identification and development of digital services. Following Shah et al. (2006, p. 105), a product-centric organization has a strong transaction-orientation with a basic philosophy of selling products and a strong focus on new product development. Accordingly, an informant of Delta highlights that the firm struggles to identify the business value of digital services due to the strong product-centric mindset: *"[…] we are still at a point where we are surprised that we could earn money with services. We still have the feeling that you make money with the product; you do not make money with services. That is fixed in our minds"* (D2, 23). Therefore, Gebauer and Friedli (2005, p. 76) highlight that servitizing manufacturers have to establish a "value-added managerial service awareness", meaning that services are no longer considered as non-value-adding activities (Schuh et al., 2004, p. 41).

Finally, the cross-case analysis indicates that the industry setting of medical technology companies induces a risk-averse corporate culture. Alpha, Gamma, and Delta develop digital services that are regulated as medical devices. However, existing medical device regulations and quality management systems require a risk-averse development approach that focuses on patient safety. Accordingly, the case companies find the risk-averse culture

of medical technology firms as barrier for the implementation of experimental development models such as "trial and error" or "probe and learn" approaches: *"But if it is a medical device, we find it difficult, extremely difficult as you cannot go there and say 'trial and error' and give it a trial"* (D1, 48) However, research on technology-induced innovation emphasizes the need for iterative and incremental development models to deal with the underlying uncertainties and risks (Gerpott, 2005, p. 42; Herstatt & Lettl, 2006, p. 157).

#### *5.1.1.3 Strategy-related barriers*

Research on servitization in manufacturing has described a missing or not clearly defined service strategy as a major factor that inhibits service innovation and service revenues. Gebauer et al. (2006, p. 378) find that "a clear service strategy encourages companies to make the appropriated organisational arrangements and resource allocations." The case studies of Alpha, Gamma, and Delta provide evidence that a *missing digital service strategy* or the lack of anchoring the topic within the corporate strategy is a major barrier to the initiation of innovation activities, the development of necessary capabilities, as well as the creation of adequate organizational structures. The case of Beta illustrates that a digital service strategy and underlying strategy process results in clearly defined strategic priorities that guide the development of new digital services. Furthermore, without a strategy, the required organizational change is not initiated.

Another strategy-related barrier refers to the challenge to identify and develop adequate business models for digital services: *"But the business model is not transparent to me, yet. In other words, if the customer is willing to pay."* (C1, 58). Thus, especially Alpha, Gamma, and Delta struggle to develop and implement adequate business models for digital services. As the quote highlights, medical technology firms find it difficult to define value propositions for which the customer is willing to pay. However, without a clear understanding of the business model of digital services, senior managers are not willing to provide sufficient financial resources for digital service innovation: *"The budget [for digital services] is missing. Now I draw the line to the beginning. As long as one does not see the business model, the business case, the budget will not be provided"* (D2, 35).

Closely related to the unclear business model of digital services is the missing business case. Innovation projects are assessed and selected based on clearly defined business cases that provide relevant performance indicators such as the break-even time. Without an adequate business model, firms are not able to calculate business cases that fulfill existing performance indicators of innovation projects. However, without a business case, firms are not able to calculate the financial returns of digital service innovation. Thus, digital

service innovation is associated with high risks and uncertainties regarding the commercialization: *"A fundamental problem is of course that you cannot write a real business case and that there is an investment into the future required, which is somehow abstract. Abstract would not be so bad, but which is without a tangible business case, or at least not in numbers*" (D1, 33).

#### *5.1.1.4 Structure-related barriers*

Structure-related barriers refer to the organizational structure, as well as processes and routines. In general, the cross-case analysis resulted in the identification of three major structural barriers that affect the innovation process. First, a *lack of organizational anchoring* of digital service innovation constraints a focused and targeted innovation approach. Especially, Alpha and Delta, which did not create dedicated units responsible for developing digital services, face the challenge of unclear responsibilities. However, without a clear organizational anchoring of digital service innovation, the topic depends strongly on the initiative of individual employees, as well as their competencies: *"Well, it is always the case that if the person does it well, then it is a great thing and it will work. However, if someone, who does not have enough intuition or background knowledge, which services are really promising, then it just goes wrong, because there is no corresponding process for it"* (A1, 96). Thus, the successful development of digital services becomes a coincidence.

The other two identified barriers relate to the procedural anchoring of digital service innovation. The case studies showed that without a dedicated service development process, service concepts, user experience, and business models tend to be developed only indirectly within hardware and software engineering. Thus, development activities mainly focus on the technical components, while service components are not systemically developed and tested: *"That we think about the service as a 'Design Object', that is something that is missing, and that creates various challenges. First of all, with regard to the development process, up to the point that the service is not accepted by the market, as is was not sufficiently specified and tested. There is no service prototyping. We do technical prototyping, but no service prototyping"* (A1, 115).

Also related to the procedural anchoring of digital service innovation is the *integrated development of service, hardware, and software components of digital services*. Due to the strong interrelations of the different components, Alpha and Gamma highlight the need for a holistic and integrated development approach. However, the companies find it also challenging to integrate these different development activities as the development cycles of software and hardware development are substantially different. Nevertheless, it remains

unclear how to organize the development of service, hardware, and software components. Are the activities integrated into a single development project or developed in separated streams within dedicated development teams and units?

#### *5.1.1.5 Resources-related barriers*

Resource-related barriers refer to a lack of tangible and intangible resources. With regard to digital service innovation, all case companies highlight that they face major challenges to hire qualified software engineers: *"So you do not find the people with expertise. [...] The challenge is to recruit and find the right people"* (C1, 30). On the one hand, the overall demand for software engineers in industrial companies is very high, which leads to a highly competitive labor market. On the other hand, applicants often lack the necessary skills for digital service in an industrial and regulated environment. Additionally, the lack of necessary skills does not only apply to technical personnel but is also an issue within marketing and sales: *"Not only on the technical side but also in marketing, i.e., on the strategic and product management side"* (D2, 42). According to an informant of Alpha, managers and employees lack a basic problem understanding of how digital service innovation differs from product innovation: *"To make it clear, one could of course also say that there is a lack of awareness of the problem"* (A1, 54).

Another resource-related barrier that was identified across the case companies refers to a lack of customer process knowledge. Insufficient customer process knowledge was mentioned as a major barrier by Alpha, Gamma, and Delta: *"[...] but the actual knowledge of what the customer actually needs or how the customer really uses the product is missing"* (A1, 20). One reason for the lack of customer process knowledge relates to the organizational structure and anchoring of the development team. For example, Alpha's development team struggles to create relevant insights into customer process, as the team members have only very limited access to customers and customer-facing employees: *"And in the medical device unit, we have hardly any customer contact ourselves, [...]"* (A1, 20). In contrast, Beta facilitates the generation of customer insights by having integrated the digital service unit within the sales organizations. Thus, Beta's development team is in constant exchange with customers and customer-facing employees.

Finally, the companies also face challenges due to a *lack of technical knowledge*. Especially, missing knowledge about cybersecurity, as well as the regulatory requirements of IoT-enabled medical devices, are a barrier of digital service innovation in medical technology firms: *"Security, for example. We simply notice that we do not have the know-how in-house. As soon as you open up to the big world, security is a big issue, and we do not have this competence in-house"* (C1, 3). However, the case analysis shows that general

software engineering competencies are available to the companies. Thus, the barrier relates to specific competencies about medical device connectivity, cloud computing, and mobile software application.

#### *5.1.1.6 Innovation governance-related barriers*

According to Deschamps and Nelson (2014, p. 4), innovation governance deals with the top management task of stimulating and steering innovation. Thus, innovation governance refers to "a holistic system that sets and aligns goals, defines policies and values, prioritizes processes, allocates resources, and assigns roles, responsibilities, and decision-making authority to key players." The cross-case analysis resulted in the identification of three different governance-related barriers to digital service innovation: (1) *missing leadership and senior management support*, (2) *misaligned incentives*, and (3) *inadequate portfolio decision criteria*

While senior management support is a well-known success factor that facilitates innovation activities (Evanschitzky et al., 2012, p. 28), *missing leadership and senior management support* might turn into a barrier. An informant of Alpha mentioned that their senior management faces difficulties in understanding the organizational implications of digital service innovation and is therefore unable to initiate the required organizational change, e.g., implementing an adequate governance and steering system. Furthermore, the senior management has to provide leadership and direction by defining and communicating a vision for digital service innovation: *"Of course you need leadership, someone who has a clear vision where it is going. […] Well, we would have required more leadership"* (A2, 53). While Alpha faces challenges in driving digital service innovation due to missing leadership and senior management support, Beta benefits from top management sponsors that foster digital service innovation and the required organizational change: *"It requires a champion who drives the topic"* (B1, 40).

The second governance-related barrier refers to *misaligned incentives*. Research on servitization finds that manufacturing firms have to align their incentive system to promote services sales (Kanninen et al., 2017, p. 237). However, the case studies indicate that an adequate incentive system is also relevant to foster service-related innovation activities within product-centric firms. In the case of Alpha, misaligned incentives hinder cross-functional collaboration, as important internal stakeholders are incentivized to different goals and objectives*: "They are also not incentivized to the same goals. […] This makes it difficult, at least in individual cases, to motivate them to support you directly with their knowledge. Alternatively, that they do things proactively"* (A1, 49) Additionally, the misaligned incentives also hinder the integrated development of digital services, as the

project leaders of hardware and software engineering are incentivized towards hardware and software specific goals and not towards an integrated system of hardware, software, and service.

Portfolio management is a crucial aspect of innovation management that aims to optimize "the trade-off between return and risks" (Adams, R., Bessant, J., & Phelps, 2006, p. 35). The systematic allocation of limited resources is a key task of innovation portfolio management. Firms employ various decision criteria to evaluate and select innovation projects (D. L. Hall & Nauda, 1990, pp. 126–127). The case studies showed that most firms still rely on financial criteria that are based on product-oriented performance metrics and business models: *"If I simply take the criteria that we have, such projects would fail because they do not generate any revenue, they do not generate the required revenue"* (D1, 61). Therefore, the cross-case analysis indicates that *inadequate portfolio decision criteria* are a barrier to digital service innovation. In order to facilitate digital service innovation, medical technology firms need to implement decision criteria that are able to reflect the commercial and strategic value of digital services and service-oriented business models.

### 5.1.2 Interdependency of innovation barriers

The cross-case analysis indicates that certain identified barriers occur in dependence on each other and can be mutually reinforcing. Thus, none of the identified innovation barriers occur in isolation. Figure 8 tries to systemize the interdependencies of the barriers, as well as illustrate the most important interfaces. Starting with the interface of strategy- and structure-related barriers, the case studies show that companies without a clear digital service strategy are more reluctant to initiate the required organizational change. Therefore, they face challenges due to undefined responsibilities and a lack of organizational anchoring of digital service innovation. However, it is found that not only "structure follows strategy" (Chandler, 1962), but also that the structure affects the strategy and strategy formulation process (cf. D. J. Hall & Saias, 1980). Thus, without an adequate anchoring of digital service innovation and the definition of corresponding responsibilities, the identification and formulation of a digital service strategy are hindered or at least constrained. One could argue that the top management is responsible for formulating and executing the digital service strategy, and therefore the strategy formulation should not be influence by the organizational structure. However, the cases show that the formulation of the digital services strategy requires comprehensive knowledge of customer processes and the firm environment, which is fostered by a decentralized structure (cf. case Alpha and Beta). Accordingly, the cross-case analysis

suggests that the formulation of a digital service strategy benefits from a decentralized anchoring of digital service innovation.

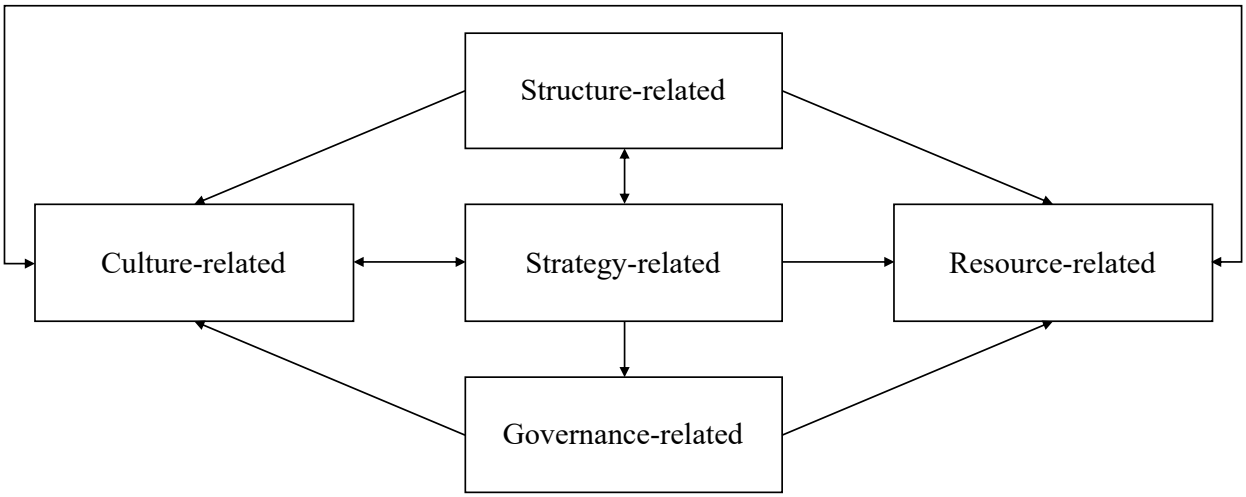



*Figure 8: Interdependency of identified innovation barriers*

In addition, three out of four case companies face difficulties in identifying and implementing adequate business models for digital services. This strategy-related barrier is influenced by the organizational culture. Similar, Shrivastava (1985, p. 110) observes that "organizational culture is a critical variable for effective strategy making." Thinking and experimenting with service-oriented business models is found to be more difficult in organizations with a strong product-centric mindset. Additionally, companies with a short-term-oriented culture struggle to formulate explorative digital services strategies, as their limited resources are rather spent on exploiting existing market and customer segments. Furthermore, a formulated and communicated digital service strategy, which states the mission and goals of service innovation, is able to create service awareness within the organization, which consequently promotes the development of a service-oriented culture and mindset. Therefore, the relationship between strategy- and culture-related barriers is found to be reciprocal.

Innovation governance steers the implementation of innovation. Therefore, implementing appropriate governance mechanisms requires the formulation of strategic goals and objectives (Deschamps & Nelson, 2014, p. 51). The case studies indicate that companies that miss a clearly defined digital service strategy face difficulties in implementing adequate governance mechanisms to steer innovation activities. Besides the interface to strategy-related barriers, governance mechanisms also relate to the organizational culture. By implementing service-oriented KPIs, as well as reward and incentives systems, the management is able to influence the organizational culture. This finding is in accordance with Kerr and Slocum (2005, p. 137), which state that "a careful consideration of reward

system design can help decision makers successfully modify the organization's culture. Reward systems are, in effect, powerful mechanisms that can be used by managers to communicate desired attitudes and behaviors to organization members".

Organizational culture is not only influenced by the strategy and governance mechanisms, but also by the organizational structure. By establishing a dedicated and decentralized digital service unit that applies an iterative and incremental development process, Beta was able to promote an entrepreneurial culture, which is considered to foster digital service innovation. Thus, by implementing a suitable organizational structure, firms are able to reinforce values and beliefs that foster digital service innovation (cf. Hartnell et al., 2011).

With regard to resource-related barriers, various interfaces towards the other barrier dimensions are found. First, by implementing a decentralized organizational structure, Beta was able to increase customer-orientation, as well as the acquisition of customer process knowledge. Furthermore, by applying an iterative and incremental development process, Beta facilitates external learning and the generation of customer insights. Secondly, the case studies show that the allocation of sufficient resources to digital service innovation is hindered due to a limited understanding of the underlying business model and business case of digital services. Accordingly, due to strategy-related barriers, firms are reluctant to recruit qualified personnel for digital service innovation. Thirdly, the case study of Delta demonstrates that inadequate portfolio decision criteria hinder the evaluation and selection of digital service innovation projects, which results in the allocation of only limited resources for digital service innovation. Finally, a reciprocal link between resource- and culture-related barriers is found. Short-term orientation and an unbalanced customer-orientation with a strong focus on articulated and explicit customer needs fosters incremental product innovation and hinders investments into explorative digital service innovation. Therefore, companies build only limited resources for digital service innovation. One the other hand, a lack of qualified human resources that have comprehensive experience in service innovation hinders the implementation of a service-oriented organizational culture. Regarding changing the organizational culture, Schwartz and Davies (1981, p. 48) find that "major changes in management personnel, including adding outsiders as a source of new skills and new cultural patterns, are often necessary. Massive management education may be required".

## 5.2 Strategic importance of digital service innovation

The cross-case analysis shows that all case companies assume that in mid- and long-term digital services gain high strategic importance. Medical technology firms expect that

healthcare customers will increasingly demand complex digital services that support the core processes of healthcare delivery. Nevertheless, how digital services will exactly impact their current business is still rather vague. Thus, except for Beta, the case companies face difficulties in determining the business value of digital services. Therefore, these companies mainly develop digital services to differentiate their physical product offerings from competitors, as well as to increase customer retention. However, generating additional revenues is not considered as a major strategic priority. The limited revenue focus within these firms can be explained by the barrier to identifying adequate business models and corresponding business cases.

*Table 18: Strategic relevance of digital services*

| | Strategic priorities | | | Strategic relevance |
|---|---|---|---|---|
| | **Revenue** | **Customer retention** | **Product differentiation** | |
| **Alpha** | - | + | + | o |
| **Beta** | + | ++ | + | + |
| **Gamma** | - | o | + | o |
| **Delta** | - | o | + | - |

++ = very high; + = high; o = medium; - = low

The comparison of the cases reveals that the ability to determine the business value of digital services is associated with the strategic importance of these services. Companies that develop digital services only to increase product differentiation or customer retention face difficulties in determining the business value of these services. However, without tangible and measurable outcomes, digital services receive only limited strategic importance within the case companies (see Table 18). This finding is highlighted by an informant of Delta, who states: *"I think the strategic importance is very small at the moment because people do not calculate the business case or do not see it, so they do not understand where to make money with it"* (D2, 1). Additionally, as a result of the limited strategic relevance of digital services for today's business, companies are rather reluctant to comprehensively invest in digital services innovation, as well as to initiate organizational and managerial measures to develop required organizational capabilities. Accordingly, the cross-case analysis indicates that medical technology firms have to balance short-term and long-term objectives of digital service innovation. While investments into exploratory innovation activities, whose business value is more difficult to determine, might be necessary for long-term survival, firms also have to focus on

innovation activities that provide tangible outcomes in the short-term. Without creating tangible business value in the short-term, establishing structures and capabilities for exploratory digital service innovation seems to be difficult, as digital service innovation remains secondary and is considered of only limited strategic importance.

*Proposition 1: To increase the strategic importance of digital services and to initiate the development of required organizational capabilities and structures, managers have to balance the short- and long-term objectives of digital service innovation.*

## 5.3 Digital service innovation capabilities

Based on the guiding research framework (see chapter 3.2), the cross-case analysis has led to the identification of 15 different routines and practices that enable and drive digital service innovation. The overview of routines and practices that facilitate the development of digital services in medical technology is necessarily not complete but rather reflect those routines and practices that have been identified across multiple companies. Table 19 gives an overview of the identified routines and practices, as well as the corresponding findings. In the following, each routine or practice is explained, and their occurrence within the case companies is shortly described.

*Table 19: Routines and practices of digital service innovation capabilities*

| Dimensions | Routines and practices | Findings |
|---|---|---|
| Reconfiguration | *Establishing a dedicated organizational function* | Separating digital service innovation from medical device innovation and establishing dedicated roles and processes fosters the identification and execution of digital service innovation projects |
| | *Applying a structured and formalized strategy process* | Applying a structure and formalized strategy process to digital service innovation promotes the systematic identification and selection of opportunities |
| | *Implementing dedicated steering mechanisms* | Establishing dedicated steering mechanisms such as dedicated performance indicators, steering boards, and top management sponsors facilitates the selection and execution of digital service innovation projects |
| Internal coordination | *Implementing a dedicated digital service innovation process* | Establishing a dedicated digital service innovation process that follows an iterative and incremental development methodology facilitates the development of software and service components of digital services |
| | *Integrating service, software and hardware development* | Integrating service, software and hardware development by using integrative liaison devices such as multi-disciplinary project teams facilitates holistic and integrated development of IoT-enabled digital services |
| | *Establishing autonomous and independent development teams* | Establishing autonomous and independent development teams facilitates the application of iterative and incremental development methodologies |

| Dimensions | Routines and practices | Findings |
|---|---|---|
| External coordination | *Collaborating with external partners* | Establishing external collaborations facilitates access to relevant technological capabilities, but requires sufficient subject-matter knowledge and adequate steering processes |
| | *Establishing strategic partnerships* | Establishing strategic partnerships facilitates access to complementary capabilities, but require adequate routines and processes to manage and orchestrate the service ecosystem |
| Internal learning | *Building digital service prototypes* | Digital service prototypes promote internal learning by facilitating codification and internal communication of service-related knowledge |
| | *Integrating frontline employees into the innovation process* | Integrating frontline employees into the innovation process facilitates the assessment of the viability and desirability of new service concepts |
| | *Promoting cross-functional collaboration* | Cross-functional collaboration promotes holistic and integrated development of digital services by facilitating knowledge exchange between functional units and experts |
| External learning | *Establishing a hypothesis-driven development methodology* | Implementing a hypothesis-driven development methodology promotes experimentation and identification of latent customer needs |
| | *Validating digital service prototypes with customers* | Testing digital service prototypes with customers reduce uncertainty and ambiguity of new service concepts and foster the generation of customer knowledge |
| | *Integrating customers into the innovation process* | Integrating customers into the development of digital services facilitates the identification and validation of customer needs and the acquisition of customer knowledge |
| | *Integrating external partners into the innovation process* | *Integrating external partners into the innovation process fosters knowledge acquisition and development of relevant technological capabilities* |

### 5.3.1 Reconfiguration: Identifying and initiating digital service innovation

#### *5.3.1.1 Establishing a dedicated organizational function*

The analysis of the main organizational barriers of digital services innovation showed that a lack of organizational anchoring hinders a focused innovation approach. Consequently, it is found that the organizational setup directly affects the capability to identify and execute new opportunities for digital services innovation. Thus, the cross-case analysis shows that establishing a dedicated organizational function for digital service innovation fosters the identification and execution of digital service innovation projects. The case studies of Alpha and Delta revealed that a missing organizational anchoring of digital service innovation results in a lack of accountability for identifying new opportunities and formulating digital service strategies. Therefore, Beta and Gamma established dedicated

teams that are responsible for driving digital service innovation. Furthermore, in the case of Beta, the head of digital service innovation directly reports to the CEO, which increases the visibility and priority of the topic within the firm, as well as accelerates the execution of new initiatives. The importance of establishing specialized departments for digital service innovation is confirmed by recent research on service innovation (den Hertog et al., 2010; Dörner et al., 2011; Kindström et al., 2013). Thus, Kindström et al. (2013, p. 1067) find that firms need to create "new organizational roles, systems and processes that continuously capture and relay customer demands" to be able to sense new service opportunities.

#### *5.3.1.2 Applying a structured and formalized strategy process*

The cross-case analysis of organizational barriers to digital service innovation has shown that a missing service strategy is a major barrier to initiating digital service innovation. The case studies indicate that a structured and formalized strategy process is a prerequisite for developing a digital service strategy. Beta has established a formalized strategy process to identify and execute new opportunities for digital services. The process is conducted every year. Accordingly, at least once a year, Beta reviews new opportunities for digital services innovation. Additionally, a formalized strategy process facilitates the transition from the fuzzy front-end of the innovation process to actual development projects. However, Alpha and Delta find that their existing strategy processes for tangible products are not suitable for identifying and executing digital service opportunities. According to an informant of Delta, the underlying structure of the existing strategy process for medical devices does not fit digital services, as it fosters rather exploitative innovation within well-defined markets, as well as for explicit customer needs. However, in the case of explorative digital services innovation, which rather creates new markets and addresses latent customer needs, developing a business case that is based on figures such as market size and expected market share is difficult. Thus, the existing strategy process for medical devices does not reflect the nature of digital services. In summary, the cross-case analysis finds that a dedicated, formalized, and structured strategy process drives the identification and execution of new opportunities for digital services.

#### *5.3.1.3 Implementing dedicated steering mechanisms*

Closely related to a structured and formalized strategy process are dedicated steering mechanisms for digital service innovation. The cross-case analysis shows that missing or inadequate steering mechanisms are a major organizational barrier to digital service innovation. For example, Alpha and Delta struggle to execute digital service opportunities

as no dedicated steering mechanisms are in place. In contrast, Beta has established a dedicated steering board for digital service innovation. The steering board is run by the Group CEO and regularly reviews new opportunities. By establishing a centralized steering board and appointing top-management sponsors to new initiatives, Beta is able to drive the execution of new digital service opportunities. Similarly, Gamma finds that a steering board facilitates the transition from the fuzzy front-end of the innovation process to the actual development phase.

Besides, structural steering mechanisms, the case studies also indicate that medical technology firms need to establish adequate portfolio decision criteria for digital service innovation. The case of Delta reveals that inadequate portfolio decision criteria that are based on product-oriented performance metrics and business models hinder the identification and execution of digital service opportunities. Therefore, medical technology firms need to establish decision criteria that take into account the commercial and strategic value of digital services.

### 5.3.2 Internal coordination: Managing the digital service innovation process

#### *5.3.2.1 Implementing a dedicated digital service innovation process*

The majority of the case companies have not implemented a dedicated innovation process for digital services. Alpha, Gamma, and Delta develop digital services according to their existing medical device innovation process that follows a waterfall development methodology. These processes have to be compliant with existing medical device industry regulations such as ISO 13485 and IEC 62304. Only Beta has implemented a dedicated digital service innovation process. In contrast to the medical device innovation process, this process follows an iterative and incremental development methodology. Thus, software features are incrementally developed and continuously deployed. The informants of all case companies emphasize that due to the technology-push nature of digital service innovation, waterfall-based innovation processes are less suitable for the development of digital services. The cases indicate that the development teams of digital services face high uncertainty and ambiguity regarding the design problem and possible solutions, which results in high development risks. Therefore, the informants suggest implementing an innovation process that follows an iterative and incremental development methodology.

Furthermore, the cross-case analysis reveals that existing medical device innovations processes only focus on the development of technical components of digital services. Thus, service components are not considered as distinct design objects and are therefore not specifically developed. Therefore, the case study of Beta indicates that a dedicated

digital service innovation process facilitates the development of service components, such as the service concept, user experience, and business model.

#### *5.3.2.2 Integrating service, software and hardware development*

IoT-enabled digital services consist of service, software, and hardware components with strong interdependencies between the different components. The case studies show that hardware and software components are currently mainly developed in independent development projects with separate responsibilities. However, due to the different development cycles, integrating software and hardware development is found to be difficult. Nevertheless, Alpha and Gamma see the necessity to develop IoT-enabled digital services as an integrated system of service, software, and hardware components. Therefore, the different development streams have to be integrated by adequate liaison devices such as multi-disciplinary project teams that share the joint responsibility for service, software, and hardware development. Additionally, Gamma considers developing IoT-enabled digital services according to the layered architecture of an IoT-stack (cf. Fleisch et al., 2015, p. 447), whereas the hardware, connectivity, and software layer are developed in independent streams but integrated by pre-defined hardware and software interfaces. This development set-up allows taking into account the idiosyncratic features of software and hardware development while ensuring an integrated development of the different layers of IoT-enabled digital services.

#### *5.3.2.3 Establishing autonomous and independent development teams*

The cross-case analysis indicates that establishing autonomous and independent development teams facilitates the implementation of iterative and incremental development methodologies. Beta has established such teams by merging most relevant competencies such as project management, software engineering, marketing, and logistics into an integrated development team. The integration of these competencies into autonomous and independent development teams facilitates coordination and reduces the need for complex cross-functional collaboration between project teams in matrix organizations. Furthermore, these digital solutions development teams are equipped with comprehensive authority for the use of the resources, but on the other hand, are also accountable for the project outcomes. Thus, by establishing autonomous and independent development teams that are responsible and accountable for the development outcomes, firms are able to accelerate the decision-making process, which facilitates the implementation of an iterative and incremental development methodology. Mintzberg (1980) calls such an organizational setup an Adhocracy, which groups functional

specialists into market-based teams with “quasi-formal” authority. As the name indicates, Mintzberg (1980) suggests that an Adhocracy is rather of temporary nature as it aims to solve complex problems ad hoc. However, the case of Beta suggests that digital service innovation teams should not be set-up in a temporary project organization but as constant product teams. A constant product organization facilitates a continuous development and deployment of digital services, which is the foundation of an iterative and incremental development methodology.

### 5.3.3 External coordination: Integrating external capabilities

#### *5.3.3.1 Collaborating with external partners*

The cross-case analysis shows that collaborating with external partners is an important element of digital service innovation. The cases indicate that medical technology firms establish external collaborations to gain access to relevant technological capabilities. External collaborations provide access to technological capabilities more quickly compared to an internal development. As many companies are just starting to develop digital services, external collaborations are important to kick off digital service innovation activities and to achieve first results more quickly. However, the cases also reveal the importance of having sufficient technological capabilities internally to be able to identify, select, coordinate, and steer external collaborations. Else, insufficient internal capabilities lead to high dependencies from external partners and to a failure of the collaboration. The importance of internal knowledge to acquire and integrate external knowledge during innovation activities is confirmed by research on open innovation that refers to the importance of absorptive capacity (West & Bogers, 2014, p. 821). Accordingly, Cohen and Levinthal (1990, pp. 135–136) find that “prior knowledge permits the assimilation and exploitation of new [external] knowledge.”

#### *5.3.3.2 Establishing strategic partnerships*

The case studies reveal that establishing strategic partnerships is becoming especially relevant when medical technology firms aim to provide customer-process oriented digital services. These services often integrate several companies and their specific capabilities into the service delivery system. Thus, to support the entire customer processes, firms require complementary capabilities that are not entirely available internally. Therefore, Alpha and Delta consider external collaborations that focus on integrating complementary capabilities such as service- and customer-related knowledge as strategic partnerships, as they directly affect the value creation and positioning of the firm within the service ecosystem. Accordingly, both firms highlight the importance of adequate processes and

functions to manage the joint value creation and to orchestrate the service ecosystem. The relevance of establishing adequate routines and practices to manage and orchestrate the service ecosystem is also highlighted by existing research on service innovation (Gebauer et al., 2013; Kindström & Kowalkowski, 2014; Parida et al., 2014).

### 5.3.4 Internal learning: Assimilating digital service knowledge

#### *5.3.4.1 Building digital service prototypes*

Alpha and Beta do not only use prototypes to collect early user feedback but also to facilitate internal learning about new service ideas and concepts. By building digital service prototypes and service blueprints, the case companies are able to increase the tangibility of new service concepts, which enables team members to communicate ideas and features to other team members and managers. According to Beta, prototypes make it easier to discuss and evaluate the feasibility and desirability of new service concepts during the very early stage of the development process. Additionally, Alpha emphasizes the importance of testing prototypes to improve the codification of intangible and implicit customer knowledge. By systematically testing prototypes and documenting these tests, customer knowledge becomes codified, which facilitates knowledge management and promotes internal learning. Therefore, the cross-case analysis shows that building digital service prototypes promote internal learning by facilitating the codification and internal communication of service-related knowledge.

#### *5.3.4.2 Integrating frontline employees into the innovation process*

Research on service innovation discusses the importance of integrating frontline employees into the innovation process (Åkesson et al., 2016; Cadwallader et al., 2010; Karlsson & Skålén, 2015). Ordanini and Parasurman (2011, p. 18) find that frontline employees improve service innovation outcomes due to their "proximity to and frequent interactions with service customers, coupled with their latent knowledge (gained through experience) about how things could/should be done differently to improve customer service." The cross-case analysis reflects these findings. Beta's development team closely collaborates with frontline employees from the sales organization. Frontline employees are involved in testing and prioritizing new digital service concepts. By integrating frontline employees into the innovation process, the development team obtains relevant customer knowledge from the sales organization. Additionally, Beta integrates frontline employees into the development of digital services, by building multi-disciplinary development teams that include employees from sales and marketing. Alpha also highlights the importance of integrating frontline employees into the innovation process

to gain access to customer knowledge. However, the company misses adequate communication channels and liaison devices to facilitate the knowledge transfer between the sales and marketing organization and the development team.

#### *5.3.4.3 Promoting cross-functional collaboration*

Innovation research shows that cross-functional collaboration is an important success factor of new product and service development (Cooper & Kleinschmidt, 1995, p. 377; Storey & Hull, 2010, p. 140). Furthermore, cross-functional interfaces increase absorptive capacity and facilitate organizational learning (Cohen & Levinthal, 1990, p. 134; Jansen, Van Den Bosch, et al., 2005, p. 999). The cross-case comparison shows that companies have to implement liaison devices such as cross-functional teams, regular team meetings, and adequate communication channels to promote cross-functional collaboration. Beta has established cross-functional teams with team members from marketing, sales, engineering, and supply chain management to foster knowledge exchange. Gamma facilitates cross-functional collaboration and knowledge exchange between different R&D units by establishing regular exchange meetings and by encouraging direct contact between functional experts. However, Alpha faces difficulties to foster cross-functional collaboration as adequate communications channels are missing. Furthermore, the cross-case analysis shows that organizational distance between the different stakeholders affects cross-functional collaboration. Alpha's development team struggles to collaborate with marketing and medical affairs as these functions are located in different divisional units. To decrease organizational distance and improve cross-functional collaboration between the development team and frontline employees, Beta has established the digital service unit within the sales organization.

### 5.3.5 External learning: Acquiring external knowledge

#### *5.3.5.1 Establishing a hypothesis-driven development methodology*

For developing digital services, Beta uses a hypothesis-driven instead of a requirements-driven development methodology: *"It is not like [developing] medical devices, where you specify the requirements and two years later you compare if they are met. Here they [the requirements] are rather variable. You start with a hypothesis and over the course of the [development] process, one realizes that the hypotheses have to be adapted"* (B1, 35). Whereas a requirements-driven approach requires comprehensive knowledge of customer needs and requirements in advance, a hypothesis-driven approach is applied when considerable uncertainty regarding the desirability and viability of a proposed product, service, or business model exists (Blank, 2013, pp. 67–68; Eisenmann et al., 2012, p. 1).

Thus, a hypothesis-driven development methodology is based on a series of experiments that aim to validate or reject falsifiable hypotheses (Reed & Schaub, 2019). A hypothesis-driven development approach is often combined with an iterative and incremental development methodology. Accordingly, Reed and Schaub (2019) notice that "[i]nstead of developing a monolithic solution and performing a big-bang release, we iterate through hypotheses, evaluating how features perform and, most importantly, how and if customers use them." Hence, establishing a hypothesis-driven development methodology promotes experimentation and the identification and validation of latent customer needs.

#### *5.3.5.2 Validating digital service prototypes with customers*

The cross-case analysis has revealed that missing customer process knowledge is one of the main barriers to digital services innovation. Therefore, medical technology companies often face a high degree of uncertainty and ambiguity regarding the design problem of digital services. Due to the technology-push nature of digital service innovation, not only the solution to be developed is unknown, but also the customer problem to be solved is not well understood. Accordingly, all case companies highlight the importance of building and testing prototypes, as well as validating minimum viable products (MVPs) to learn about customer needs and to generate customer knowledge. Ries (2011, p. 74) defines an MVP as that product version that allows the development team to generate sufficient information to validate basic customer hypotheses with the least amount of development time. Furthermore, Ries highlights that MVPs compared to prototypes aims to test fundamental business hypotheses instead of focusing on technical or design-related questions. Alpha, Delta, and Gamma mainly build and test prototypes before the first release of the service. Beta also uses prototypes such as wireframes during early development phases, but also develops MVPs to validate the product-market fit: "By using the minimum viable product approach, you have to test and understand if it works, before you go into standardization." To test and validate MVPs, Beta collaborates with lead users and early adopters. Hence, the cross-case analysis indicates that testing and validating prototypes and MVPs allows medical technology companies to reduce uncertainty and ambiguity of new service concepts, as well as to foster the generation of customer knowledge.

#### *5.3.5.3 Integrating customers into the innovation process*

Customer co-development is a widely discussed concept within service innovation research (Kindström & Kowalkowski, 2014; Parida et al., 2015; Salunke et al., 2019). The ability to integrate customers into the development process and to learn about customer

needs and requirements is found to be an important service innovation capability (Kindström & Kowalkowski, 2014, p. 102). All case companies, to a certain extent, involve key customers and lead users into the development of digital services. Alpha, for example, uses advisory boards and focus groups to involve key customers and "thought leaders" into the development process and to learn about customer needs. Beta's development team directly visits customers and discusses potential ideas and solutions with them. Additionally, Beta applies a lead user approach to integrate customers into the development process. The lead user concept was introduced by von Hippel (1986), and it refers to users that "face needs that will be general in the marketplace – but face them months or years before the bulk of that marketplace encounters them" and who "are positioned to benefit significantly by obtaining a solution to those needs" (von Hippel, 1986, p. 796). Applying a lead user approach allows Beta to generate insights into latent customer needs. Furthermore, Delta highlights the importance of co-development activities, such as joint development workshops to generate customer process knowledge. In general, the cross-case analysis indicates that integrating customers into the innovation process facilitates the identification of customer needs, as well as to generate customer knowledge.

#### *5.3.5.4 Integrating external partners into the innovation process*

To gain access to external technological capabilities and knowledge such as software architecture or cybersecurity capabilities, Gamma and Delta collaborate with external suppliers and solution providers during the development of digital services. The informant of Gamma notes that the focus of these collaborations is not only to access these capabilities but also to initiate a knowledge transfer to internalize such technological capabilities. However, collaborating with external partners to gain access to customer-related knowledge is considered as less relevant as this knowledge is perceived as highly idiosyncratic and has to be obtained directly from customers and users. Thus, integrating external partners into the innovation process of digital services promotes the acquisition and internalization of technological capabilities. Accordingly, Teece et al. (1997, p. 515) emphasize that the ability to integrate and deploy external competencies is at the core of dynamic capabilities.

## 5.4 Antecedents to digital service innovation

### 5.4.1 Organizational structure

The case companies use different organizational structures to develop digital services, as well as anchor digital service innovation. Table 20 shows how the case companies have allocated digital service innovation activities.

*Table 20: Allocation of digital service innovation activities*

| | R&D | Marketing | Sales | IT | Dedicated unit | External partners |
|---|---|---|---|---|---|---|
| **Alpha** | ++ | + | o | o | n.a. | +++ |
| **Beta** | o | o | ++ | + | +++ | + |
| **Gamma** | ++ | + | o | o | ++ | ++ |
| **Delta** | +++ | + | o | o | n.a. | + |

Legend: +++ = very high; ++ = high; + = medium; o = low; n.a. = not applicable

Despite Beta, most digital service innovation activities are driven by the R&D departments of the case companies. This illustrates the strong focus of medical technology companies on the development of the technical components of digital services. Marketing and the corresponding product management are mainly responsible for specifying the basic market requirements. Gamma and Delta currently have no dedicated product managers for digital services, while Alpha has established dedicated product managers within selected therapeutic areas. However, all companies highlight the importance of establishing dedicated organizational roles responsible for driving digital service innovation. Accordingly, Gamma and Delta are planning to recruit dedicated product managers for digital services, who will be responsible for the acquisition of comprehensive customer knowledge, as well as the development of service components and business models.

Within Alpha, Gamma, and Delta, the sales department does not play a relevant role in the development of digital services. Thus, the limited integration of customer-facing employees into the development process further indicates the strong technology-driven approach to digital service innovation. Furthermore, the cross-case analysis shows that IT departments are not considered as an important contributor to digital services. Within the case companies, the IT departments are responsible for providing and maintaining the internal IT infrastructure and do not have any responsibilities regarding digital services. According to an informant of Beta, IT departments follow a centralized and synergy-

driven approach to information systems, meaning that they try to operate one standardized information system across the entire company. However, digital service innovation requires a decentralized and customer-driven development approach: "*An IT department is traditionally driven by synergy. If possible, a standard system, preferably with a joint development team. Which in best case scales, as well as is nearshored. However, this is completely diametrically. That diverges. The digital people say: 'I want to be close to the customer'"* (B2, 12).

Alpha and Gamma are sourcing substantial technological capabilities and resources from external service providers. In the case of Alpha, this is the result of a company-wide strategy to keep operations lean, while Gamma considers external sourcing mainly as an opportunity to gain access to relevant capabilities and resources more quickly. Accordingly, the company aims to establish all the required capabilities to develop digital services internally. The importance of having all relevant competencies internally is further underlined by Beta, which collaborates only for selected topics with external providers: *"If I want to be competitive in 'digital', I have to have the required core competencies in my digital unit; thus, I will try to build up those competencies internally"* (B2, 54).

Beta and Gamma have established dedicated units for the development of digital services. Gamma has integrated all technological capabilities and resources within the dedicated unit, while the product management is currently still separated, but will be become part of the integrated digital service unit in the near future. Beta has already established a fully integrated digital service unit. The unit is organized as a multi-disciplinary product organization compared to a matrix project organization. Thus, Beta tries to integrate all relevant competencies in independent and autonomous digital service teams. Compared to project-related assignments or tasks, those teams that are constantly assigned to specific digital services. Furthermore, these teams are part of the sales department, which facilitates the acquisition of customer knowledge. Moreover, by integrating the digital service unit within the sales department, Beta is able to establish a result-oriented reward and incentive system. Finally, the cases of Beta and Gamma indicate that establishing a separated digital service innovation unit increases the visibility and awareness within the organization and therefore facilitates the required organizational and cultural change.

The comparison of the allocation of digital service innovation activities shows that the organizational setup of digital service innovation varies across the cases. Those variations can be partly explained by the path-dependent development of the organizational structure. However, an analysis of the most relevant dimensions of organizational structures

indicates certain "design parameters" (Mintzberg, 1980) that facilitate digital service innovation. Table 21 provides an overview of dimensions across the case companies.

*Table 21: Comparison of organizational dimensions*

| | Centralization | Formalization | Specialization | Separation |
|---|---|---|---|---|
| **Alpha** | +++ | +++ | + | o |
| | Centered in a firm-wide medical device unit. Only limited coordination with marketing and sales | Digital service innovation follows a highly formalized medical device development process | Within selected therapeutic areas, dedicated product managers for digital services | Digital service innovation activities are integrated within functional R&D and marketing units |
| **Beta** | o | + | +++ | ++ |
| | Decentralized development of digital service in a dedicated unit that is integrated into sales | Dedicated digital service innovation process that provides basic structure but is rather informal | A dedicated team of digital service managers and software engineers | Dedicated digital service unit separated from R&D and marketing, but integrated into sales |
| **Gamma** | + | +++ | ++ | + |
| | Centered in a dedicated digital service team and coordinated with product management | Digital service innovation follows a highly formalized medical device development process | A dedicated team of software and hardware engineers for digital service innovation | Dedicated digital service development team, separated from embedded software and hardware engineering |
| **Delta** | ++ | +++ | o | o |
| | Centered and integrated into the functional R&D unit and coordinated with product management | Digital service innovation follows a highly formalized medical device development process | No dedicated organizational roles for digital service innovation | Digital service innovation activities are integrated within functional R&D and marketing units |

+++ = very high; ++ = high; + = medium; o = low

Past research that aimed at analyzing organizational structures of firms has focused on various organizational dimensions. Among the most cited dimensions are centralization of decision making, formalization of processes and procedures, and specialization of tasks (Fredrickson, 1986; Hage & Aiken, 1967; Mintzberg, 1979; Pugh et al., 1963). Besides these well-known dimensions, structural separation is added as another organizational dimension to compare the organizational structure of the cases. Structural separation refers to research on organizational ambidexterity, which suggests that organizations can manage ambidexterity by separating exploitative and explorative innovation by creating autonomous structural units (Birkinshaw & Gibson, 2004; O'Reilly & Tushman, 2013; Raisch & Birkinshaw, 2008).

*Centralization:* Alpha and Delta have no dedicated units for digital services innovation. Therefore, decision-making authority cannot be delegated to dedicated managers and employees. Thus, the decision-making authority for digital service innovation stays mainly with the department heads of R&D and marketing, as well as the CEO. In comparison, Beta has implemented a rather decentralized organizational structure. Decision-making authority is mainly within the "independent and autonomous" development teams, which

are located within the sales department. Additionally, by locating these teams within sales, Beta increases customer proximity and fosters the involvement of customer-facing employees into the decision-making process of digital service innovation.

*Formalization:* Besides Beta, all case companies develop digital service based on a highly formalized Stage-Gate development process that is compliant to medical device regulations and quality management systems. Therefore, the innovation process is characterized by well-defined and formalized stages, gates, responsibilities, as well as comprehensive design controls. Beta applies an iterative and incremental development process that provides a basic structure but is less formalized compared to the medical device development process. Therefore, the development team is able to quickly adapt the development process and related activities to specific customer needs and requirements. All case companies emphasize that the formalized and rigid structure of the medical device development process hinders an iterative and incremental development approach. Therefore, the cross-case analysis shows that an iterative and incremental development approach is facilitated by a reduced formalization of procedures and processes.

*Specialization:* Alpha and Delta have integrated digital service innovation within their exiting functional marketing and R&D departments. Delta has not created dedicated roles and positions for digital service innovation neither within its R&D nor marketing department. Alpha has established dedicated roles for digital service innovation selectively, e.g., within product management and user experience (UX) design. However, none of the companies has created specialized functions or units for digital service innovation. On the contrary, Beta and Gamma have established specialized functions for the development of digital service. While Gamma's digital service unit is part of the R&D department and focuses on the technical development of IoT-enabled services, Gamma has created a specialized development team that covers the entire innovation process of digital services. Accordingly, Beta and Gamma have introduced specialized roles and structures to facilitate digital service innovation.

*Separation:* Specialization of tasks and structural separation seem to correlate. Beta and Gamma, which have established specialized positions and roles, also have separated digital service innovation from medical device innovation. The separation of digital service innovation into an independent and autonomous unit enables the companies to establish dedicated development processes, reward and incentive systems, as well as a service-oriented culture. Furthermore, the integration of all required competencies within a multi-disciplinary innovation unit improves internal coordination and organizational learning, as well as accelerates the decision-making process. Finally, organizational

separation increases the internal visibility of digital service innovation, which increases awareness among employees for the strategic importance of digital services. However, Alpha and Gamma, who develop IoT-enabled digital services, also indicate the importance of integrating hardware and software development of digital services. Although the organizational separation of digital services and medical device innovation enables firms to create structures, processes, and systems that best fit the corresponding organizational tasks, IoT-enabled digital services require adequate integration mechanisms and liaison devices to coordinate medical device and digital service innovation. Accordingly, the degree of organizational separation (e.g., separate sub-unit, distinct business unit, or spin-off) is dependent on the type of digital services, as well as the interdependencies of the required resources.

These findings are mostly in accordance with research on organizational structure and innovation, especially concerning exploitative and explorative innovation. General research on organizational structure and innovation has suggested that an organic structure, compared to a mechanic structure, facilitates innovation (Aiken & Hage, 1971; Burns & Stalker, 1961; Damanpour, 1991; Damanpour & Aravind, 2012b). An organic structure is characterized by decentralization of decision-making, lower formalization, and higher specialization, as well as lateral communication (Burns & Stalker, 1961, pp. 121–122; Damanpour, 1991, p. 579). According to Burns and Stalker (1961, p. 121), an organic structure is more appropriate in dynamic environments, which confront organizations with "fresh problems and unforeseen requirements for action which cannot be broken down or distributed automatically arising from the functional roles defined within hierarchic structure." Similar Mintzberg (1980, pp. 336–337) finds that innovation requires an organic structure with a low formalization of behavior, high horizontal specialization, and selective decentralization where decision making power is delegated to the project teams. The author calls this type of organization an *Adhocracy*. Accordingly, an Adhocracy can be described as a cross-functional project organization that temporally unites multi-disciplinary specialists for the purpose of solving complex organizational problems such as "sophisticated innovation". In such a project organization, the professional specialists are still grouped in functional units and only assigned to small market-based teams for the duration of the project. Therefore, an Adhocracy "relies extensively on matrix structure, combining functional and market base for grouping concurrently and thereby dispensing with the principle of unity of command" (Mintzberg, 1980, p. 337).

While the cross-case analysis confirms that digital service innovation benefits from an organic structure, the findings indicate that organizing digital service innovation in temporary project teams is less suitable. Beta emphasizes that a project organization is not

suitable for digital service innovation: *"Digital as a project is already lost, as a project ends, whereas digital solutions continuously develop further. After the project, people are tied in the next project, mainly other projects"* (B2, 43). Gamma also mentioned the difficulty of defining the endpoint of digital service innovation projects. Additionally, Beta highlights that the implementation of an iterative and incremental development process in a matrix organization is difficult, as responsibilities are distributed across specialized departments. The distribution of responsibilities leads to complex decision-making processes, which limits the flexibility and adaptability of the project organization. Finally, operating digital service innovation in a project organization does not create the same visibility and awareness within the organization as the creation of a distinct organizational unit. Therefore, the cross-case analysis indicates that digital service innovation is facilitated by creating a dedicated organizational unit that constantly integrates most of the necessary resources and competencies.

*Proposition 2: Digital service innovation in medical technology firms is fostered by an organizational structure that is characterized by customer proximity, decentralized decision-making, limited formalization of procedures and processes, as well as specialized roles and functions, which are grouped in a dedicated organizational unit.*

### 5.4.2 Organizational culture

The cross-case analysis confirms that organizational culture is an important antecedent of digital service innovation capabilities (cf. Bock et al., 2012; Schilke et al., 2018). The analysis of innovation barriers showed that various cultural properties might hinder or constrain digital service innovation. Nevertheless, the case studies also uncover cultural properties that enable and drive digital service innovation. Alpha and Beta highlight that market- and customer-orientation are important drivers for identifying customer needs and solutions, as well as generating customer knowledge. As opposed to this, the cases of Gamma and Delta show that customer-orientation can hinder digital service innovation, as medical technology firms tend to focus mainly on articulated customer needs and solutions, which results in incremental product innovation. However, this contradictory result can be explained by the different types of customer orientation. Slater, Narver and MacLachlan (2004, p. 336) differentiate between responsive and proactive market-orientation. While responsive market-orientation focuses on expressed needs, proactive market-orientation tries to uncover and address latent customer needs. Furthermore, Slater and Narver (1998, p. 1004) find that responsive market-orientation is characterized by a short-term view, focusing on customer satisfaction, while responsive market-orientation takes a long-term view, focusing on customer value. Slater and Narver's (1998) findings

indicate that Gamma and Delta have a responsive customer-orientation as both companies are short-term oriented, focusing on innovation activities with immediate returns. With the background that digital service innovation is found to be a technology push type of innovation that addresses evolving markets and latent customer needs, firms need to develop a proactive market orientation that seeks to identify latent customer needs and solutions.

Besides a proactive market orientation, Beta and Delta refer to an entrepreneurial culture that promotes experimentation as an important driver of digital service innovation. Similarly, Alpha is also emphasizing the importance of a culture that supports experimentation. In the context of technology-push innovation, experimentation is considered as an important approach to successful innovation outcomes. Souder (1989, p. 24) emphasizes that technology-push innovations require an iterative and incremental development approach that allows innovators to "interact with as many users as possible, and experiment with as many new product prototypes as possible within the user's setting." By experimenting with prototypes within the user setting, firms are able to identify latent customer needs and solutions: "This is a key element in catalyzing a joint awareness of the user's needs, and in crystallizing ideas for a product to satisfy these needs" (Souder, 1989, p. 24).

Finally, the case studies indicate that the risk-orientation of a firm is considered as a cultural factor that affects the magnitude of digital service innovation. The cases of Alpha and Gamma showed that a risk-averse culture could hinder digital service innovation. Thus, the firms are not willing to invest in development projects with uncertain outcomes. However, as digital service innovation addresses evolving markets and latent customer needs, it involves a certain degree of uncertainty. Therefore, it can be assumed that a risk-taking culture will facilitate digital service innovation.

Concluding, the cross-case analysis finds that an organizational culture that fosters (1) a proactive market orientation, (2) experimentation, and (3) risk-taking will facilitate digital service innovation. These three characteristics are well reflected in research on firm-level entrepreneurship and entrepreneurial orientation. Miller (1983, p. 771) describes an entrepreneurial firm as one "that engages in product-market innovation, undertakes somewhat risky ventures, and is first to come up with 'proactive' innovations, beating competitors to the punch." Following Miller's (1983) conceptualization of entrepreneurial orientation, most research refers to the underlying dimensions of innovativeness, risk-taking, and proactiveness (Rauch et al., 2009, p. 763). Innovativeness describes the willingness of a firm to engage in experimentation and creative processes with the goal of

introducing new products, services, and processes. Risk-taking refers to decision-making under uncertainty, as well as allocating significant resources to innovation despite unknown outcomes. Proactiveness is a forward-looking perspective that aims to identify opportunities for new products and services ahead of the competition by anticipating future demands (Dess & Lumpkin, 2005, p. 148; Rauch et al., 2009, p. 763). In a study on entrepreneurial and market orientation, Baker and Sinkula (2009) find that an entrepreneurial orientation improves innovation success and that entrepreneurial and market orientation complement each other. Accordingly, for identifying and proactively pursuing new market opportunities, firms require an entrepreneurial orientation grounded in a strong market orientation (Baker & Sinkula, 2009, p. 457).

*Proposition 3: Digital service innovation is driven by an organizational culture that fosters (1) proactive market orientation, (2) experimentation, and (3) risk-taking.*

### 5.4.3 Resource base

The existing resource base is an important driver of dynamic capabilities (Schilke et al., 2018, p. 404). Teece et al. (1997, p. 524) refer to strategic assets that determine dynamic capabilities. Accordingly, the existing resource base is an important antecedent of dynamic capabilities (cf. 3.1.2.3). In the context of this thesis, the cross-case analysis has identified different resources and operational capabilities that enable the development and exploitation of digital service innovation capabilities. Table 22 provides an overview of the identified resources and capabilities:

#### *5.4.3.1 Market resources*

Having direct access to customers and end-users is considered an important factor for developing digital services. Beta emphasizes that owning the customer interface is a prerequisite for digital service innovation as direct customer interactions provide relevant insights into customer needs and requirements, as well as facilitates prototyping: *"We are very close to our customers. We have very good sales channels. That is one of our strengths. That means we understood at a very early stage what they actually want"* (B1, 12). Furthermore, Delta highlights that established sales and distribution channels provide a better understanding of entire medical technology ecosystems as it also allows the acquisition of market knowledge about competitors and relevant stakeholders. Thus, having established *sales and distribution channels* is an important resource that enables digital service innovation in medical technology firms.

*Table 22: Resources and capabilities enabling digital service innovation*

| Resources and capabilities | Alpha | Beta | Gamma | Delta |
|---|---|---|---|---|
| ***Market resources*** | | | | |
| Sales and distribution channels | + | +++ | +++ | ++ |
| Installed base of medical devices | ++ | n.a. | ++ | ++ |
| Customer process knowledge | o | ++ | + | o |
| ***Technological resources*** | | | | |
| IoT capabilities | ++ | n.a. | + | + |
| Software engineering capabilities | + | ++ | ++ | ++ |
| Cybersecurity capabilities | ++ | + | o | o |
| ***Slack resources*** | | | | |
| Dedicated human resources | o | ++ | + | o |

Presence of resources and capabilities: +++ = very high; ++ = high; + = medium; o = low; n.a. = not applicable

Another resource that facilitates the development of digital services is an *installed base of medical devices* and equipment. According to Delta, the existing installed base of medical devices provides many opportunities for the development of IoT-enabled after-sales services such as remote diagnostics and predictive maintenance. Additionally, Alpha finds that the installed base is generating many direct customer and market insights that can be applied for the development of digital services: *"Because we have such devices in the field for ten years now, we know at least to some extent what interests the various stakeholders have regarding such digital platforms"* (A1, 41).

Comprehensive *customer knowledge* is considered as an important resource that facilitates the development of new products and services (García-Murillo & Annabi, 2002, p. 877; Koenig & Srikantaiah, 2000, p. 34; Li & Calantone, 1998, p. 13; Luca & Atuahene-Gima, 2007, p. 95). The cross-case analysis provides evidence that comprehensive customer knowledge is a prerequisite for digital service innovation. Alpha highlights that the existing customer knowledge enables the firm to identify "unmet needs" that can be addressed by digital services. Furthermore, Gamma and Delta have developed comprehensive knowledge about the clinical application of their medical devices. This applicatory knowledge is considered as an important resource for developing digital services: *"Our applicatory competencies, that we know how the devices are actually used"* (C1, 1). Another informant of Gamma stresses that the existing applicatory knowledge provides that the starting point for the development of digital: *"The opportunities lie in the fact that we have special knowledge. If we manage to make it available to intensive care medicine in the form of digital services, this would be the opportunity."* (C2, 6). Besides, customer knowledge that refers to the clinical application of the medical devices, the case companies highlight the importance of customer process knowledge about the

underlying clinical workflows. Knowledge about clinical workflows is often very customer specific and accordingly difficult to capture and generalize. As many digital services are developed to support and optimize customer processes and clinical workflows, customer process knowledge is considered as a key resource for digital service innovation. This finding is confirmed by Biege et al. (2012, p. 949), which found that "[t]he offering of successful new service strategies depends on the acquisition of detailed customer process knowledge and what services these customers perceive as valuable."

#### *5.4.3.2 Technological resources*

In the context of the medical technology industry, digital service innovation is strongly driven by the deployment of IoT technologies. Therefore, having comprehensive *IoT capabilities* promotes the development of digital services. Alpha was among the first companies that introduced a connected drug delivery device to the market. Thus, the firm had built knowledge and capabilities about medical device connectivity, cloud storage, and data processing. Similarly, Gamma highlights that device connectivity is a prerequisite for digital service innovation. Therefore, the company is currently focusing on establishing the IoT infrastructure to enable the development and provision of digital services: *"Our devices must be connected in some way, so that we can offer the customer a benefit with digital services at all"* (C1, 27). According to Whitmore et al. (2015, p. 261), IoT capabilities comprise sensing, networking, and processing capabilities that allow medical devices "to communicate with one another and with other devices and services over the Internet to achieve some useful objective." Hence, the cross-case analysis provides evidence that IoT capabilities drive digital service innovation.

Additional to IoT capabilities, the cross-case comparison shows that *software capabilities* are another relevant technological resource that enables digital services innovation. Over the last few years, all case companies have built capabilities in the field of software engineering. Accordingly, an informant of Gamma notes that in the context of digital service innovation, having software capabilities in-house provides an advantage compared to pure hardware suppliers. Nevertheless, besides the enabling role of software capabilities, Delta highlights that these technological resources are not a key asset as they are much more generic compared to market resources: *"But I do not think it is the key resource we have in the company. Very probably, a big software company would make this happen much faster. They just do not have the knowledge about our customers and about all the players that are present in the market"* (D2, 18).

In the context of medical devices and healthcare, cybersecurity is a major issue. Therefore, the case companies highlight that digital service innovation requires sufficient

cybersecurity capabilities. These capabilities are new to medical technology firms and are currently being developed. However, Gamma believes that cybersecurity capabilities are key to digital service innovation in healthcare and therefore need to be developed internally and should not be sourced from external service providers: *"So technological wise the topic of security: At the end of the day, we want to have this competence in-house, so that we know which encryption is applicable and how it is done"* (C1, 6). Similarly, Whitmore et al. (2015, pp. 265–266) find that cybersecurity issues are major barriers to the adoption and diffusion of IoT-enabled devices and services.

#### *5.4.3.3 Slack resources*

Organizational slack is defined as the "cushion of actual or potential resources which allows an organization to adapt successfully to internal pressure for adjustment or to external pressure for change in policy, as well as to initiate changes in strategy with respect to the external environment" (Bourgeois, 1981, p. 30). According to Danneels (2008, p. 525), slack resources refer to "a 'reserve' of resources that are in excess of what is needed for the immediate continuation of the firm's operations, and are thus available to spend on explorative activities." Furthermore, Nohria and Gulati (1996, p. 1249) highlight that firms with limited slack are more likely to focus on "short-term performance issues rather than on more uncertain innovation projects." Thus, slack human and financial resources provide the basis for long-term oriented exploratory innovation and are an important antecedent of dynamic capabilities (Danneels, 2008, p. 525; Schilke et al., 2018, p. 404).

The cross-case analysis provides evidence that slack human resources are an important antecedent of digital service innovation. Gamma and Delta are strongly short-term oriented and mainly focus on exploitative product innovation. Both companies highlight that digital service innovation is constraint by the day-to-day business: *"Because we are growing so strongly and there are so many open projects at the moment, we do not really have the capacity to look for new ideas"* (C2, 35). Furthermore, the informant of Gamma notes: *"As soon as our [medical] devices have a problem and need resources, everything is called in"* (C2, 47). Similarly, Alpha finds that limited resources hinder the development of new business activities: *"As a pharmaceutical company, we are very lean when it comes to strategic and development resources. People like to do a lot with outsourcing and just manage it. This often hampers the development of in-house competencies, which are essential, especially for entering new business areas"* (A1, 104). Accordingly, to facilitate exploratory activities and to enable digital service innovation, firms require sufficient slack human resources for exploration, which are not occupied by the daily business.

## 5.5 Refined research framework

Chapter 5 focused on analyzing similarities and differences across the cases. Based on the cross-case analysis, various antecedents, as well as routines and practices for digital service innovation in medical technology firms could have been identified. Figure 9: Refined research framework summarizes the results of the cross-case analysis and refines the research framework that was introduced in chapter 3.2.

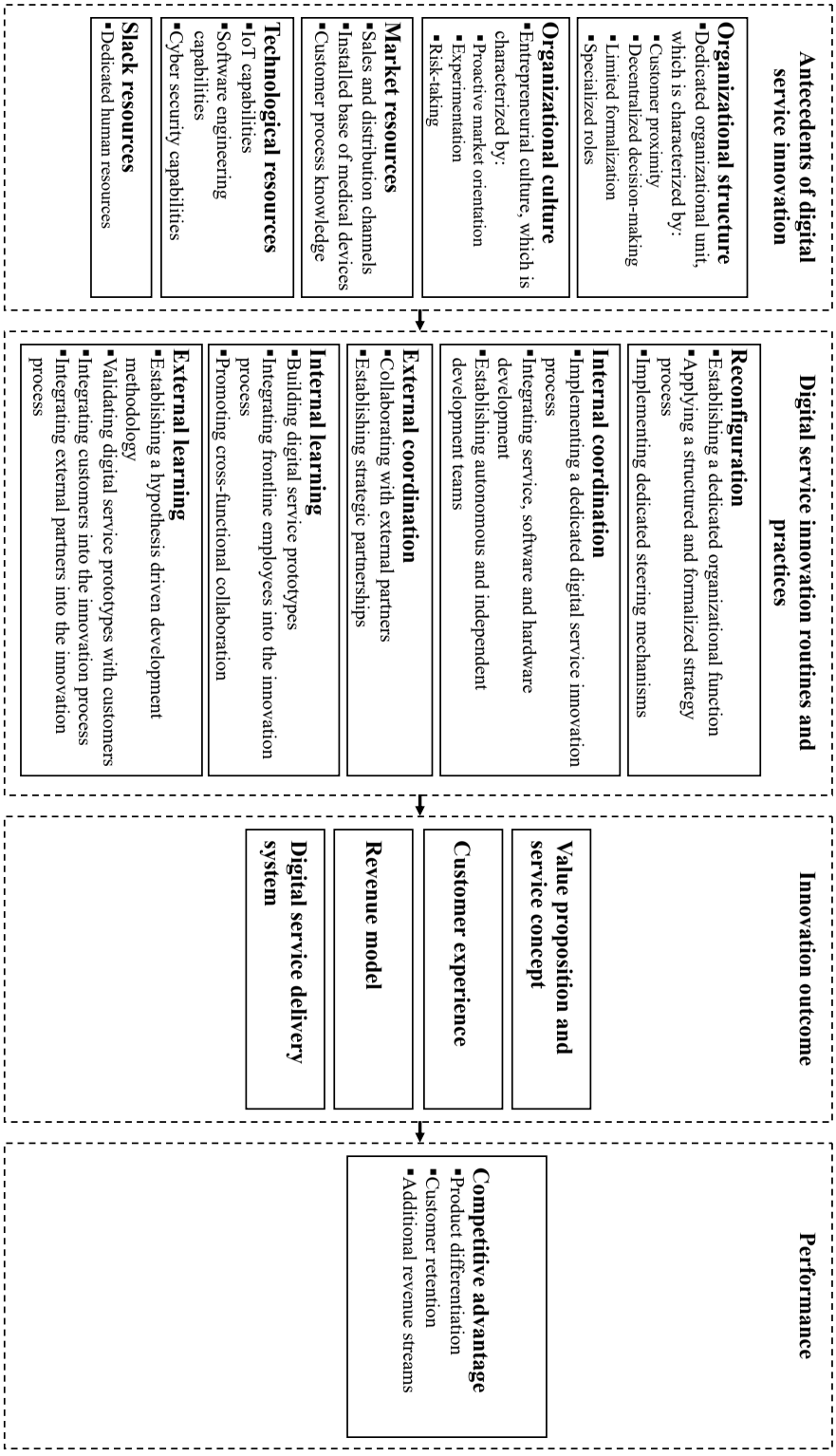



*Figure 9: Refined research framework*

# 6 Organizational and managerial levers

The case studies and the cross-case analyses have identified various barriers, capabilities, and antecedents of digital service innovation in medical technology firms. Based on the refined research framework, as well as the identified capabilities and antecedents, the following chapter derives organizational levers to promote the development of digital service innovation capabilities. The cross-case analysis has shown that the organizational structure and the applied innovation process are important antecedents of digital service innovation. Therefore, this chapter provides managerial implications that support medical technology firms in managing digital service innovation.

## 6.1 Balancing exploitative and explorative innovation

In the context of innovation, organizational ambidexterity deals with balancing exploitative and explorative innovation within the same organization (Duncan, 1976; Tushman & O'Reilly, 1996). The case studies and the cross-case analysis reveal that digital service innovation in product-oriented medical technology firms has many features that suggest a context of organizational ambidexterity. Exploitative innovations are incremental innovations that focus on existing customer's needs and build upon existing knowledge and skills (Benner & Tushman, 2003, p. 243). The case studies have clearly shown that product innovations within medical technology firms often follow an exploitative innovation approach. Accordingly, the firms focus mainly on market-pull innovations that are characterized by explicit customer needs within established market segments, which need to pay off in the short-run. The focus on exploitative innovation is further reinforced by the applied type of Stage-Gate innovation process, which additionally fosters incremental innovation.

Explorative innovations are radical innovations that address emerging customer needs and new market segments, as well as require new knowledge or even a departure from existing knowledge and skills (Benner & Tushman, 2003, p. 243; Jansen et al., 2006, p. 1662). Again, the case studies and cross-case analysis indicate that digital service innovations in medical technology firms should be considered as explorative innovations as they are initiated by a technology-push and often focus on latent customer needs, as well as evolving markets. The explorative nature of digital service innovation is further supported by the finding that these innovations benefit from iterative and incremental innovation methodologies, which are associated with explorative approaches.

Research on organizational ambidexterity highlights that firms need to pursue exploitative and explorative innovation to be successful in the long-run (Tushman & O'Reilly, 1996).

However, scholars suggest that both types of innovation have different organizational antecedents, which creates substantial tensions within the organization, as different organizational structures, processes, and cultures have to be aligned consistently (O'Reilly & Tushman, 2008, p. 190). Exploration is enabled by an organic structure, while exploitation benefits from mechanic structures (Duncan, 1976, p. 179; O'Reilly & Tushman, 2008, p. 193). Furthermore, companies seeking to promote exploitation and exploration simultaneously face a trade-off between focusing on existing resources and skills or investing in future skills and competencies – in other words, "whether the present should be hedged for the future" (Lavie et al., 2010). Accordingly, Levinthal and March (1993, p. 105) summarize that "[t]he basic problem confronting an organization is to engage in sufficient exploitation to ensure its current viability and, at the same time, devote enough energy to exploration to ensure its future viability."

To deal with the underlying organizational tension of exploitation and exploration, scholars have suggested different approaches. First, firms can either externalize exploitation or exploration by establishing joint ventures, alliances, or spin-offs (Raisch & Birkinshaw, 2008, p. 389; Tushman et al., 2010, p. 1335). Christens (1997) argues that due to different customer needs and underlying processes, firms are only able to engage in disruptive innovation by creating completely independent spin-offs or ventures (Christensen, 1997; Raisch & Birkinshaw, 2008, p. 390). Other scholars suggest that organizations should temporarily cycle between exploitation and exploration phases (Brown & Eisenhardt, 1997). Thus, they should shift their organizational design between mechanic and organic structures (Benner & Tushman, 2003, p. 247). However, sequential shifts between exploitation and exploration are more suitable in less dynamic environments, where the need for continuous exploration is reduced (O'Reilly & Tushman, 2008, p. 201). Raisch (2008, p. 492) finds that the temporal separation of exploitation and exploration is mainly employed to account for fundamental shifts in operational and supply-side processes.

In fast-paced and dynamic environments, firms need to pursue exploitation and exploration simultaneously (Jansen, Van den Bosch, et al., 2005, p. 351). To balance and synchronize both types of innovation within the same organization, firms should establish separate but aligned subunits for exploitation and exploration (He & Wong, 2004; Jansen et al., 2009; O'Reilly & Tushman, 2008; Tushman & O'Reilly, 1996). The structural separation enables the firms to implement "different competencies, systems, incentives, processes and cultures" (O'Reilly & Tushman, 2008, p. 193) that best fit the different types of innovation (Lavie et al., 2010, p. 131). Accordingly, exploitation units are expected to be larger, more centralized with tight processes and cultures, whereas exploration units are

expected to be smaller, decentralized with loose processes and cultures (Benner & Tushman, 2003, p. 247). However, both types of organizations should not just coexist within the firm but should be strategically aligned to generate synergistic results (Raisch, 2008, p. 389). O'Reilly and Tushman (2008, p. 194) call for a strategic integration that requires "a common strategic intent, an overarching set of values, and targeted structural linking mechanisms to leverage shared assets." Accordingly, the authors devote great importance to senior management, who is responsible for coordinating exploitation and exploration within the organization.

The results of the case studies and cross-analysis are well reflected in the research on organizational ambidexterity. Medical technology firms that aim to engage in digital service innovation are confronted with the challenge of balancing and synchronizing exploitative and explorative innovation within the same organization. The cross-case analysis has shown that digital services innovation benefits from an organic structure that is characterized by customer-proximity, decentralized decision-making, and limited formalization. Furthermore, the cross-case analysis indicates that digital service innovation should be separated from product innovation and carried out in small, autonomous teams that have most of the required resources and capabilities directly at their disposal. These autonomous teams facilitate internal and external coordination, as well as fast decision-making, which is a prerequisite for incremental and iterative development methodologies.

Despite the strong evidence for an organizational separation of product and digital service innovation, the cross-case analysis also revealed that especially IoT-enabled digital services require the integration of hardware, software, and service development. Only by integrating the different development activities, firms are able to create a holistic customer experience. Accordingly, in the context of digital service innovation, it remains unclear how an adequate degree of separation and integration is achieved. The following paragraph will propose a management framework to support medical technology firms in identifying adequate organizational designs to address the tension of product and digital service innovation.

## 6.2 Determining organizational designs for digital service innovation

The case studies have shown that medical technology firms adopt different organizational structures to anchor digital service innovation within their organization. Alpha and Delta develop digital services mainly within cross-functional teams, whereas the team members are still part of the core functions of the product organization or even have dual

responsibilities for product and digital service innovation. In contrast, Beta and Gamma decided to separate digital service innovation from product innovation. While Beta created an autonomous department that directly reports to the CEO and has the most required capabilities and resources directly at its disposal, Gamma separated only software engineering activities and hired a dedicated product manager for digital services. However, also Gamma aims to separate product and digital service innovation, as well as to create an autonomous department once the topic has reached a certain size. Thus, the adopted organizational designs of the case companies differ regarding the degree of separation and integration of product and digital service innovation.

In the context of corporate entrepreneurship, Burgelman (1984, pp. 158–164) suggests that the adequate degree of separation and integration of new opportunities can be assed based on the strategic importance and the required operational linkage. The author proposes a framework that enables organizations to structure the relationship between new opportunities and the core business based on the manifestation of these two dimensions. O'Reilly and Tushman (2008, pp. 195–196) adopt this framework to evaluate conditions when organizations would benefit from an ambidextrous organizational design. They find that firms should create ambidextrous organizations when explorative innovations are both strategically important, as well as benefit from existing resources and capabilities. Burgelman (1984), as well as O'Reilly and Tushman (2008) provide the background for a management framework to identify adequate organizational designs to structure the relationship between digital service innovation and the core business of medical technology firms. Figure 10 outlines the proposed framework.

The cross-case analysis indicates that when the strategic importance of digital services is still low or rather uncertain, but the services are strongly related to the existing product or market segments, such as in the case of IoT-enabled digital services, firms use cross-functional teams to develop digital services. With the increasing scope of digital services innovation, dedicated digital service roles within the existing functional departments are established. However, in this organizational setting, digital services rather remain an appendix to the medical products, e.g., a digital product feature that is not commercialized independently

With growing strategic importance, cross-functional teams do not provide an adequate organizational setting to foster digital service innovation. As shown by the cross-case analysis, digital service innovations require distinct and different organizational capabilities that can only be developed and nurtured within a separated organizational unit. However, if the digital services benefit from or even rely on existing technological or

market assets, a complete organizational separation of product and digital service innovation is not advisable. In this case, medical technology firms should establish an integrated digital service department that is able to establish distinct and internally aligned organizational capabilities. By integrating all necessary resources and capabilities into a single department, the firms enable an iterative and incremental development approach, which will facilitate digital services innovation. Nevertheless, by establishing the digital service unit on the functional level, a close linkage to the other functional departments such as R&D, marketing, and sales is ensured. Thus, the opportunity to transfer and leverage existing resources remains significant (cf. Burgelman, 1984, p. 162). O'Reilly and Tushman (2008, p. 196) describe these types of organizational designs as ambidextrous organizations. The authors emphasize that senior management in ambidextrous organizations plays a pivotal role in coordinating the divergent types of innovation in order to achieve synergistic outcomes.

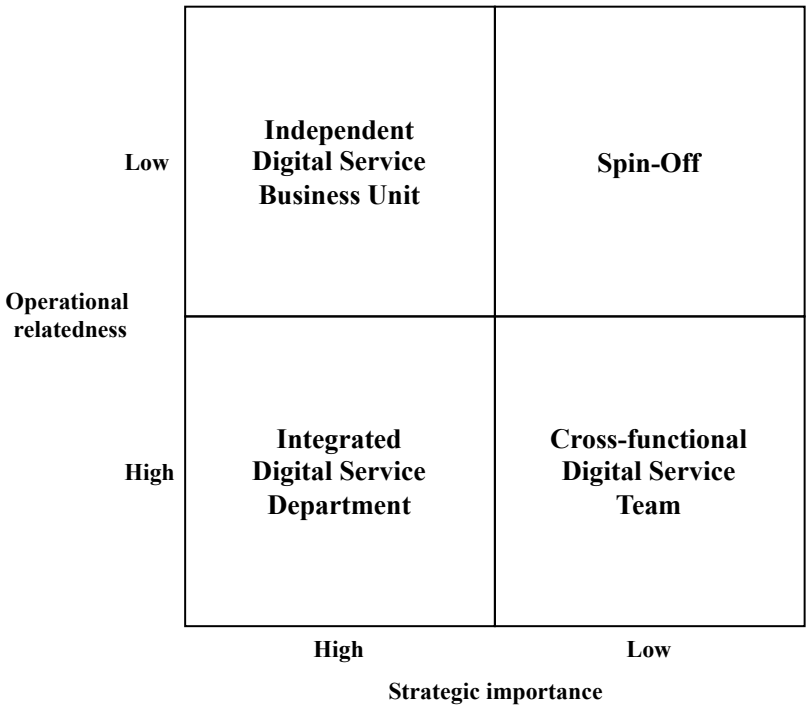



*Figure 10: Organizational designs for digital service innovation (adapted from Burgelman (1984) and O'Reilly and Tushman (2008))*

If the operational linkage between product and digital service innovation is only weak and digital services do not build upon existing technological and market assets, medical technology firms should consider developing digital service innovations outside their medical product units. Depending on the strategic importance, firms can create independent digital service business units or even completely spin-off digital services.

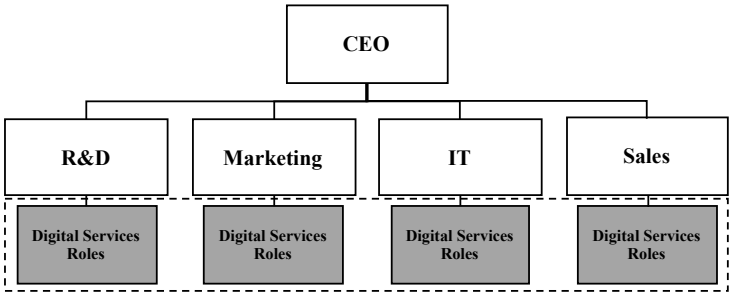
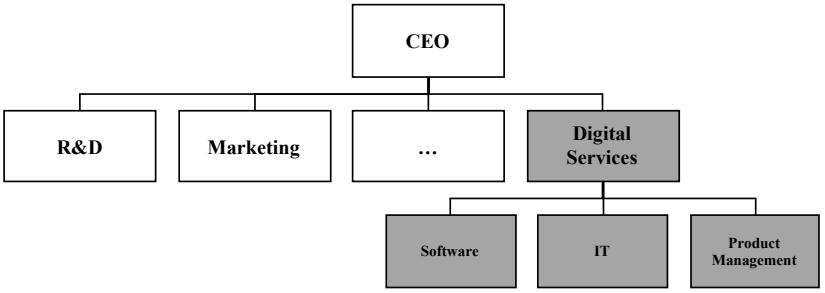
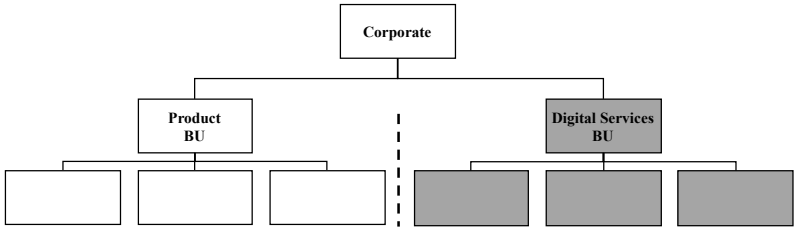
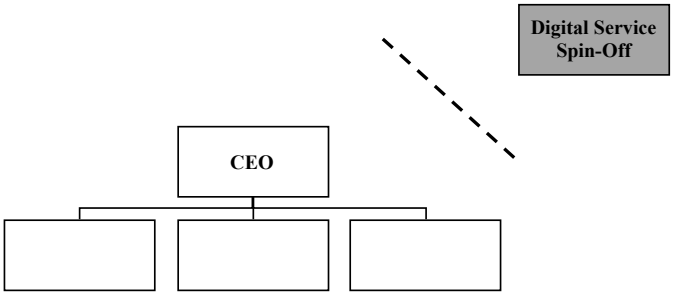
When digital services are strategically important, but with low operational relatedness, the separation of product and digital service innovation into different business units provides an appropriate organizational design. Thus, the separated business units are able to establish distinct organizational structures, processes, cultures, and business models that best fit their task environment (cf. Lawrence & Lorsch, 1967). By keeping medical products and digital services within the same corporate structure, corporate management ensures that the different business units are strategically aligned with each other. Burgelman (1984, p. 162) finds that new opportunities with high strategic importance, but low operational relatedness, which are best developed in dedicated business units, will be later on combined and integrated with some of the existing businesses to create "new operating divisions within the corporate structure." Accordingly, we can assume that medical technology firms that establish dedicated business units for digital service innovation, will at a later stage combine and integrate part of these activities with their existing product business in order to provide solutions for the entire customer journey. This is likely to be the case, when digital services are at a later stage of the product lifecycle and innovations tend to be rather exploitative.

Finally, if digital service innovations have no strategic importance and are not related to existing resources and capabilities, medical technology firms should consider developing digital services outside their corporate structure. Following Burgelman (1984, pp. 163–164), as well as O'Reilly and Tushman (2008, p. 195), a Spin-Off will be the most appropriate organizational design. Table 23 summarizes exemplary organizational structures for digital service innovation in medical technology firms.

In conclusion, the findings from literature and the case studies suggest that medical technology firms have to assess the appropriate organizational designs for digital services based on the strategic importance and the operational relatedness with their core business. However, the cross-case analysis also indicates that this assessment is a recurring task as the strategic importance and operational relatedness might change over time. Raisch and Birkinshaw (2008, p. 401) confirm this finding and state that "[a]ligning organizations to exploitation and exploration may be a task of dynamic rather than static alignment." Accordingly, the cross-case analysis shows that initially, when the strategic importance is difficult to evaluate and to foresee, firms initiate digital service innovations within cross-functional teams. By developing the first digital services, the boundary conditions become more clear, and an adaption of the organizational setting might become necessary. With increasing maturity of these activities, the strategic importance increases, and firms start to establish dedicated roles, which are later merged into a dedicated unit or department. The case of Beta indicates that these dedicated departments will increasingly search for

growth opportunities beyond the existing product and market segments, which will decrease the operational relatedness to the core business. Thus, at a certain point, the management will consider creating a dedicated business unit. Predicting this evolutionary path further into the future and assuming that service and software-oriented business models, which are reflected in the term "as-a-Service", will gain further importance (cf. Porter & Heppelmann, 2015), we can even suppose that in certain firms, one day the product business will be reintegrated into the digital service business.

*Table 23: Exemplary organizational structures for digital service innovation*

| Organizational designs | Exemplary organizational structures |
|---|---|
| **Cross-functional Team**<br>• Low strategic importance<br>• High operational relatedness |  |
| **Integrated Digital Service Department**<br>• High strategic importance<br>• High operational relatedness |  |
| **Independent Digital Service Business Unit**<br>• High strategic importance<br>• Low operational relatedness |  |
| **Spin-Off**<br>• Low strategic importance<br>• Low operational relatedness |  |

## 6.3 Linking product and digital service innovation

The cross-case analysis has shown that not only the organizational structure but also internal coordination processes are important enablers of digital service innovation. Accordingly, O'Reilly and Tushman (2008, p. 191) emphasize that "[t]he crucial task there is not the simple organizational structural decision in which the exploratory and exploitative subunits are separated, but the processes by which these units are integrated in a value-enhancing way." Similar, Jansen et al. (2009, p. 800) find that ambidextrous organizations need to establish formal integration mechanisms "to access and integrate knowledge sources flexibly across relatively autonomous exploratory and exploitative units." Thus, to create customer value, firms need to integrate their differentiated and spatially dispersed capabilities (Jansen et al., 2009, p. 807).

The challenge of integrating exploitative and explorative innovation is well reflected in the context of IoT-enabled digital services, where medical technology firms need to integrate product and digital service innovation in order to create a holistic customer experience. Accordingly, the innovation process plays a crucial role in coordinating and integrating the different development activities of IoT-enabled digital services. The case findings suggest that medical technology firms should adopt an iterative and incremental development methodology to develop digital services. However, the cases also highlighted that due to industry regulations, medical technologies and devices are mainly developed according to a sequential waterfall model. Therefore, medical technology firms need to establish an innovation process that links product and digital service innovation in a value-enhancing way while considering their idiosyncratic features and requirements. Accordingly, firms need to coordinate and integrate service, software, and hardware development.

In order to achieve legal and regulatory compliance with medical device regulations, medical technology firms adopt quality management systems that are compliant with industry regulations such as ISO 13485. These regulations also describe requirements regarding the innovation process, which is the reason why most medical technology firms develop software and hardware components according to a sequential waterfall model (W. Lin & Fan, 2009, p. 389). The sequential medical device innovation process typically consists out of five stages: (1) design input, (2) design output, (3) design verification, (4) design validation, and (5) product release (Teixeira, 2019). Each stage requires a formal review and approval process. In addition, product and software specifications need to be traceable from the design input to the design validation stage. These design controls make the medical device innovation process very formalized and rigid. The formalized and rigid

nature of the medical device innovation process is found to be a major reason for its limited suitability for digital service innovation. However, digital services that aim to support the diagnosis or treatment of patients will be considered as medical devices and therefore have to be developed according to a compliant quality management system. Adopting a "try and error" development approaches to medical devices is not possible. Therefore, medical technology firms face the great challenge of introducing an iterative and incremental process that facilitates exploratory innovation.

In order to enable medical technology firms to manage the trade-off between regulatory compliance and fast-paced iterative and incremental development methodologies, a separation of the development of technical and non-technical components of digital services is suggested. Accordingly, the development of service components such as the service concept, user experience, or revenue model, should follow an iterative and incremental development approach that is hypothesis-driven and uses prototypes and mockups to generate customer insights as early as possible. However, hardware and software components will continue to be developed according to a waterfall model that ensures regulatory compliance. Furthermore, it is proposed that the development of service components should precede the development of software and hardware components. Thus, the service components define the necessary user requirements for hardware and software development.

The sequential separation of service design, as well as software and hardware development, is also supported by Spender und Kessler (1995, pp. 41–43), which find that the management style of innovation projects changes while the project moves from the initial stage to the implementation stage. Early stages of the innovation processes are characterized by uncertainty and therefore benefit from an organic structure that enables a free flow of information and close linkage to internal and external stakeholders. When the project proceeds, uncertainty is reduced, and mechanic structures that foster goal attainment are becoming more appropriate. Thus, while iterating through the service design process, knowledge about the customer process is generated that reduces uncertainty and ambiguity about customer needs and requirements. Once the service design has become sufficiently tangible, software and hardware development are initiated.

Johnson et al. (2000) have synthesized and integrated prior research on new service development processes and have suggested an iterative process model. The authors divide the process model into a planning phase consisting of the stages of design and analysis, as well as an execution phase involving the stages of development and full launch. In general, they differentiate between design and development activities (cf. 2.2.2.3). Design

activities focus on the development and testing of the service concept, while development activities deal with the implementation of the service concept. Research on design processes such as "Design Thinking" finds that design processes typically consist out of three main activities: "(1) needfinding, encompassing the definition of a problem or opportunity through observation; (2) brainstorming, a framework for ideation; and (3) prototyping, building models to facilitate the development and selection of concepts" (Seidel & Fixson, 2013, p. 20).

Figure 11 proposes an exemplary structure of a digital service innovation process in medical technology firms. The proposed innovation process integrates the results from the cross-case analysis with the insights on medical device innovation processes. Thus, service components are developed systematically using an iterative and incremental development methodology. The use of an iterative and incremental development methodology enables medical technology firms to reduce uncertainty and ambiguity regarding the design problem, as well as possible solutions. However, to meet legal and regulatory requirements of medical technologies, hardware and software components continue to be developed according to a waterfall model.

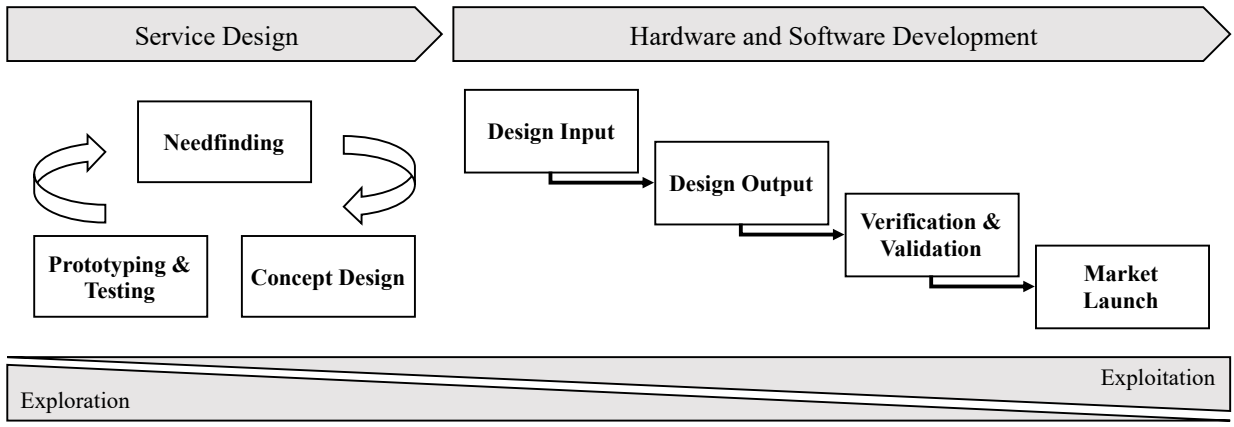



*Figure 11: Exemplary digital service innovation process*

# 7 Conclusion and outlook

This chapter concludes the dissertation and summarizes the key findings and contributions. Thus, chapter 7.1 summarizes and reflects the findings with regard to the underlying research questions, followed by a discussion of the main contributions to theory and practices (7.2). Finally, chapter 7.3 outlines the limitations of the results and applied research design and provides an outlook on possible future research directions.

## 7.1 Summary of the findings

The role of digital technologies in manufacturing firms has gained much attention from research and practices. Under the umbrella term *digital servitization*, scholars discuss the interplay of digitalization and servitization while referring to various concepts such as smart services, IoT, Industrial Internet, or Industry 4.0 (Coreynen et al., 2017; Opresnik & Taisch, 2015; Rymaszewska et al., 2017). Initial studies agree that digitalization is an important driver and enabler of servitization, as manufacturing firms have to adopt service-oriented business models to fully profit from digital technologies in their downstream activities (Kohtamäki et al., 2020). However, recent studies show that manufacturing firms struggle to fully exploit and commercialize digital technologies and that the financial returns are still limited (Wortmann et al., 2019). It is found that manufacturing firms not only have to invest in technological capabilities but also need to transform organizational routines and practices across various hierarchical levels and functional units to foster digital servitization (Hasselblatt et al., 2018; Porter & Heppelmann, 2015). However, studies on the organizational implications of digital servitization are still limited (Sklyar et al., 2019). Furthermore, until now, scholars have not addressed how digital servitization will affect the innovation process and how manufacturing firms can foster their innovation capabilities for digital services. To address the identified research gaps, this dissertation was guided by the following main research question:

**How can medical technology firms foster their innovation capabilities for digital services?**

To increase the internal validity of the research outcomes, the dissertation has focused on the medical technology industry. In order to address the main research question comprehensively, three sub-research-questions (SRQ) were formulated. The key findings regarding each SRQ are summarized and reflected in the following.

*SRQ 1: What are the main organizational barriers to digital service innovation in medical technology firms?*

Innovation barriers are an important research topic within the field of innovation management (Mirow et al., 2007). However, despite evidence that manufacturing firms struggle to exploit and commercialize digital technologies, research until now has not addressed barriers that hinder digital services innovation. By using a multiple case study approach, the dissertation was able to identify 18 organizational barriers that hinder or constrain the successful development of digital services in medical technology firms. These innovation barriers affect different dimensions, such as strategy, organizational structure, culture, or innovation governance. It became evident that multiple and interrelated organizational factors contribute to the difficulties of medical technology firms to initiate and execute innovation activities successfully (see chapter 5.1). In the following, selected innovation barriers are shortly outlined.

The case studies revealed that digital service innovation has to be considered as a technology-push instead of a market-pull type of innovation. Existing studies on the differences between technology-push and market-pull innovations show that the source of innovation has implications for the innovation process (cf. Herstatt & Lettl, 2006). It is found that today's innovation processes of medical technology firms rather foster development projects that are driven by a market-pull. Accordingly, the firms struggle to develop digital services that address latent customer needs and are driven by a technology-push.

Furthermore, digital service innovation can also be hindered by a strong short-term oriented corporate culture that focuses only on opportunities within existing market segments, which pay off immediately. Thus, long-term investments in technologies that create new markets are not considered. Moreover, the cases showed that short-term orientation is further reinforced by strong customer orientation, as companies tend to focus only on articulated and explicit customer needs. Hamel and Prahalad (1994) referred to the “tyranny of the served market”, where the existing customer needs prevent the development of a future perspective of the industry (cf. Slater & Narver, 1998, p. 1002).

The technology-push nature of digital services also has implications on the strategy and governance processes. Currently, there are no blueprints for business models, and thus medical technologies firms have difficulties to derive viable business cases. However, existing steering mechanisms often required performance indicators such as the break-even time of an innovation project. Thus, without a viable business case, senior managers are not willing to provide sufficient financial resources for digital service innovation.

Finally, it became apparent that misaligned organizational structures, processes, and routines are a major innovation barrier to digital service innovation. A lack of organizational anchoring and missing responsibilities for digital service innovation constrain a focused and target-oriented innovation approach. Without dedicated roles, functions, and processes, digital service innovation will depend on the individual initiative of employees. Thus, medical technology firms are at risk that the successful development of digital services becomes a coincidence.

Pointedly summarizing, medical technology firms face the challenge that they have to develop services for customer and market segments that do not exist yet, in an organization that is structured to serve today's business efficiently. This challenge is not so new to industrial firms and well documented in the literature (e.g. Prahalad & Hamel, 1990). However, digital technologies seem to reinforce this challenge at a new pace.

> *SRQ2: What organizational routines and practices facilitate digital service innovation in medical technology firms?*

The review of the literature in chapter 3.3 has revealed that current research does not provide a holistic and in-depth perspective of service innovation capabilities as well as their underlying routines and processes. In addition, the literature lacks an understanding of the capability requirements for digital service innovation. By applying a theory-guided case study approach, building on the theory of dynamic capabilities, the dissertation was able to identify 15 routines and practices that enable and drive digital service innovation (see chapter 5.3). Furthermore, the findings of the case studies also improve the understanding of organizational antecedents to develop and nurture these capabilities. Accordingly, it is found that the organizational structure, culture, and existing resource base have a significant influence on the effectiveness of innovation capabilities (see chapter 5.4). In general, the results of the study show that routines and practices relating to the innovation process, as well as the organizational structure, have a significant impact on the digital services innovation capabilities of medical technology firms. Selected findings are briefly highlighted.

Due to legal and regulatory requirements, medical technology firms apply an innovation process that follows a waterfall model, such as the Stage-Gate process. However, the case studies indicate that digital services benefit from iterative and incremental development methodologies, which enable early customer feedback by testing prototypes. Furthermore, within existing innovation processes, service components such as the service concept or user experience are rather a by-product of the hardware and software development. Thus, the findings suggest that medical technology firms should establish a dedicated digital

service innovation process to foster a systematic development of service components. Moreover, in the context of IoT-enabled digital services, service, hardware, and software development have to be integrated to create a holistic customer experience. Finally, integrating frontline employees, as well as customers into the innovation process, facilitates the identification of desirable and viable new service concepts.

Regarding the organizational structure, the dissertation finds that multiple organizational characteristics can foster digital service innovation in medical technology firms (see chapter 5.4.1). Comparing the case findings along the organizational dimensions of centralization, formalization, specialization, and separation revealed that digital service innovation is enabled by an organic organization structure. An organic organizational structure is characterized by decentralization of decision-making, limited formalization, higher specialization, and lateral communication (Burns & Stalker, 1961; Damanpour, 1991). Furthermore, the cross-case analysis indicates that an ambidextrous organizational design facilitates digital service innovation. Accordingly, the development of products and digital services is separated in dedicated units, while adequate integration mechanisms and liaison devices ensure coordination between these units.

> *SRQ 3: What are organizational and managerial levers to foster digital service innovation in medical technology firms?*

Based on the findings regarding organizational barriers, as well as digital service capabilities, organizational and managerial implications that support medical technology firms in the management of digital service innovation have been derived (cf. chapter 6). Throughout the case studies, it became evident that the organizational structure, as well as the innovation process, are important antecedents of digital service innovation. Furthermore, existing literature does not provide an adequate understanding of how digital service innovation can be organized in manufacturing firms. Therefore, a management framework to determine appropriate organizational designs for digital service innovation is proposed (see chapter 6.2). Additionally, chapter 6.3 derives an exemplary digital service innovation process that integrates the results of the case studies with insights on innovation processes in the medical technology industry.

The management framework to determine organizational designs for digital service innovation is grounded in research on organizational ambidexterity and corporate entrepreneurship. The case studies have shown that digital service innovation is facilitated by an ambidextrous organizational design. Research on organizational ambidexterity suggests that firms should group exploitative and explorative innovation activities in separate organizational units (O'Reilly & Tushman, 2008). However, the degree of

separation of the explorative activities depends on the strategic importance, as well as the operational relatedness to the existing core business. (Burgelman, 1984). Accordingly, the proposed management framework (Figure 10) enables medical technology firms to structure the relationship between product and digital service innovation along the dimensions of operational relatedness and strategic importance.

Finally, the research project revealed that medical technology firms face a trade-off between regulatory requirements and the requirements of digital services for iterative and incremental development methodologies. Therefore, the separation of the development of non-technical and technical components of digital services is suggested. Accordingly, the service concept, user experience, and revenue model are developed according to an iterative and incremental development model and precede the development of software and hardware components. In contrast, software and hardware components continue to be developed according to a waterfall model that complies with industry regulations. The exemplary digital service innovation process is illustrated in Figure 11.

## 7.2 Contribution to theory and practice

### 7.2.1 Contribution to theory

The theoretical foundation of this dissertation is rooted at the intersection of research on servitization and service innovation and addresses the emerging topic of digital service innovation in manufacturing firms. By following a theory-guided case study approach and adopting an organizational capability perspective, this research follows the recent call for more theoretically grounded research on servitization (Eloranta & Turunen, 2015; Kowalkowski et al., 2017). Furthermore, by conducting an in-depth case study on service innovation in the manufacturing context, this dissertation contributes to research on service innovation, which is currently dominated by quantitative research approaches in service industries (Biemans et al., 2016). Moreover, the findings extend the emerging research field of digital servitization, which still lacks systematic empirical studies (Kohtamäki et al., 2020). The contributions to each research field are highlighted in the following.

First, the findings extend existing research on innovation barriers. Mirow et al. (2007, p. 102) highlight that "[b]arriers to innovation are a frequently mentioned, but rarely in-depth investigated research topic." By conducting four in-depth case studies to identify factors that hinder or constrain digital service innovation, this dissertation provides a thorough analysis of organizational barriers to digital service innovation. The study shows that multiple and interrelated organizational factors hinder and constraint the successful

development of digital service. An improved understanding of barriers to digital service innovation will facilitate research on the organizational implications of digital servitization.

Second, the developed and refined research framework provides a theoretical-grounded perspective on innovation capabilities for digital services. Recently, scholars have highlighted the need for a better understanding of manufacturers' capabilities to IoT-enabled services (Hasselblatt et al., 2018; Kohtamäki et al., 2019). Similar, Kohtamäki et al. (2020, p. 8) have called for in-depth qualitative studies that help to "develop a more detailed understanding of the needed capabilities, practices and microfoundations" of digital servitization. The identified organizational routines and practices, as well as antecedents of digital service innovation, add to this understanding. Thus, having a holistic view on routines and practices that facilitate digital service innovation, will enable further research on overcoming the so-called digitalization paradox (cf. Gebauer et al., 2019; Wortmann et al., 2019).

Another contribution of this dissertation relates to the perspectives of service innovation. Scholars on the synthesis perspective have highlighted the need to combine findings from product and service innovation into integrative frameworks, as manufacturing and service industries increasingly converge (cf. chapter 2.2.2.2.). However, studies on the synthesis perspective have been mainly conceptual without empirical validation (Droege et al., 2009, p. 135). Studying digital service innovation in manufacturing firms provides rich empirical insights into the synthesis of product and service innovation. Therefore, the identified innovation capabilities, the management framework, as well as the innovation process model extent existing research within the field of service innovation.

Finally, the cross-case analysis has revealed that the challenges of medical technology firms regarding digital service innovation are well reflected in the literature on the tension of exploitative and explorative innovation. Accordingly, the proposed management framework for determining organizational designs extends and supplements existing research on the organizational aspects of digital servitization. Furthermore, by applying the organizational ambidexterity theory to the context of digital service innovation, the dissertation extends the theoretical understanding of digital servitization, as well as the digitalization paradox.

### 7.2.2 Contribution to practice

By investing in digital technologies, manufacturing companies are increasingly adopting service-oriented business models. Thus, digitalization and digital service innovation are

further accelerating the process of servitization. Within the last twenty years, research on the service transition of manufacturing has provided various recommendations on managing the organizational change. However, these recommendations were mainly derived from research on after-sales services, where the boundaries between product and service provision are obvious. With the emergence of digital technologies such as IoT, the boundaries between product and service are blurring, and the recommendation to organize the product and service business in separated business units with distinct and dedicated capabilities is becoming questionable. Furthermore, initial research on digital servitization has mainly addressed the technological capabilities that manufacturing firms have to develop. However, it remains unclear which organizational capabilities and structures enable digital service innovation. Therefore, this dissertation seeks to support medical technology firms in organizing for digital servitization.

First, empirical evidence has indicated that manufacturing firms struggle to fully exploit digital services. Thus, the comprehensive overview of organizational factors that hinder or constrain digital service innovation increases the understanding of challenges that managers encounter in daily practice. An in-depth understanding of barriers to digital service innovation is a necessary first step to identify and initiate organizational and managerial measures. Additionally, to determine appropriate measures, the proposed capability framework provides a detailed description of routines and practices that facilitate the development of digital services. Combined with the insights on structural and cultural antecedents, the research findings enable managers to identify organizational and managerial levers to foster digital service innovation.

Second, the developed management framework to determine organizational designs offers a normative guideline on how to organize digital service innovation in medical technology firms. The findings of the dissertation show that a simple separation of product and service innovation in distinct business units is not advisable under all circumstances. Depending on the strategic importance and operational relatedness of digital services to the core business, managers have to consider ambidextrous organizational designs, which facilitate the strategic alignment of product and service innovation. The proposed framework promotes such considerations.

Finally, the case studies have revealed that medical technology firms face divergent requirements regarding their innovation process. On the one hand, industry regulations encourage the implementation of a rigid waterfall model. On the other hand, digital services benefit from a less formalized iterative and incremental development approach. The proposed process model offers medical technology firms an approach to overcome

this trade-off. By separating the development of non-technical components and technical components of digital services, medical technology firms are able to develop service components according to an iterative and incremental methodology. In contrast, technical components, such as software and hardware, continue to be developed according to a waterfall model, which facilitates regulatory compliance.

## 7.3 Limitations and future research

The findings of this dissertation are based on in-depth case studies of four medical technology firms. They provide new insights into the routines, practices, and antecedents that enable digital services innovation, as well as offer various management implications. However, inherent with the adopted theoretical perspective and applied research design are limitations, which have to be considered when disseminating the research findings. Nevertheless, these limitations also offer avenues for further research.

First, the dissertation follows a multiple case study approach. Case studies provide rich empirical insights on emerging topics. However, due to the relatively small sample size of four medical technology firms, the generalizability and representativeness of the research findings might be limited. Furthermore, the empirical context of this research project has been Swiss and German medical technology firms. Therefore, regional and cultural characteristics that influence how firms organize their innovation activities are not considered. Hence, the research findings cannot be transferred directly to firms from other regions or cultural settings. Moreover, the case studies focus on a single industry. Single industry case studies increase the internal validity of the research findings, but the external validity might be limited. Thus, the theoretical and practical implications cannot be transferred and applied to other manufacturing industries without further research and empirical validation.

Second, the dissertation uses cross-sectional data and static observations, which are derived from semi-structured interviews. Therefore, this research can only provide limited insights into causal relationships, as well as the dynamic and reinforcing effects of interrelated capabilities. Thus, statements regarding the importance of single capabilities and their performance implications are not possible. Therefore, longitudinal case studies could further extend the understanding of causal relationships of the identified antecedents and capabilities. Moreover, the conceptual research frameworks could be used to guide quantitative studies, which aim to investigate the performance effects of different capabilities and antecedents, as well as to validate the findings of this dissertation.

Furthermore, the insights generated by the literature review and the case studies revealed further research avenues besides addressing the limitations of this study. The case analysis showed that the applied innovation process has a significant influence on the ability of manufacturing firms to develop digital services. By identifying routines and practices of digital services innovation, this study provides a solid starting point to investigate the configuration of innovation processes for digital services more deeply. The proposed high-level process model is very specific to the circumstances of medical technology firms. Therefore, further research could build on the insights generated by this dissertation and could provide a general process model for digital service innovation in manufacturing firms. This process model would address Biemans et al. (2016, p. 382) finding that current research "fails to provide managers with consistent answers to basic questions about how to most effectively manage NSD processes."

Besides the innovation process, the case studies also highlighted that a structured and formalized strategy process fosters the initiation of digital service innovation. Firms have to define the direction of their innovation activities before starting specific development projects. However, the interviews and discussions with the representatives of the case companies revealed that the existing strategy processes of the manufacturing firms are of limited applicability to digital services. These strategy processes mainly apply frameworks and tools that are rooted in the structure-conduct-performance paradigm and the theory of industrial economics (e.g. Porter, 1980, 1985), which aim to identify favorable product-market positions. Thus, the derived portfolio decisions mainly address existing customer and market segments. However, the study has shown that digital services often address latent customer needs in emerging markets or that they even create new markets. Therefore, manufacturing firms require appropriate tools and frameworks for their strategic considerations regarding digital services. Accordingly, future research could examine the strategy process of digital service innovation in detail.

Finally, this study draws on literature at the intersection of servitization and service innovation. Therefore, other research fields, such as information systems and business model innovation, which deal with related topics, could provide additional theoretical perspectives for research on digital service innovations in manufacturing firms.

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# Appendix

## Appendix A: Systematic literature review

### Appendix A1: Overview systematic review process

*Table 24: Systematic literature review: databases and search terms*

| Database | Restriction | Search term |
|---|---|---|
| Web of Science (Social Science Citation Index (SSCI)) | Article, English | TI=("service innovation" OR "new service" OR "NSD" OR "service develop*") AND TS=("capabilit*") |
| EBSCOHost (Business Source Ultimate) | Academic Journals, English | TI("service innovation" OR "new service" OR "NSD" OR "service develop*") AND (AB("capabilit*") OR SU("capabilit*") OR TI("capabilit*")) |
| ProQuest (Abi/Inform) | Scholarly Journals, English | TI("service innovation" OR "new service" OR "NSD" OR "service develop*") AND (AB("capabilit*") OR SU("capabilit*") OR TI("capabilit*")) |

*Table 25: Search results according to the literature review process (see chapter 3.3.1)*

| Literature search | Database | | | Total (without duplicates) |
|---|---|---|---|---|
| | **Web of Science** | **EBSCOHost** | **ProQuest** | |
| Database research (step 1 to 4) | 88 | 56 (15) | 62 (6) | 109 |
| Reading of abstract (step 5) | | | | 50 |
| Reading entire article (step 6) | | | | 27 |

*As of January 28, 2019*

### Appendix A2: Overview identified literature on service innovation capabilities

| Author | Conceptual foundation | Research approach |
|---|---|---|
| Agarwal and Selen (2009) | DCV | Mixed method: case study and survey (n=225); telecommunication service provider; Australia |
| Agarwal and Selen (2013) | DCV | Two surveys (n=225; n=224); telecommunication industry; Australia |
| (Bhatnagar & Gopalaswamy, 2017) | Competence-based view | Case study; hospitality, mobile telecommunication, and financial services; India |
| (Cantaleano et al., 2018) | DCV | Survey (n=168); micro and small businesses; Brazil |
| (Carbonell & Rodriguez-Escudero, 2014) | DCV | Survey (n=102); service firms; Spain |
| (Chen et al., 2016) | RBV | Survey (n=170); servitization- and service-based sectors; Taiwan |
| (den Hertog et al., 2010) | DCV | Conceptual; |
| (Ghoshal et al., 2018) | DCV | Case study; IT services industry |

| Author | Conceptual foundation | Research approach |
|---|---|---|
| (Giannopoulou et al., 2014) | RBV | Case study; research and technology organizations; Europe |
| (Grawe et al., 2009) | RBV | Survey (n=105); Electronics industry; China |
| (Janssen et al., 2016) | DCV | Survey (n=391); multiple industries; Netherlands |
| (Jin et al., 2014) | DCV | Conceptual |
| (Kindström & Kowalkowski, 2014) | RBV | Case Study; manufacturing firms; Sweden |
| (Kindström et al., 2013) | DCV | Case Study; manufacturing firms |
| (Liu & Huang, 2018) | Competence-based view | Survey (n=142); OEM-Electronic manufacturers; Taiwan |
| (Mennens et al., 2018) | DCV | Survey (n=100); SME manufacturing firms; Netherlands |
| (Ordanini & Parasuraman, 2011) | DCV | Survey (n=91); hotel industry; Italy |
| (Parida et al., 2015) | RBV | Case Study; multinational manufacturing firms |
| (Salunke et al., 2019) | DCV | Conceptual & survey (n=192 & n=261); project oriented B2B service firms; Australia & USA |
| (Shang et al., 2009) | DCV | Case Study; automotive industry; Taiwan |
| (Sharma et al., 2014) | DCV | In-depth interviews; healthcare organizations |
| (Storey & Hughes, 2013) | RBV | Survey (n=105); financial services, travel/ transportation, retail, and ICT sectors; UK |
| (Tang et al., 2013) | RBV | Survey (n=147); hotel industry; Taiwan |
| (Tsai & Wang, 2017) | RBV | Survey (n=170); service-oriented firms; Taiwan |
| (Tsou & Cheng, 2018) | DCV | Survey (n=97); IT B2B service industry; Taiwan |
| (Weng & Huang, 2012) | RBV; Knowledge-based view | Survey (n=185); Healthcare services; Taiwan |
| (Witell et al., 2017) | RBV | Conceptual |

# Appendix B: Interview guideline in German

**Einleitung**

- Das Case Study Interview ist Teil meiner Dissertation, die organisatorische Fähigkeiten von Medizintechnikunternehmen im Bereich von digitalen Service-Innovationen untersucht.
- Ziel der Dissertation ist es zu identifizieren welche neuen Anforderungen digitale Dienstleistungsinnovationen an die Organisation der Medtech-Unternehmen stellen, und wie Prozesse und Strukturen angepasst werden müssen, um die Innovationsfähigkeit in diesem Bereich zu steigern.
- Sofern Sie es erlauben wird das Interview aufgezeichnet und transkribiert. Die Ergebnisse werden anonymisiert in meiner Dissertation veröffentlicht. Sie erhalten jedoch vor der Veröffentlichung den entsprechenden Abschnitt zur Freigabe.
- Gerne stelle ich Ihnen die finalen Ergebnisse der Dissertation im Anschluss detailliert vor.

Strategische Bedeutung digitaler Dienstleistungen und Lösungen

- Welche Bedeutung haben digitale Dienstleistungen für ihr Unternehmen heute?
    - (z.B. bzgl. Produktdifferenzierung, Kundenbindung, zusätzliche Einnahmequelle)
- Welche Bedeutung werden digitale Dienstleistungen zukünftig für ihr Unternehmen haben?
    - Wo sehen Sie ihr Unternehmen in Bezug auf digitale Dienstleistungsinnovationen in fünf Jahren?
    - Welche Chancen und Risiken assoziieren Sie mit digitalen Dienstleistungen für ihr Unternehmen?

**Organisationsstruktur/-setup**

- Bitte beschreiben Sie das organisationale Setup für die Entwicklung digitaler Dienstleistungen und Lösungen.
    - Welche Unternehmensbereiche sind in die Entwicklung von digitalen Dienstleistungen involviert?
    - Inwiefern unterscheidet sich das Setup zur Entwicklung digitale Dienstleistungen vom Setup zur Entwicklung von physischen Medizinprodukten?
- Welche organisatorischen Herausforderungen haben sich in der Vergangenheit bei der Entwicklung von digitalen Dienstleistungen gezeigt?
- Welche Anpassungen an das organisationale Setup wurden bereits vorgenommen bzw. sind zukünftig geplant, um bessere organisationale Voraussetzungen für die Entwicklung von digitalen Dienstleistungen zu schaffen?
    - (z.B. Schaffung spezifischer Funktionen, Abteilungen und Unternehmensbereiche)

**Existierende Fähigkeiten und Kompetenzen**

- Bitte beschreiben Sie welche existierenden Fähigkeiten, Kompetenzen und Wissen für die Entwicklung digitaler Dienstleistungen und Lösungen genutzt werden.
    - (z.B. technologisch (Software, IT) und nicht-technologisch (Markt- und Kundenbezogen, Methodik))
- Welche Unternehmensbereiche ausserhalb der F&E-Abteilung verfügen über relevantes Wissen, Fähigkeiten und Kompetenzen für die Entwicklung innovativer digitaler Dienstleistungen?
    - (z.B. zu Kundenbedürfnissen und -anforderungen; Kundenprozessen, Markt und Wettbewerbern, regulatorischen Rahmenbedingungen und Technologie)
    - Wie werden diese Unternehmensbereiche in die Entwicklung von digitalen Dienstleistungen einbezogen?
- Welche Fähigkeiten und Kompetenzbezogenen Herausforderungen haben sich in der Vergangenheit bei der Entwicklung digitaler Dienstleistungen gezeigt?

**Kompetenz- und Wissensaufbau**

- Welche neuen Fähigkeiten und Kompetenzen werden für die erfolgreiche Entwicklung von datenbasierten Dienstleistungen im Unternehmen **intern** aufgebaut?
    - Welche neuen technologischen Fähigkeiten und Kompetenzen?
    - Welche nicht-technologischen Fähigkeiten und Kompetenzen?
        - (z.B. neue Entwicklungsmethoden, Markt- und Kundenwissen)
- Wie werden diese Fähigkeiten und Kompetenzen im Unternehmen aufgebaut?
    - Durch interne Forschungs- und Entwicklungstätigkeiten?
    - Durch Rekrutierung und Weiterbildung entsprechender Mitarbeiter?
    - Durch Schaffung neuer Abteilungen und Unternehmensbereiche mit spezifischen Kompetenzen?
    - Durch Unternehmenskäufe (M&A)?
    - Welche weiteren Methoden und Ansätze nutzt ihr Unternehmen zum Aufbau von relevantem Wissen, Fähigkeiten und Kompetenzen?
        - (z.B. Marktforschung, Feldstudien, Experimente)
- Welche Fähigkeiten und Kompetenzen werden **extern** von Lieferanten und Partnern bezogen?
    - Wie ist die Zusammenarbeit mit externen Partnern ausgestaltet?
        - Reine Dienstleister und Lieferanten, Strategische Partnerschaften und Allianzen?
    - Wer ist für die Identifikation und Koordination von externen Partnerschaften und Allianzen verantwortlich?
- Welche Rollen spielen Kunden beim Aufbau von Kompetenzen und Fähigkeiten?
    - Wie identifizieren Sie Kundenbedürfnisse und Anforderungen in Bezug auf digitale Dienstleistungen?
    - Wie ist die Zusammenarbeit mit Kunden bei der Entwicklung digitaler Dienstleistungen ausgestaltet?
        - (z.B. Lead Users, Fokusgruppen, Entwicklungspartnerschaften)
    - Wer ist für die Identifikation und Ausgestaltung der Zusammenarbeit mit Kunden verantwortlich?
- Welche Herausforderungen haben sich beim Aufbau von neuen Fähigkeiten, Kompetenzen und Wissen für die Entwicklung von digitalen Dienstleistungen gezeigt

**Innovations- und Entwicklungsprozess**

- Bitte beschreiben Sie die wesentlichen Aktivitäten und Prozessschritte ihres Innovations- und Entwicklungsprozesses für digitale Dienstleistungen?
    - Inwiefern unterscheidet sich dieser Prozess von ihrem existierenden Prozess für die Entwicklung von physischen Medizinprodukten?

    - Was sind die wesentlichen Gründe, dass sie einen spezifischen Innovations- und Entwicklungsprozess für digitale Dienstleistungen etabliert haben bzw. etablieren werden?
- Nutzt ihr Unternehmen spezifische Entwicklungsmethoden wie z.B. Design Thinking, Service Design, Business Model Design, agile Entwicklungsmethoden, oder Minimum Viable Products (MVP) für die Entwicklung digitaler Dienstleistungen?
    - Was sind die wesentlichen Gründe für die Nutzung dieser Entwicklungsmethoden?
    - Wie und an welcher Stelle sind diese Methoden in den Innovations- und Entwicklungsprozess integriert?
- Welche Innovations- und Entwicklungsprozess-bezogenen Herausforderungen haben sich bei der Entwicklung von digitalen Dienstleistungen gezeigt?

**Strategie- und Portfoliomanagement-Prozess**

- Bitte beschreiben Sie ihren Strategie- und Portfoliomanagement-Prozess im Bereich der digitalen Dienstleistungen und Lösungen?
    - Wie identifizieren und bewerten sie mögliche Innovationsprojekte im Bereich der digitalen Dienstleistungen?
    - Was sind die wesentlichen Aktivitäten und Prozessschritte dieses Prozesses?
    - Welche Funktion oder Unternehmensbereich ist für den Strategieprozess verantwortlich?
    - Welche weiteren Funktionen und Unternehmensbereiche sind an diesem Strategieprozess beteiligt?
- Welche Strategieprozess-bezogenen Herausforderungen haben sich bei der Entwicklung von digitalen Dienstleistungen gezeigt?

**Unternehmenskultur**

- Wie würden Sie die Unternehmenskultur ihres Unternehmens beschreiben?
- Wie beeinflusst diese Unternehmenskultur die Innovationsfähigkeit ihres Unternehmens in Bezug auf digitale Dienstleistungen und Lösungen?
- Was sind aus ihrer Sicht Eckpunkte für eine Unternehmenskultur, die die Innovationsfähigkeit in Bezug auf digitale Dienstleistungen fördert bzw. unterstützt?

**Abschliessende Bemerkungen**

- Welche allgemeinen Herausforderungen und Barrieren haben Sie in der Vergangenheit in Bezug auf digitale Dienstleistungsinnovationen identifiziert?
- Wie bewerten Sie die Innovationsfähigkeit ihres Unternehmens im Bereich der digitalen Dienstleistungen?
- Was sind die wichtigsten Massnahmen und Veränderungen, die Sie in ihrem Unternehmen in den nächsten fünf Jahren in Bezug auf digitale Dienstleistungsinnovationen erwarten?

- Haben Sie weitere Unterlagen (z.B. Organisationsdiagramm, Prozessbeschreibungen), die das Management von digitalen Dienstleistungen in ihrem Unternehmen verdeutlichen, und die Sie in der Lage sind zu teilen?

# Curriculum Vitae

| | |
|---|---|
| Name: | Lorenz Stähle |
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**Education**

| | |
|---|---|
| 2016 – 2020 | **University of St. Gallen, Switzerland**<br>Ph.D. in Business Innovation |
| 2011 – 2013 | **Berlin University of Technology, Germany**<br>M.Sc. in Industrial Engineering and Management |
| 2007 – 2011 | **Berlin University of Technology, Germany**<br>B.Sc. in Industrial Engineering and Management |
| 1998 – 2007 | **Gymnasium Achern, Germany**<br>Abitur (German A-Level equivalent) |

**Professional Experience**

| | |
|---|---|
| Since 2019 | **Hamilton Medical AG, Switzerland**<br>Product Manager Digital Solutions |
| 2016 – 2019 | **University of St. Gallen, Switzerland**<br>Research associate at the Institute of Technology Management |
| 2013 – 2016 | **Hamilton Medical AG, Switzerland**<br>Product Manager |