CHALMERS
UNIVERSITY OF TECHNOLOGY

Digital Transformation and New Product Development at Incumbent Manufacturing Firms

A Case Study on the Effects of Digital Transformation on New Product Development

Master's Thesis in Management and Economics of Innovation

CARL HAMMARLUND
MANTAS TRAKANAVICIUS

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF ENTREPRENEURSHIP AND STRATEGY

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2023
www.chalmers.se
Report No. E2023:015

REPORT NO. E2023:015

Digital Transformation and New Product Development at Incumbent Manufacturing Firms

A Case Study on the Effects of Digital Transformation on New Product Development

CARL HAMMARLUND
MANTAS TRAKANAVICIUS

Department of Technology Management and Economics
Division of Entrepreneurship and Strategy
Chalmers University of Technology
Gothenburg, Sweden 2023

Digital Transformation and New Product Development at Incumbent Manufacturing Firms
A Case Study on the Effects of Digital Transformation on New Product Development
CARL HAMMARLUND
MANTAS TRAKANAVICIUS

Report No. E2023:015
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone +46 (0)31-772 1000

Gothenburg, Sweden 2023

Digital Transformation and New Product Development at Incumbent Manufacturing Firms
A Case Study on the Effects of Digital Transformation on New Product Development

CARL HAMMARLUND
MANTAS TRAKANAVICIUS

Department of Technology Management and Economics
Chalmers University of Technology

Abstract

Digital transformation (DT) has disrupted industry after industry through technological advances, changing customer behavior and increasing competition between incumbent, born-digital and de alio entrant firms. Consequently, this rapidly changing environment raises the stakes for firms to digitally transform their businesses.

An example of this is the manufacturing industry. As incumbent manufacturing firms' (IMFs) offerings become more reliant on digital technologies to sustain competitive advantage, both the nature of products themselves and the processes used to develop them are affected. Furthermore, the impact of DT is especially relevant to understand for IMFs, as their organizational legacies may cause inertia and resistance to change.

As digitalization becomes more prevalent and pervasive, there is a need to better understand its effects on NPD processes that IMFs face. Therefore, this study aims to investigate how DT affects IMFs' new product development (NPD) processes within R&D in practice and how such effects can be managed. The intersection of these academic fields has been identified as lacking empirical studies, which is where this study aims to contribute.

To this end, a single case study was performed at a globally operating Sweden-based IMF. The intended audience is affected individuals and organizations in academia and firm management that are interested in the governance of R&D processes, more specifically NPD processes and how they are affected by DT.

The findings from this study showed that eight main effects emerged in this regard, some of which were not extensively covered by current literature. Moreover, four areas of intervention were identified regarding the management of these effects, and several implications for management and further research opportunities were also identified and outlined. Thereby, this thesis provides both practitioners and academia with an overview of the effects on DT on NPD processes, as well as indicates areas ripe for further investigation.

Keywords: digital transformation, digitalization, new product development, research and development, agile, stage-gate, dynamic capabilities, competitive advantage.

Acknowledgements

Conducting this study would not have been possible without the support of many individuals. We would like to express our gratitude to everyone who has devoted their time and attention to support us throughout the writing of this thesis. Without your knowledge, insights and guidance this thesis we would not have been able to finish it.

Thanks to all individuals at SwedCo who participated by providing valuable insights on our research topic and dedicated your time to helping us conduct our research. Without your input writing this thesis would not have been possible. A special thanks goes out to our supervisor and contact person at the case company, as well as all colleagues who provided support when needed. We would also like to thank our supervisor and examiner at Chalmers University of Technology, Maria Kandaurova and Professor Robin Teigland, for providing detailed feedback and encouraging us to put our insights and knowledge to work in completing this thesis. Thank you for your interest and support during this semester.

Finally, we would like to thank our friends and family for providing support and inspiration to write this thesis at the end of our five years of study. A special thanks is dedicated to the late Professor Emeritus Yngve Hammarlund for your interest and inspiration for attending Chalmers University of Technology.

Carl Hammarlund & Mantas Trakanavicius
Gothenburg, June 2023

Terminology

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

CAPEX	Capital Expenditure
CDO	Chief Digital Officer
CI/CD	Continuous Integration & Continuous Delivery
DT	Digital Transformation
ERP	Enterprise Resource Planning
IMF	Incumbent Manufacturing Firm
IT	Information Technology
KPI	Key Performance Indicator
MVP	Minimum Viable Product
NPD	New Product Development
NSR	New Sales Ratio
OPEX	Operating Expense
PI	Planning Interval
PLC	Product Life Cycle
ROI	Return on Investment
SAFe	Scaled Agile Framework
SLA	Service Level Agreement
SM&CP	Smart & Connected Product
SwedCo	Anonymized Case Company

Contents

List of Figures

List of Tables

1

Introduction

Digital transformation (DT) affects incumbent firms in the manufacturing industry in terms of technological advances, growing consumer demand for increasingly digital products, and competition from digital-born firms (Verhoef et al., 2021; Vial, 2019). As their offerings become more reliant on software and connectivity, both the nature of products themselves as well as the processes and methods used to develop them are affected (Porter & Heppelmann, 2015). Therefore, this thesis intends to investigate further how DT affects incumbent manufacturing firms (IMFs) new product development (NPD) processes within R&D in practice. This introductory chapter contains further information on the background, purpose, prior research, research questions and delimitations that were considered during the writing of this thesis.

From here onwards, NPD processes are defined as the processes whereby IMFs develop and bring to market new products; whereas NPD methods refers to the development methods used within their NPD processes (such as stage-gate and agile).

1.1 Background

The developments of digital technologies during the past decades have resulted in increasing competition and changing customer needs, and consequently the rules of the game are changing in many traditional industries (Verhoef et al., 2021). Furthermore, the push towards digitalization has been accelerated by advancements in response to the COVID-19 pandemic during the past couple of years, and these effects are likely to remain (Gavin et al., 2020; LaBerge et al., 2020). This has enabled the emergence of new digital-born firms, lower barriers to entry, increasingly globalized competition, new forms of digital offerings, and combinations of existing products and services, which all can impede the long-term viability of IMFs' competitive advantages (Björkdahl, 2020; Verhoef et al., 2021; Vial, 2019). In addition, it has also invited competition from de alio entrants from other industries where digital technologies have been adopted to a larger extent, which further increases the pressure on IMFs (Björkdahl, 2020). As a result, there are multiple external developments which raise the stakes for IMFs to digitally transform their businesses today (Verhoef et al., 2021; Vial, 2019).

Although providing new benefits, it is important to understand that DT is different in nature than what IMFs are used to. As digital technologies diffuse, they create pressure on firms to digitize both their new product offerings and reinventing related products by means of incorporating digital technologies in order to capture value from DT (Lyytinen et al., 2016). The shift towards digital products entails more software development in NPD processes, which in contrast to pure hardware products requires continuous development (e.g. maintenance, bug fixes, new features) even after being released – thus making it more of an ongoing task without clearly defined ending, rather than a traditional project (Aramand, 2008; Porter & Heppelmann, 2015; Svahn et al., 2017). Moreover, the interconnectivity of these products makes them pieces of larger systems of products, which both increases development and product complexity, requirements on integration and maintenance, as well as draws new industry boundaries by exposing firms to competition from a broader array of actors than before (Aramand, 2008; Björkdahl, 2020; Humble & Molesky, 2011; Pernstål et al., 2013; Porter & Heppelmann, 2014, 2015).

It is therefore important to note that effective software development is conducted using fairly different methods than traditional hardware development. In today's environment with constantly changing technical and market developments, there is a need for fast and iterative methods of software development (Olsson et al., 2012). To address these challenges, companies are adopting agile methodologies that provide more flexibility in the development process, using an iterative and incremental development fashion more suitable for changing requirements (Cooper & Sommer, 2016; Fitzgerald & Stol, 2017; Fricker, 2012; Olsson et al., 2012). However, agile development methodologies are quite different in nature from traditional product development methods, focusing on individuals and interactions, working minimum viable products (MVPs), customer collaboration, and responsiveness (Dybå & Dingsøyr, 2008). Moreover, since legacy products will likely continue to be of major importance for IMFs for some time, this may in turn imply the coexistence of different development methodologies over a certain period (Porter & Heppelmann, 2015). Therefore, the implementation of new agile methods in an established R&D organization may require substantial changes regarding established processes, ways of working, culture, and governance, which need to be better understood.

Consequently DT is particularly relevant for IMFs, which may face substantial challenges due to their organizational legacies and experience conflicts and trade-offs with their existing businesses (Verhoef et al., 2021). However, DT may not necessarily imply radical disruptions of their core businesses only – it can also imply the exploitation of new and complementary opportunities offered by digital technologies and serve as a way to increase value for customers and find sustained competitive advantage in the new digital world (Barney, 1991; Björkdahl, 2020; Correani et al., 2020; Furr & Shipilov, 2019; Srivastava et al., 2013).

In the near future, new and old digital technologies such as the internet, smartphones, cloud computing, blockchain, AI, and IoT are expected to cause further impact as more and more industries are disrupted by agile, born-digital competitors who accelerate this evolution. However, as IMFs progressively enter the digital do-

main, they must adapt to their new environment and its circumstances. Moreover, as competition intensifies and digital technologies become more widely adopted, there is another threat looming on the horizon for IMFs: hardware commoditization (Straehle et al., 2022). Better product performance is no longer sufficient for enabling sustained competitive advantage, and it is also becoming more resource intensive to continue improving pure performance at the same rate as before (Bloom et al., 2020). Therefore, industrial companies are driven to expand beyond legacy hardware offerings to increasingly capable digital offerings, as customers' demands are increasing with the progress of technological developments. The focus is thus shifted from competition on price or specific features alone to the complete and unique offerings of individual companies, for instance to digital offerings such as smart and connected products (SM&CPs) and the services enabled by capitalizing on data they provide – all of which increasingly requires capabilities for software development during new product development processes (Baines et al., 2009; Björkdahl, 2020; Correani et al., 2020; Porter & Heppelmann, 2015).

Thus, DT is increasingly challenging the status quo for IMFs through changes to the nature of products, development processes and the methods they employ there. If handled correctly, strong NPD capabilities can provide means for creating and capturing value from sustained competitive advantage by allowing firms to develop and bring to market superior next-generation products and solutions. Indeed, developing new products is one of the main factors for companies' success in the long run, providing opportunities for establishing competitive advantages for long-term successes (Marxt & Hacklin, 2005; Tzokas et al., 2004). It is simultaneously one of the most critical and challenging tasks that IMFs face today, as the current business environment is fraught with turbulence in terms of unprecedented technical and market uncertainty caused by developments within the field of digital technologies (Iansiti, 1995; Tzokas et al., 2004). A better knowledge of the effects caused by DT in this context is thus becoming increasingly important for IMFs, which is what this thesis aims to explore.

1.2 Prior Research

Plenty of research has been conducted in the fields of digital transformation in theory and practice, explaining how the emergence of digital technologies affects firms in general (Björkdahl, 2020; Correani et al., 2020; Dąbrowska et al., 2022; Matt et al., 2015; Verhoef et al., 2021; Vial, 2019). Furthermore, existing literature also covers agile (e.g., scrum) and traditional NPD methods (e.g., stage-gate) as solitary concepts for developing products (Cooper & Kleinschmidt, 1991; Cooper & Sommer, 2016; Dybå & Dingsøyr, 2008; Iansiti, 1995; Rising & Janoff, 2000; Tzokas et al., 2004). However, there is a lack of research on several aspects of these academic areas, for instance: how performance of NPD projects is evaluated during development (Tzokas et al., 2004); the consequences of DT on innovation performance (Dąbrowska et al., 2022); how incumbent firms progress through different phases of DT and its impact on performance (Verhoef et al., 2021); how incumbents lagging in digital technology adoption can renew themselves (Dąbrowska et al., 2022); and

a lack of empirical research regarding the combination of agile and traditional NPD methods in IMFs (Cooper & Sommer, 2016). Thus, there seems to be insufficient empirical research that investigates how DT in conjunction with new NPD methods affect IMFs in the context explained above – in spite of the developments outlined previously that increasingly puts more and more firms in that exact position. Hence, there is a gap in the research regarding how DT and new digital offerings enabled by it impacts NPD processes within R&D at IMFs. By conducting research to explain those gaps, IMFs embarking on their DT journeys could benefit from information that may help them make more informed decisions regarding how they can adapt their NPD processes to an increasingly digitalized environment.

1.3 Problem Statement

In light of the developments and research gap outlined previously, there is a need to better understand the effects on NPD processes that IMFs face due to the new digital offerings enabled by DT. For instance, the fact that development itself becomes more of an ongoing task rather than something with clearly defined start and end points. This has substantial ripple effects on e.g., development process governance, cost, evaluation, culture, and ways of working that need to be better understood to provide reliable and correct information for rational decision-making and prioritization in these businesses as they conduct their NPD. Moreover, there is a need for a more nuanced understanding on not only the benefits of DT, but also its possible drawbacks and complications for incumbent manufacturing firms going forward, as well as how these can be managed.

As digitalization becomes more prevalent and pervasive in society, the need for IMFs to react to emerging digital technologies, changing customer behavior and new competitors will only become more apparent and pressing. Therefore, addressing the lack of literature on the effects of DT on NPD in this setting is vital. Otherwise, there is a risk that firms will continue applying their old processes and thinking, while the world around them has changed dramatically, which could possibly lead to inefficiencies and misunderstandings. In sum, this thesis intends to shed light on how DT affects IMFs in practice, specifically with respect to their NPD efforts within R&D.

1.4 Purpose & Research Questions

The following section shortly describes the intended purpose of the study, as well as outlines the research questions formulated to fulfill this purpose

1.4.1 Purpose

The purpose of this study is to explore what the effects of DT are on NPD processes for IMFs, and how they can cope with these effects. This includes for instance understanding how the nature of NPD and their offerings is changing due to emerging

digital technologies. The aim is to contribute with insights regarding both practical and theoretical implications in this context. To accomplish this, a single case study analysis was performed at the case company, which is a globally operating IMF based in Sweden, hereafter called SwedCo. The intended audience is affected individuals and organizations in academia and firm management that are interested in the governance of R&D processes, more specifically NPD processes and how they are affected by DT.

1.4.2 Research Questions

Two research questions were formulated to provide guidance in fulfilling the research purpose. The first research question was aimed at exploring how DT affects IMFs' NPD processes, as focus is shifted toward digital offerings that are more reliant on software and connectivity. The intention was to provide clarity over which parts of their NPD processes are most impacted by these developments, and what issues and opportunities might be caused by such changes. The first research question was thus formulated as follows:

1. How does the introduction of digital offerings enabled by DT affect NPD processes within R&D in IMFs in practice?

The second research question was then aimed at understanding and explaining how IMFs can manage these effects, based on what had emerged from answering the first research question:

2. How can IMFs manage the effects on NPD processes within R&D that result from the introduction of digital offerings enabled by DT?

1.5 Delimitations

Some delimitations were made in this study in order to allow an in-depth investigation of the research questions to be conducted. First, only the development of new products were included to arrive at a feasible scope – thereby omitting other aspects such as the commercialization of new products, which may also be impacted by DT. This further means that other parts of R&D efforts such as early-stage research were omitted as well. Second, while there is a wide range of digital offerings enabled by DT, this thesis focuses primarily on SM&CPs, as defined in Chapter 2. Third, the study focuses solely on one case company, the IMF SwedCo as explained further in Chapter 3. While some transferability outside of this context may possibly be achieved, this was not an inherent objective of the study (apart from extending current theory and providing implications for practitioners and academia).

2

Theory

The following chapter outlines the theoretical foundation for this thesis, gathered from relevant literature analyzed during the literature review. First, a brief description of DT literature is presented, explaining why firms go through DT with regards to market and technology developments, as well as why this can be difficult for incumbent firms due to their legacy businesses. Second, the change in product nature towards SM&CPs enabled by DT is explained in more detail. This will require new competences and capabilities for handling increased complexity and data analysis, which will incur additional costs compared to traditional product development. Finally, this chapter aims to outline what current literature has contribute regarding the effects DT has on NPD processes, such as additional costs, organizational culture, increasing importance of software development, and performance measurement when compared to formal product development.

2.1 Digital Transformation

The emergence and confluence of digital technologies have led to virtually unprecedented levels of technological and market uncertainties which has led to major effects on today's business environment (Björkdahl, 2020; Iansiti, 1995). In this unstable environment, digital technologies are reshaping everything from customer needs and behaviors to technological possibilities, business models, manufacturing systems, entire markets and ultimately society at large through frequent and substantial technological advancements (Dąbrowska et al., 2022; Iansiti, 1995). This contributes to increasing the level of complexity in the environment where organizations are operating, as well as enabling new ways to collaborate in more distributed networks of actors (Vial, 2019). In turn, this can result in firms having less control over their environment and more difficulties in sustaining their competitive advantage over time (Vial, 2019).

Since the terms "digitalization" and "digital transformation" have been used interchangeably by some authors, from this point onwards they will be referred to as digital transformation (DT).

2.1.1 Defining Digital Transformation

Building on extant definitions, DT can be defined in a number of different ways. For instance, Dąbrowska et al. (2022) refer to it as the implementation of digital technologies which leads to opening up both new opportunities as well as challenges for organizations. Specifically, information, computing, connectivity, platforms and SMACIT technologies (social, mobile, analytics, cloud and IoT) have been interpreted as vital emerging digital technologies used in the context of DT (Dąbrowska et al., 2022; Vial, 2019). Moreover, combinations of these technologies are particularly prominent when it comes to DT (Vial, 2019).

However, this phenomenon can be viewed from other angles as well. Prokhin (2020) offers a somewhat different definition of DT as the use of digital technologies for business development, optimization, and business model innovation (BMI) to lend new benefits to a firm. As DT forms a new basis for organizations to develop deeper ties to consumers and suppliers, it goes beyond solely being an effect of technological progress (Prokhin, 2020). Björkdahl (2020) further describes DT as contributing to increased generation and use of data that can be utilized to promote both organizational efficiency and growth through increased added value for customers.

Vial (2019) as well as Furr and Shipilov (2019) further comment on DT as a process in which digital technologies create disruptions that trigger strategic responses from firms seeking to change their value creation activities. These include managing organizational and structural changes as well as overcoming possible barriers to DT. Building on these notions, Correani et al. (2020) and Björkdahl (2020) explain how DT can lead to competitive advantages in terms of creating more efficient products and services that are better aligned with customer needs, shorter time to market and possibilities for creating digital ecosystems.

As such, DT can be interpreted simultaneously as an endogenous enabler of organizational renewal providing opportunities to transform organizational legacies, structures, processes, capabilities, products, services, and business models – or as exogenous disruptive changes that could cannibalize on incumbent organizations' core activities and threaten the survival of firms and entire industries (Correani et al., 2020; Dąbrowska et al., 2022; Vial, 2019).

Managers are sometimes struggling with understanding what DT means in practice, and what opportunities and initiatives should be prioritized. As a result, they often expect DT to involve radical disruptions of their businesses (Furr & Shipilov, 2019). However, Furr and Shipilov (2019) explain that it does not have be the case that radical disruptions need to be involved. Instead, they claim that DT more often than not implies incremental changes to a firm's business in order to augment and better deliver their core value proposition to serve known customer needs, since these will likely remain the same in the future (Furr & Shipilov, 2019). Instead, they view DT as the latest wave of modernization affecting firms and conclude that if incumbent firms can better meet the needs of customers through DT, they can continue to be competitive in spite of disruptions in the environment they operate

in (Furr & Shipilov, 2019). DT should therefore be understood as encompassing both transformation of a firm's core business utilizing digital technologies as well as exploiting new and complementary opportunities offered by digital technologies (Björkdahl, 2020; Correani et al., 2020; Furr & Shipilov, 2019).

What unites these different definitions is that they refer to DT as a process whereby firms actively or reactively adopt emerging digital technologies as part of their offerings and internal processes in order to stay relevant in a changing environment, provide more value and develop deeper ties to their customers, and reap the benefits of these developments. This is the definition of DT that will be used in this thesis going forward.

2.1.2 Types of Disruption

Considering the definition for DT used in this thesis, Vial (2019) and Verhoef et al. (2021) identify some notable drivers and disruptions of DT: new digital technologies, consumer behavior, competition, and data availability.

New Technologies

As stated previously, there has been a steady stream of innovations and combinations of technologies within IT, computing, connectivity and SMACIT technologies (Dąbrowska et al., 2022; Vial, 2019). This has paved the way for current developments regarding increased competitive intensity and need for strategic renewal for firms (Porter & Heppelmann, 2014; Verhoef et al., 2021). Although it is likely that not all new digital technologies will have as substantial impact as for instance mobile devices and IoT have had, it is clear that the disruptions entailing from emerging digital technologies force firms to adapt and react – i.e., transform digitally (Björkdahl, 2020; Verhoef et al., 2021).

Altering Consumer Behavior & Expectations

As digital technologies have enabled customers to gain access to information in new ways through digital touchpoints, they are able to engage in dialogue with the firms whose products and services they consume, thus becoming an important part of developing new products (Verhoef et al., 2021; Vial, 2019). For instance, Verhoef et al. (2021) explain how digital technologies lend customers power in the sense that they make publicly available the sharing of reviews and customer-originated information about products to virtually anyone. Furthermore, the ubiquity of mobile digital devices enables new types of customer interactions and behaviors. Vial (2019) describes that these developments have led to increasing consumer expectations on new products, thus making it important for firms to anticipate and adapt to changing customer behaviors. If firms cannot cope with these changes, they are not well positioned for competing in the digital markets of the future.

Disrupting the Competitive Landscape

The emergence of digital technologies also has a severe impact on competition and brings about disruptions of current markets (Verhoef et al., 2021; Vial, 2019). New, born-digital firms emerge, competition becomes globalized, and the possibility of combining existing products and services enables new forms of digital offerings, favoring services over products, lowering barriers to entry, and impeding the long-term viability of incumbents' competitive advantages (Verhoef et al., 2021; Vial, 2019). Furthermore, DT has invited competition from previously unrelated fields, as well as new competitors with asset-light business models (Björkdahl, 2020). However, new digital technologies can also be leveraged to improve the competitive performance of firms: for instance, by enabling updating and continuously improving products that have already been released to markets (Correani et al., 2020).

Increasing the Availability of Data

Digital technologies also result in the generation of vast amounts of data (Vial, 2019). Firms undergoing DT strive to capitalize on the existence of this data by either monetizing it through data sales, or to utilize it to offer products and services better suited to their customers' needs, and to improve internal processes (Vial, 2019). One way in which such data can be made available widely within an organization is through a data lake, which acts as a single storage point of all firm data to enable easy access to the collected data (Björkdahl, 2020; Porter & Heppelmann, 2015; Prokhin, 2020). Similarly, Correani et al. (2020) explains the need for a data platform where data is collected, structured and can be used as a basis for data mining and other types of data analyses.

2.1.3 Strategic Implications

Vial (2019) explains how digital technologies do not add much value on their own, but rather that it is their implementation and use within a given context that can enable firms to find new value creation opportunities. As described by Vial (2019) DT is radically changing firms' external environments by blurring market boundaries, disrupting industries, and changing roles in all parts of traditional value chains. Remaining competitive today therefore increasingly hinges on firms' abilities to take a comprehensive strategical approach to adapt its current business activities and decide on an adequate scope of their DT efforts (Matt et al., 2015; Vial, 2019). It is also important to secure alignment between firms' business models and strategies in order to achieve successful DT and improve operational performance (Matt et al., 2015; Vial, 2019). As DT radically alters the way organizations create and capture value, they must respond to this new reality by adapting their offerings to enable further collection of data to continue this journey (Vial, 2019).

The data collected due to the increased connectivity and prevalence of SM&CPs allow remote monitoring, predictive maintenance, and other complementary services to be offered to customers (Björkdahl, 2020; Porter & Heppelmann, 2015). This allows firms to increase their customer proximity and centricity by moving down-

stream in the value chain, which has been shown to positively affect profitability (Björkdahl, 2020). Correani et al. (2020) further highlight how the vast amounts of data from consumers and their use of a firm's products can enable radical transformation of firms' value creation processes and increase their competitive advantage (Correani et al., 2020).

To support long-term digital transformation strategies and secure future competitivenes, Björkdahl (2020) underlines the importance of basing sound DT strategy on customer needs and focusing on strengthening the core business in order to achieve competitive advantage. To accomplish successful implementation, several measures are important, chief of them the redefinition of business models to increase consistency with firm's strategies, as well as defining a clear scope of and responsibilities for implementation (Correani et al., 2020; Matt et al., 2015). Firms should strive to identify competence gaps and the extent of external cooperation needed in specific areas to acquire complementary assets from partners (Björkdahl, 2020). Björkdahl (2020) further mentions a culture of consistent, coherent, and comprehensive values and norms that promote the use of digital technologies and data as tools to achieve success in the long run. Therefore, business leaders must foster such a culture, clearly signal the need for DT and make sure that all parts of the organization are aligned and feel responsible for working towards this common goal (Björkdahl, 2020; Matt et al., 2015).

2.1.4 Transformation of Value Creation Processes

Several authors moreover state that substantial changes to firms' business models may be needed to leverage effective use of digital technologies and data to create and capture value in new ways (Correani et al., 2020; Verhoef et al., 2021; Vial, 2019). This makes DT particularly relevant for incumbent firms, which may face substantial challenges due to their organizational legacies and experience conflicts and trade-offs with their existing businesses (Verhoef et al., 2021). Research suggests that incumbents perform gradual transformation of their businesses into the digital world. For instance, Correani et al. (2020) provide four vital steps to do so: leveraging customer data to improve a firm's offerings, empowering employees through digitally enabled productivity and collaboration improvements, optimizing operations through the use of digital technologies, and finally transformation of products, services, and business models (Correani et al., 2020). Furthermore, the literature reviewed suggests prominent changes in some business model components that impact the transformation of firms' value creation processes, relating to: value propositions, agility and ambidexterity, and digital platforms (Björkdahl, 2020; Vial, 2019).

Value Propositions

Digital technologies have been found to enable new value propositions increasingly focused on servitization as a means of implementing a growth agenda to realize value from DT (Björkdahl, 2020; Vial, 2019). Services can be utilized to offer operational and complementary services to transition from or augment sales of products to offer

innovative solutions and gather data on customer usage to better satisfy customer needs (Björkdahl, 2020; Vial, 2019). Matt et al. (2015) further describe that DT can enable and possibly even require new forms of monetization and changes to a firm's business scope, for instance if new markets or customer segments are addressed and depending on the extent to which new digital activities deviate from their existing business models (Matt et al., 2015). Moving further from the legacy business is related to higher risks and a greater need for new competences but can also offer opportunities to expand current offerings (Matt et al., 2015). Therefore, firms need to decide on their technological ambitions – whether they want to become first-movers or followers in the use of digital technologies; standard-setting market leaders or passive users of already established technology standards in order to optimize their operations (Matt et al., 2015).

Agility & Ambidexterity

Vial (2019) mentions organizational agility (similar to dynamic capabilities; cf. Björkdahl, 2020) and ambidexterity as two major prerequisites for DT. Correani et al. (2020) as well as Björkdahl (2020) further suggest that processes during DT should be agile and lean to allow quick adaptation to fast and unpredictable changes – something they describe of typical behavior of startups (Correani et al., 2020). This is especially important when firms do not have experience with the concepts and solutions they are developing, which may often be the case during DT (Björkdahl, 2020). Furr and Shipilov (2019) further mention the need to reorganize both people and technology using agile methods to enable connection of formerly siloed parts of the organization and distributing capabilities and responsibilities (Furr & Shipilov, 2019). In short, these authors highlight the need to adapt tools and methods used by entrepreneurial, born-digital startups to succeed in competing with them, as firms need more flexible forms of organizing to allow for quick response to fast changes in digital technologies (Björkdahl, 2020; Verhoef et al., 2021).

Digital Platforms

Another strategic decision regarding transformation of value chains regards new digital growth strategies – most prominent thereof, the use of digital platforms. According to Verhoef et al. (2021), firms capitalizing on digital platforms have showcased substantial growth figures in user bases, earnings and equity per employee compared to other firms; hinging on high scalability and reinforcing network effects. The more customers or suppliers there is on either side of the platform, the more utility is provided to both sides, thus creating virtuous feedback loops. This ensures that digital platforms can handle quick growth in terms of users on any side of the platform. Verhoef et al. further explain that since the marginal cost of catering to additional customers is low, the growth of digital platforms can be virtually exponential. The rising power of platforms consequently means that selecting suitable partners to work with in this domain becomes critical (Verhoef et al., 2021).

2.1.5 Structural & Processual Changes

Owing to its profound impact on firms' organization, DT is associated with certain important changes in organizations (Matt et al., 2015; Verhoef et al., 2021; Vial, 2019). These are described in more detail below and relate to organizational structure, digital assets, leadership, employee roles and skills, and partners (Matt et al., 2015; Verhoef et al., 2021).

Organizational Structure

Matt et al. (2015) mention that structural changes are often needed to provide a solid basis for future operations in the context of DT. For instance, cross-functional teams are vital to further collaboration across divisional borders and breaking functional silos, and for enabling agility and ambidexterity (Björkdahl, 2020; Prokhin, 2020; Vial, 2019). Another change is that many activities such as improving products and services, project management and monitoring customer needs in real time become continuous, permanent, and ongoing tasks (Prokhin, 2020). Furthermore, the amount of data processed and made available to all parts of the organization weaken the traditional models of centralized management and control, thus extending and delegating responsibility and decision-making authority (Prokhin, 2020). Finally, incumbent firms may need to handle the coexistence of both new digital products and legacy products for extended periods of time (Porter & Heppelmann, 2015; Prokhin, 2020).

Digital Assets

A major key to achieving successful DT is digital assets, such as data lakes to enable storage and retrieval of data for analysis (Porter & Heppelmann, 2015; Verhoef et al., 2021). However, very few firms have centralized control of their data today (Björkdahl, 2020). If the decentralized functions who have control over data today do not routinely share data in cooperation, it can become difficult for an organization to progress in their DT journey (Björkdahl, 2020). Relatedly, there is also a need for building capabilities to support decision-making, such as data analytics or data science groups (Björkdahl, 2020; Dąbrowska et al., 2022).

Leadership

Developing a digital mindset to foster organizational support in an organization undergoing DT is important and can be facilitated by the creation of new leadership roles, such as a chief digital officer (CDO) (Correani et al., 2020; Dąbrowska et al., 2022; Vial, 2019). This both signals the strategic importance of DT to the organization and helps foster closer alignment between IT and other functions (Vial, 2019). However, according to Björkdahl (2020) it is then important to make sure that DT is not governed by one single function since that can create internal frictions. Instead, digital technology is no longer only the responsibility of an IT department, but a vital part of the firms' value chain and it must transform into a role of orchestrating and supporting DT in the entire organization (Furr & Shipilov, 2019; Verhoef et al.,

2021). Finally, Matt et al. (2015) finds it important to secure top management support during the entire DT process, to counteract any resistance, since it has such wide-ranging impacts on the entire organization.

Employee Roles & Skills

Moreover, the cultural and structural changes implied by DT lead to employees fulfilling responsibilities which previously lay outside their roles, e.g., non-IT employees being involved in IT-heavy projects and vice versa (Vial, 2019). This mutual extension and potential partial overlapping of roles and skills of employees are required to enable the increased cooperation and coordination needed for successful DT (Dąbrowska et al., 2022; Verhoef et al., 2021; Vial, 2019). Moreover, employees' digital skills may need strengthening as DT is reshaping the labor market (Dąbrowska et al., 2022; Verhoef et al., 2021). Therefore, it becomes relevant to assess how the future needs and capabilities are to be put in place in terms of hiring employees with the right competences – which might be scarce and coveted by many firms – and the extent to which current staff can be trained to assume new roles (Vial, 2019). Furthermore, introducing new tech-savvy staff may create tensions between the existing workforce and may result in a cultural conflict, if not managed properly (Dąbrowska et al., 2022).

Partners

As organizations venture on their DT journeys, substantial changes to their core capabilities may necessitate acquiring knowledge and competences through more extensive collaboration with partners (Correani et al., 2020). Thus, there is a need to adopt a more network-centric or ecosystem-oriented approach to find and cooperate with other digitally connected firms to share information, co-create value and improve interfirm relationships (Dąbrowska et al., 2022; Verhoef et al., 2021; Vial, 2019). As an extension of this consideration, Björkdahl (2020) discusses that the extent of cooperation across firm boundaries may indeed increase with DT, and that it could also be addressed by means of acquisition. Finally, Björkdahl (2020) mentions that since digitalization increases system dependence between firms' offerings, the notion of ecosystem competition becomes more important. This could prove an effective digital growth strategy due to their prominent growth possibilities but may at the same time mean that value may shift towards other actors in the ecosystem (Björkdahl, 2020).

2.2 Changing Product Nature

This subchapter outlines in more detail how the shift towards developing digital offerings – specifically SM&CPs – implies an increasing focus on software development and increasing product complexity and describes how firms can tackle these developments through the use of platforms and modularity.

The new nature of SM&CPs implies many changes for incumbent firms – such as redefining functions like R&D, IT, manufacturing, logistics, marketing, sales, and

after-sales support – emphasizing the growing need for coordination between these functions (Porter & Heppelmann, 2015). In addition, new functions are emerging to handle and analyze the large amounts of data that come from SM&CPs (Björkdahl, 2020). Moreover, changes to working and cultural norms are required as IMFs start to produce SM&CPs and evolve into something in between a traditional product firm and a software firm (Porter & Heppelmann, 2015).

2.2.1 New Generation of Smart & Connected Products

Porter and Heppelmann (2015) delineate SM&CPs as a composition of three core elements: physical elements (hardware, i.e., mechanical and electronic parts), smart components (sensors, processors, software), and connectivity components (ports, antennas, networks) that enable connecting the product to the cloud. All these necessary technologies for a product's full functionality compose a "technology stack" (Porter & Heppelmann, 2015; Wortmann & Flüchter, 2015). Furthermore, Porter and Heppelmann (2014) highlight that these new capabilities (ability to monitor environment, control and optimize performance, and operate autonomously) products are not only impacting the competition in industries but also drawing new industry boundaries when connected products can leverage each other's data and insights. This suggests a shift from competition on a product basis to systems of products. Therefore, firms can find themselves competing in a wider landscape than before (Porter & Heppelmann, 2014).

As mentioned previously, SM&CPs also introduce new product capabilities which enable them to collect data about their surroundings and interactions with users, making them a new data source for firms (Porter & Heppelmann, 2015; Tomiyama et al., 2019). This data represents an important new asset for firms (Porter & Heppelmann, 2015). Tomiyama et al. (2019) point out that collected data can be used for both commercial and technical purposes, for instance to enable performance optimization and predictive maintenance but also to understand user preferences.

As products introduce such data-collecting and monitoring capabilities, integrity and security considerations become increasingly important (Porter & Heppelmann, 2015; Tomiyama et al., 2019). All SM&CPs could become targets for hacker attacks, and successful intrusions could enable them to take control of devices and collect data that is exchanged between different parts of the technology stack (Porter & Heppelmann, 2015). Therefore, there is a need for extensive security management for protecting data transfer from, to, and between products and integrating security aspects into the product design. Furthermore, data privacy and security is receiving increasing attention from customers and regulators, raising the question of how the collected data will be used and by whom (Porter & Heppelmann, 2015).

2.2.2 Software in Smart & Connected Products

Software is a key component in the majority of SM&CPs, and acts as its nerve and operating system (Aramand, 2008; Porter & Heppelmann, 2015). In contrast to hardware products, software is not completed after the initial deployment to

end-customers, but instead require continuous maintenance and improvement of performance and features to be aligned with users' needs (Anquetil et al., 2007; Aramand, 2008). Furthermore, external factors such as competition and changing user and customer requirements result in shorter software life cycles. In addition, developments in computing hardware enable software developers to continuously create software applications with more demanding functionality, decreasing their life cycles further (Aramand, 2008).

Porter and Heppelmann (2015) also highlight that SM&CPs can be upgraded by remotely updating the software. In addition, SM&CPs that are built on modern technology stacks are dependent on service even after being brought to market (Porter & Heppelmann, 2015). The technology stack must therefore also be continuously improved and maintained during the product life cycle (PLC) to stay relevant in increasingly competitive markets (Aramand, 2008; Porter & Heppelmann, 2015).

SM&CPs have also impacted product development and manufacturing activities resulting in higher fixed costs (Porter & Heppelmann, 2014). These are related to higher initial costs of software development, complex product design, development of the technology stack, connectivity, data storage, analytics, and security (Porter & Heppelmann, 2014). Moreover, as the functionality is provided mostly by software, customizing the experience becomes cheaper when it does not involve hardware components (Porter & Heppelmann, 2015). To spread the increased fixed cost, scaling digital solutions and services efficiently becomes also increasingly important (Porter & Heppelmann, 2014).

Due to the changing product development processes of SM&CPs, new competencies such as software and application engineers, user interface developers, systems integrators, and data scientists are required for the development and maintenance of the whole technology stack (Porter & Heppelmann, 2015). In addition, development of SM&CPs require cross-functional coordination and integration of various competences with different development paces, making coordination increasingly difficult (Porter & Heppelmann, 2015). Porter and Heppelmann (2015) also highlight that coordination will be necessary over the whole PLC due to the continuous dependencies between functions and departments.

Aramand (2008) further explains that most of the cost during the software life cycle can be attributed to maintenance and enhancements, which occur after the product is released. This related to the technical debt, which refers to emerging cost of maintaining software as a result of forced development including taking shortcuts and making compromises to be able to meet deadlines and deliver software on time (Brown et al., 2010; Tom et al., 2013). Aramand (2008) further explains that it is important to not compromise the final phase of software development to reduce the cost of potential maintenance, since that is the phase where the components of the application are merged and tested for both qualitative and performance-related requirements before being deployed for end-users. Compromising this final step by not completing or not properly testing or debugging it can result in extensive maintenance and improvement costs after release (Aramand, 2008).

2.2.3 Product Complexity and Modular Platforms

New products consisting of both hardware and software components introduce new levels of complexity, which is related to the increasing number of linkages between different technology layers in products and also requires more resources during development (Persson & Åhlström, 2006; Porter & Heppelmann, 2015). Porter and Heppelmann (2014) further conclude that as SM&CPs are becoming part of larger systems due to their new capabilities and connectivity technologies, this in turn also contribute to complexity and increases the requirements for both integration and maintenance (Humble & Molesky, 2011; Porter & Heppelmann, 2015). The advancements in software technologies also contribute to both complexity and uncertainty when different software systems are required to be integrated (Pernstål et al., 2013). According to Humble and Molesky (2011), this has led to the emergence of an extensive portfolio of various systems to maintain, consuming the majority of firms' IT budgets. Furthermore, as the complexity and interconnectivity between systems increase, it also creates challenges related to the decommissioning of old systems when new systems are deployed, contributing to continuously growing IT costs (Humble & Molesky, 2011).

To address some of the aforementioned challenges of increasing complexity, platforms have been widely adopted to achieve more efficient NPD development in both hardware and software development (Meyer & Lopez, 1995; Meyer & Seliger, 1998). Meyer and Seliger (1998) define a product platform for hardware as a "set of subsystems and interfaces that provide a common structure from which a stream of derivative products can be efficiently developed and produced" (p. 61). Platforms enable businesses to develop new products in a more efficient and flexible manner, allowing them to be tailored to specific market demands (Meyer & Lopez, 1995; Meyer & Seliger, 1998). This is accomplished through the use of modules (subsystems) that can be integrated into a larger program (system) to provide specific functionality (Meyer & Lopez, 1995). Platforms can therefore be used to create customized solutions at virtually no additional cost, but this requires standardized interfaces (Meyer & Seliger, 1998). Software platforms are defined in a similar way; however, they normally contain more subsystems and interfaces between them (Meyer & Seliger, 1998).

2.3 Changing New Product Development Methods

Developing new products is one of the main factors for firms' success in the long run, providing opportunities for establishing competitive advantages for long-term successes (Marxt & Hacklin, 2005; Tzokas et al., 2004). It is simultaneously one of the most critical and challenging tasks that organizations face today, as the current business environment is fraught with turbulence in terms of unprecedented technical and market uncertainty caused by developments within the field of digital technologies (Iansiti, 1995; Tzokas et al., 2004). In this final subchapter of the theoretical framework, the shift towards, and coexistence of formal and alternative NPD methods are

discussed. This is closely linked with the increasing importance of software development in SM&CPs and has wide-ranging structural and processual implications on organizational culture, NPD processes, capabilities, and performance measurement.

2.3.1 Formal New Product Development Methods

Formal NPD methods encompass all development steps ranging from idea generation all the way through to the eventual launch of the product in the marketplace (Cooper & Kleinschmidt, 1991; Tzokas et al., 2004). Mastering such methods have been vital for firms to increase success rates in their NPD efforts as this is an area replete with failures and high risks; according to Cooper and Kleinschmidt (1991), almost 50% of product innovation resources are devoted to products that become commercial failures, and as much as 75% of NPD projects are unsuccessful.

Recent industry developments are also characterized by increasing involvement with customers and suppliers in the NPD process as well as shorter innovation processes and increasingly multidisciplinary product design (Björkdahl, 2020; Marxt & Hacklin, 2005). This confluence of increasing demand from customers and heightened levels of technological change further underlines the important role played by NPD in achieving sustained competitive advantages for firms, since these rarely can be based on incremental improvements alone (Björkdahl, 2020; Cooper & Kleinschmidt, 1991). As a result of these developments, increasing flexibility and responsiveness in NPD processes is becoming imperative for long-term success – which starkly contrasts formal models for NPD (Iansiti, 1995).

Stage-Gate Systems

A prevailing formal method of conducting NPD processes is the so-called stage-gate system, which conceptually as well as operationally provides a roadmap for the NPD process, aimed at improving its effectiveness and efficiency and thus reducing time to market (Cooper & Kleinschmidt, 1991; Tzokas et al., 2004). Cooper and Kleinschmidt (1991) mention several benefits of implementing a stage-gate model for NPD, chief among them fulfilling requirements on time, quality and cost specifications, higher customer satisfaction, improved product success rates, and a greater degree of market orientation during the process. Furthermore, Tzokas et al. (2004) suggest that the documentation produced when employing stage-gate processes in successive projects can promote organizational learning by allowing management to evaluate which measures were successful under certain circumstances. This would, if capitalized on, enable the encoding and retrieval of the tacit knowledge that has been produced historically during previous NPD efforts.

According to Cooper and Kleinschmidt (1991), a typical stage-gate system is comprised of standardized sets of stages with intermittent gates, all of them having a predefined set of prescribed activities to be performed before proceeding to the following step. The stages themselves are both multidisciplinary and multifunctional, thus cutting across organizational boundaries by involving multiple functions and departments such that no stage is dominated by any group (Cooper & Kleinschmidt,

1991).

Between each stage there is a gate where previous progress is reviewed. The evaluations performed at the gate stages also serve as guidance for assessing and potentially adjusting the performance of the preceding development stage, thus enabling reduction of managerial uncertainty and identification of areas for possible intervention and adjustment (Tzokas et al., 2004). Therefore, the gates constitute a governance measure for the project's progress – it is during these gate reviews that the innovation process is controlled, and go/kill decisions, quality checks and prioritization measures are conducted (Cooper & Kleinschmidt, 1991). The use of gates to control the process enables an incremental development approach which helps mitigate risk and selecting the most meritorious projects to proceed with, while the clearly outlined responsibilities, deliverables and requirements aids in conducting the project according to best practices (Cooper & Sommer, 2016).

Traditional Versus Flexible Product Development Methods

Furthermore, Iansiti (1995) distinguishes between "traditional product development" and "flexible product development". Traditional product development models highlight the importance of avoiding unnecessary changes in later stages of NPD efforts and exhibit a clear division between the phases of concept development and product development – the so called "concept freeze" milestone (Iansiti, 1995). This has its roots in relatively mature industries such as manufacturing, where for instance lead times for tooling and production of components and parts necessitate a concept freeze such that they can be made available in time for product launch (Eger et al., 2005).

Instead, effective product developers in more turbulent environments emphasize the creation of capabilities for flexibility and responsiveness as new information emerges, to embrace environmental changes instead of avoiding them. To accomplish this, they focus on rapid and flexible iterations through all development steps above the sequential and rigidly defined phases of traditional product development methods, and the postponement of the concept freeze milestone as close to product launch as possible (Iansiti, 1995). Flexible product methods can therefore be leveraged to promptly react to technology and market changes, lead to shorter total lead times and have been shown to achieve higher efficiency levels than traditional projects and achieve superior system-level performances (Iansiti, 1995).

2.3.2 Alternative New Product Development Methods

As software development has become increasingly important, it has become apparent that there are viable alternative methods that may be more well-suited than the prevailing formal NPD methods. Traditionally, also software development was conducted with relatively slow development cycles using stage-gate processes where customer feedback was not necessarily integrated into the development process (Olsson et al., 2012). However, today's businesses are part of a turbulent environment where market developments and customer requirements are unpredictable and changing

rapidly, which creates a need for a fast and iterative work pace that formal NPD methods such as stage-gate systems are not well suited for (Cooper & Sommer, 2016; Olsson et al., 2012).

Agile & Continuous Software Development Practices

To address these challenges, some firms are adopting agile methodologies as an alternative to formal methods, since they provide more flexibility in the development process (Fitzgerald & Stol, 2017; Fricker, 2012; Olsson et al., 2012). Dybå and Dingsøyr (2008) delineate the emergence of agile practices as a reaction to plan-based and traditional development practices. The "agile manifesto" developed by practitioners presented new ways of working: instead of focusing on processes and tools, individuals and interactions were prioritized (Beck et al., 2001). Moreover, software is usually developed in small teams using practices such as continuous improvement and testing with rapid feedback loops from customers and management instead of extensive planning (Highsmith & Cockburn, 2001). According to (Dybå & Dingsøyr, 2008), agile software development is therefore best summarized as an evolutionary development method in comparison to the more sequential style of traditional development methods (Dybå & Dingsøyr, 2008).

According to Hossain et al. (2009) Scrum is one of the most popular agile methodologies, which is especially suitable for uncertain environments and changing requirements where it is challenging to plan ahead of time (Dybå & Dingsøyr, 2008). Development of software using Scrum methods is conducted by self-organizing teams working in iterative sprints, which last between 2-4 weeks (Hossain et al., 2009; Rising & Janoff, 2000). Each sprint team produces a visible and working MVP or an increment of a product, which is presented to the customer at the end of the sprint to receive feedback and set new priorities for the next sprint of development (Cooper & Sommer, 2016; Rising & Janoff, 2000).

Software development in SM&CPs also requires continuous product operation and support, including product updates after the initial release, creating an organizational need for flexibility and rapid delivery of updates and new features (Fitzgerald & Stol, 2017; Porter & Heppelmann, 2015). Therefore, companies are employing practices such as DevOps, which is a process that provides means to increase the collaboration between software development and operations teams across the software PLC (Ebert et al., 2016). This approach enables companies to deliver value for customers continuously, by reducing miscommunication between teams and accelerating problem-solving efforts (Ebert et al., 2016). DevOps also introduces tools like continuous integration and delivery (CI/CD) of software, where revisions and updates are tested and deployed automatically (Fitzgerald & Stol, 2017; Humble & Molesky, 2011; Olsson et al., 2012).

Scaling Agile

Agile methods were initially adopted by small teams; however, recent trends indicate adoption of agile practices on enterprise-wide levels as well (Fitzgerald &

Stol, 2017). Large firms are interested in the adoption of agile methodologies at an organizational-wide level to enable rapid and cost-effective responses to unpredictable and continuously changing market conditions (Elkins et al., 2004; Pernstål et al., 2013). Ebert and Paasivaara (2017) further mention that scaling agile is not only about changing practices and roles in organizations, but also about a shift in culture and mindset, which lies at the core of agile methods – which can be one of the toughest challenges in implementing agile methods at scale.

Scaled Agile Framework (SAFe) is one of the most frequently used frameworks to scale agile practices at an organization-wide level, and one of the reasons behind the wide adoption of this framework is its extensive set of predefined roles, processes, and guidelines (Ebert & Paasivaara, 2017). However, this is simultaneously a reason why the SAFe framework is considered to create increased bureaucracy and complexity (Ebert & Paasivaara, 2017). The SAFe framework is divided into three levels: the team-, program-, and portfolio levels, each with a different scope and scale (Ebert & Paasivaara, 2017; Turetken et al., 2017). The team level consists of agile teams, which together have responsibility for defining, developing, testing, and releasing software iteratively (Turetken et al., 2017).

The organization of agile teams is then managed at the program level with the purpose of optimizing the value delivery in line with requirements and strategic themes (Turetken et al., 2017). A strategic theme includes business objectives on the portfolio level to guide portfolio strategy and decision making (Scaled Agile, 2023c). There is also a product backlog, where features are defined and prioritized (Turetken et al., 2017). Synchronization of deliverables at this level is done with the help of agile release trains (ARTs), which provide a structure to release working program increments at specific time frames, usually between 60-120 days (Ebert & Paasivaara, 2017; Turetken et al., 2017).

At the portfolio level, which is the highest level in the SAFe framework, the different programs are aligned to the overall business strategy and value streams (Turetken et al., 2017). Value streams represent sequences of activities that are necessary to perform to be able to create solutions that deliver a continuous flow of value to customers and can therefore be thought of as the replacement of a "product" (Scaled Agile, 2023a; Turetken et al., 2017). In addition, the portfolio level has a backlog of epics driving the evolution of the product portfolio, where epics represent the largest solution development initiatives in the portfolio (Ebert & Paasivaara, 2017; Scaled Agile, 2023b; Turetken et al., 2017).

Agile-Stage-Gate Hybrids

Recent developments on alternative and more flexible project development methods can also be found in Agile-Stage-Gate hybrid models (Cooper & Sommer, 2016). Such hybrids have proven beneficial for firms striving to develop products involving both hardware and software components in turbulent and constantly changing environments, where there is an increased need for iterative experimentation, early voice-of-customer input and quick learning cycles (Cooper & Sommer, 2016; Kim &

Wilemon, 2002).

By contrast to the top down-approach of traditionally implemented stage-gate systems, agile project management methods enable increased agility, flexibility, and speed to development efforts through iterative development cycles (Cooper & Sommer, 2016). Agile methods thus facilitate the adaptation to changing circumstances by feeding them into the development process in a controlled manner during the course of multiple iterative development sprints. It emphasizes the use of micro-planning tools and increased cooperation across functional borders to arrive at MVP in a fast fashion to enable validation at the end of each iteration. These are ideally demonstrated to customers or internal stakeholders, thus incorporating constant customer involvement and feedback into the NPD process.

Thus, agile methods provide traditional stage-gate models with guidelines and processes for daily work at a bottom-up level as well as iterative progress reporting in NPD projects (Cooper & Sommer, 2016). On the other hand, stage-gate models provide means for top-down coordination of projects, planning for longer time periods than short sprints, and thus tools for longer-term coordination and communication between different functions involved in the NPD project. According to Cooper and Sommer (2016), it can also enable clearer visibility for management in governing and approving project progress at the predefined gates. Integrating agile and stage-gate into a hybrid model for hardware NPD usually involves utilizing agile methods for project management between the gates of the overarching stage-gate model. However, further adjustments may be necessary to merge the two approaches.

2.3.3 New Product Development Performance Measurement

The changing external environment and introduction of new development methods also has implications for firms' performance measurement systems, requiring updates to be able to measure the intended aspects (Kerssens-van Drongelen & Cooke, 1997). Operating in a turbulent environment makes it increasingly important to understand the return on investment in NPD initiatives, for instance in order to enable improvements to NPD processes (Kerssens-van Drongelen & Cooke, 1997). In the case of DT, Verhoef et al. (2021) highlight the importance of having key performance indicators (KPIs) adapted to the new digital world. During DT, new KPIs may be necessary for IMFs, such as measuring clicks on digital products and including tracking the intermediate results of product development, while other KPIs such as revenue and profitability will remain the same (Verhoef et al., 2021). Therefore, this part of the subchapter will explore a common traditional metric for NPD performance and emerging differences with agile performance metrics.

New Sales Ratio

One of the most popular metrics to understand new product performance and NPD efficiency is the new sales ratio (NSR), which is defined as the percentage of annual sales derived from new products (Cooper & Edgett, 2012; Whiteley et al., 1998).

Shapiro (2006) states that NSR is a simple metric to understand and measure which can provide an aggregated view of new product performance in the firm. However, several authors also identify challenges with this metric. Both Whiteley et al. (1998) and Shapiro (2006) note the challenge in defining what is a new product, requiring effort in establishing the criteria for change that contributes to newness and organizational alignment on this topic.

Another challenge is defining a timeframe for how long a product is to be considered new. The timeframe of newness will vary due to the rate of change in the industry and the expected PLC. Therefore, highly diversified firms may need several different timeframes for their different products and understanding that such distinction is required (Shapiro, 2006). Moreover, Cooper and Edgett (2012) point out that the use of NSR can introduce undesirable behaviors in organizations, such as deliberate redefinitions of what is considered a new product to artificially improve the metric. Cooper and Edgett also highlight that this metric does not reflect the true value of new product performance, as newly introduced products may cannibalize sales of old ones and therefore do not provide additional value overall.

Differences Between Traditional & Agile Performance Metrics

Different types of NPD activities may require different types of metrics, measurement techniques, and norms (Kerssens-van Drongelen & Cooke, 1997)). This further depends on what level the measurement is conducted at, for instance if an organization or project is in focus. The frequency of measurement and reporting is also an important aspect to consider as continuous measurement can create additional burden for organizations and decisions may be made too quickly based on insufficient data (Kerssens-van Drongelen & Cooke, 1997).

The introduction of agile development methods further necessitates changes in measurement practices since agile methods prioritize working software over documentation which requires simple and instant metrics (Kupiainen et al., 2014, 2015). Furthermore, they also require metrics that are evolutionary in nature, due to the inherent focus on iterative, continuous development (Oza & Korkala, 2012; Padmini et al., 2015). Oza and Korkala (2012) further highlight that while traditional productivity- and financial metrics can add value in decision making, they do not fully reflect the iterative nature of the agile environment. Relevant metrics in an agile development setting are therefore more focused on following up on progress during sprints at an increased level of granularity rather than tracking specific plan-based deliverables as in traditional development methods (Kupiainen et al., 2015). These agile metrics are also used for sprint planning as well as for identifying problems during development, improving quality, and enabling better decision-making (Kupiainen et al., 2015).

3

Methods

The empirical research conducted during this study was performed in the form of a single case study at a Sweden-based IMF called SwedCo (anonymized). In addition to qualitative interviews, a literature review and analysis of data from secondary sources were utilized to triangulate and corroborate the findings that emerged, and thereafter a thematic analysis was made. The following chapter outlines in more detail the research strategy, research design and methods, data collection, research quality considerations, and ethical considerations that were employed in this study.

3.1 Research Strategy

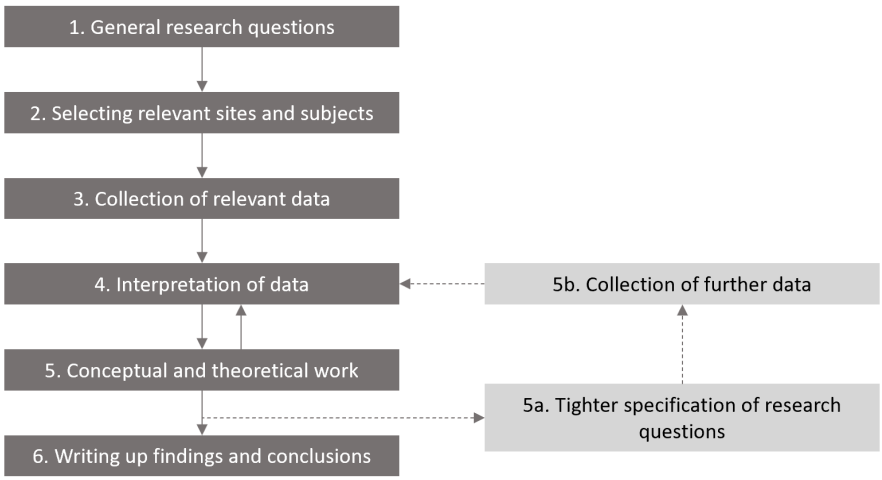
For this study, a qualitative research strategy was selected due to the exploratory nature of this thesis (Bell et al., 2019). This choice was made based on its alignment with the purpose of the study as described in Chapter 1. Qualitative research also emphasizes how individuals interpret the world they live in and takes an interpretivist approach to this social reality as something undergoing constant change which also was considered in the choice made (Bell et al., 2019). Due to the investigation of notions that are difficult to measure, and its focus on understanding social phenomena, a qualitative research strategy was deemed appropriate for this study (Flick et al., 2004; Wallén, 1996). Furthermore, semi-structured interviews were chosen as the main empirical data collection method, which is typical in case study interviews and motivated further below (Bell et al., 2019).

This study was conducted using an abductive approach with the aim of discovering new relationships and further developing existing theories. According to Dubois and Gadde (2002), such an approach can deliver new combinations of insights through the exposure of existing theories to emerging concepts from the interaction with reality. A qualitative research strategy with an abductive approach thus fits well with the purpose and intentions of developing theory to answer the posed research questions in Chapter 1 (Bell et al., 2019). This approach also enabled the delivery of contributions to the case company, by translating empirical findings and hypothetical answers to research questions into practical application.

Bell et al. (2019) also describe the iterative nature of qualitative research, as shown in Figure 3.1 below. This suited the purposes of this study well since it offered a

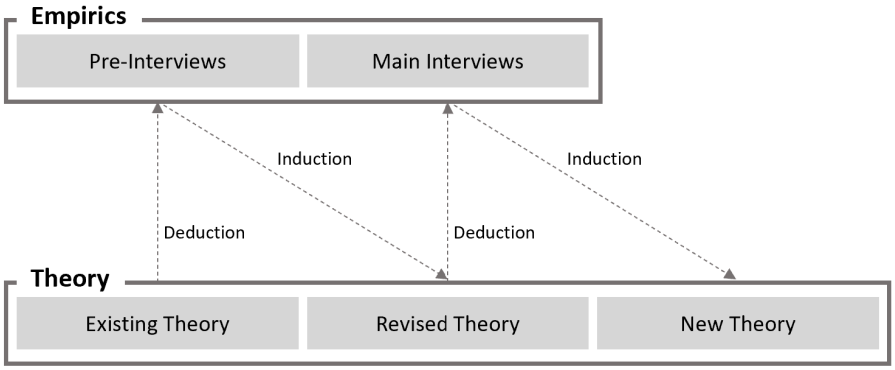
certain degree of flexibility regarding identification of gaps in the research and a possibility to further tighten the specification of the research questions as work on the study progressed. In effect, it allowed for the gathering of additional data during the conduction of the study, thus enabling further informing the theory-developing analysis in a more effective manner.

Figure 3.1: Illustration of qualitative research process proposed by Bell et al. (2019).



The abductive research approach was also well suited for the complexity of the studied phenomenon. It allowed the researchers to explore conditions that made the studied phenomenon less complex, which involved an iterative back-and-forth shuttling process between empirics, emerging theory, and existing literature (Bell et al., 2019; Mantere & Ketokivi, 2013). This resulted in a mode of alternating between deductive and inductive approaches between several iterations of interviewing and analysis, as shown in Figure 3.2. It also enabled the researchers to remain open to the possibility of being surprised by the data and adapt to changing circumstances using cognitive reasoning to find the most suitable existing theory as a starting point and successively make sense of the emerging empirical findings during the research process (Bell et al., 2019; Dubois & Gadde, 2002).

Figure 3.2: Illustration of the combined inductive-deductive approach used.



Finally, this study adopts a constructivist ontological position, whereby studied concepts such as DT are regarded as socially constructed entities subject to constant change (Bell et al., 2019; Saunders et al., 2018). This choice was based on this phenomenon being a human creation made real by humans interacting with and actively interpreting them. This choice also entails an epistemological positioning of interpretivism, as the positivistic positioning was deemed inadequate for the investigation of the socially constructed phenomena in focus. Therefore, this study is more inclined towards understanding rather than explaining these concepts and their implications on human behavior (Bell et al., 2019).

3.2 Research Design & Methods

The goal of this study was to obtain learnings about a broader phenomenon, the effects of DT on NPD at IMFs. Therefore, a single case study design was selected, in order to provide insight into a specific issue at hand and enable in-depth examinations that would not be obtainable using other research designs (Flyvbjerg, 2006; Stake, 1995). More generally, case studies are also the preferred method when questions of "why" or "how" character are to be investigated and are particularly useful when the boundaries between the investigated phenomena are not clearly visible (Yin, 2003). Thus, the chosen research design for this study is a qualitative single case study, where data about the phenomenon was collected and analyzed from an organization. In this case the organization was an IMF undergoing DT, SwedCo, and the phenomenon was studied over a six-month period including presence on-site at the company.

The decision about research design has also been impacted by the case company, as they were interested in findings from this study in order to bridge the gap between theory and practice regarding this topic, which had important implications for the study regarding data collection. The researchers were therefore to some extent reliant on the resources provided by SwedCo, such as the possibility to interview employees in different parts of the organization. These practical implications also influenced the choice of research questions. Due to the ambition of bridging this theoretical-practical gap, an engaged scholarship approach was employed. As a result, research strategy and design were selected to enable the investigation of key stakeholders' perspectives and understandings of a particular problem situation, in order to leverage empirical findings as well as existing and emerging theory to uncover potential answers to the research questions (Mathiassen, 2017; Van de Ven, 2007).

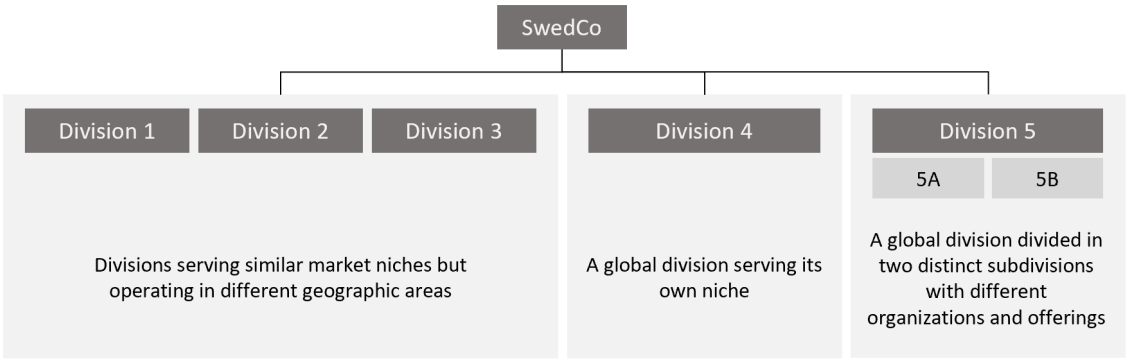
3.2.1 Empirical Context

According to Stake (1995), researchers should focus on cases with the greatest potential for learning opportunities when deciding on suitable options for case studies. Furthermore, Yin (2009) describes that single case studies can be used to observe and analyze issues previously not covered by social science inquires. Therefore, this was kept in mind when selecting the case company of this study in order to show-

case situations that IMFs are exposed to but have not been thoroughly covered by existing literature. As mentioned previously, the selected case company SwedCo is a Sweden-based IMF that has a long history of developing, manufacturing, and providing industry-specific solutions, historically mainly focused on premium physical products and complementary services and solutions. Consequently, the development of digital offerings has not historically been a part of their operations. Furthermore, they have over time come to cement their position as a global industry leader in their field through continuous acquisitions and organic growth.

SwedCo's organization is divided into five divisions based on the product category and geography served as can be seen in Figure 3.3. Some of the divisions focus more on digital offerings, while others still have mechanical and electromechanical products as their core offerings. Subdivision 5B is a front runner in this regard, and has the highest degree of digital offerings at SwedCo as well as the most widely adopted SAFe practices. As digital technologies become more capable and prevalent, they have come to increasingly affect NPD at SwedCo, which leads to the interest in investigating the research questions of this study. Therefore, SwedCo was determined to be a suitable case company to illustrate how DT and the introduction of digital technologies in their offerings affect their NPD processes within R&D, and how IMFs can manage the transition this implies for them. Furthermore, as SwedCo's divisions had achieved different degrees of maturity regarding DT, there was a possibility to delve deeper into and contrast organizations in different stages of DT. Studying the case company in this regard thus provided an opportunity to contribute with both theoretical and practical implications on the topic of this study.

Figure 3.3: SwedCo's organizational structure.



3.2.2 Data Collection

During the case study three different methods for collecting data were utilized, including: literature review, interviews, and secondary data sources such as internal and published documents and presentations. The following subchapter describes these data collection methods as well as the necessary considerations taken regarding them.

Literature Review

During this study, an extensive literature review was conducted. The objectives of the literature review for this study were multifaceted. Firstly, the literature review helped to build an understanding of what was already known in the research area and any potential gaps in existing research, as pointed out by Bell et al. (2019). Secondly, it also assisted and in part guided the formulation of research questions and to identify and confirm the existence of a suitable research gap for the study. Furthermore, it aided in the identification of suitable theories to include in the theoretical framework. As the literature review was an ongoing venture, the theoretical framework was continuously constructed with new insights until the conduction of the main interviews.

Relevant keywords were utilized to guide the search for suitable literature to review as suggested by Bell et al. (2019). Finding the right keywords involved experimentation and snowballing as the research progressed forward. Publications were found through databases such as Google Scholar and the Chalmers Library Database. The number of articles reviewed was limited due to the project scope and time constraints. Parameters such as publication year, number of citations, keywords, read through of titles, and abstracts were used to assess the relevance of the literature. Then a snowballing process was utilized to find additional literature by investigating references to and from the articles already examined (Bell et al., 2019).

Interviews

The key arguments supporting the choice of employing semi-structured interviews in this study were related to enabling adequate coverage and saturation of information, adequate flexibility, as well as the ability to deep dive into specific circumstances by follow-up questions that interviewers might otherwise have remained unaware of (Bell et al., 2019). At the same time this also provided some structure to the interviews which facilitated the comparability of the interview data during the analytical stage of the study (Schmidt, 2004). To this end, semi-structured interviews were conducted with employees at SwedCo with experience and expertise in the field of study. Moreover, the choice of data collection methods was also influenced by the research environment. As this research focused on understanding and explaining a specific phenomenon, it required understanding the views and feelings of the respondents who had experienced this phenomenon, which can be done using semi-structured qualitative interviews.

The interviews were divided in two phases: the first using initial, probing pre-interviews, and the second using more detailed main interviews. The probing pre-interviews were held with respondents at the case company that were identified as relevant by the supervisors at the case company, with the goal of exploring the topic and gaining more insight. During the second phase focus instead shifted to the more detailed main interviews with SwedCo's divisional CTOs and respondents recommended by them. These interviews aimed to provide more detailed insight and understanding of how SwedCo's NPD processes within R&D are affected by

DT, and how they manage this transition

To guide the conversation with respondents and ensure coverage of relevant themes, an interview guide was prepared for all interviews (Bell et al., 2019). The interview guide was also revised several times to improve questions and add or remove themes that did not yield satisfactory answers, and new themes and questions were added on a regular basis. An interview guide used for the main interviews in the second phase of the research can be found in the appendix, which was based on the literature review and insight from the initial pre-interviews.

Another important consideration regarding interview conduction was whom to interview, i.e., sampling (Bell et al., 2019). Due to the nature of the research questions and phenomena studied, the respondents were selected strategically so they could contribute knowledge – a method commonly referred to as purposive sampling (Bell et al., 2019; Etikan et al., 2016). The initial respondents were also chosen with the help of the supervisor at the case company, based on their knowledge of the topics investigated. As the interviews progressed, the respondents were asked to provide recommendations for other suitable people to interview. This represented a shift from purposive to snowball sampling, which allowed the researchers to navigate an unknown organization and find suitable respondents by utilizing the initial respondents' networks (Bell et al., 2019). All main interviews were conducted using online video calls due to the geographical location of the respondents. The pre-interviews were conducted either in a live setting or in the same format as the main interviews, depending on the respondents' location. When necessary, respondents were contacted after interviews to follow-up on some of the information that was uncovered to further clarify findings.

In order for the researchers to be able to devote full attention to the discussions with respondents, the main interviews were recorded for transcription purposes after obtaining consent to do so. The recordings were later transcribed and deleted. This also gave researchers the possibility to reiterate the answers and thoroughly examine the insights from main interviews, as highlighted by Bell et al. (2019). However, during the pre-interviews, extensive notetaking was conducted instead of recording. This was a choice made in order to make respondents feel comfortable and to avoid them potentially leaving out important pieces of information during the early stages of the study (Bell et al., 2019).

In total, 28 interviews were conducted with a total of 31 respondents (19 pre-interviews and 9 main interviews – a list of respondents can be found below in Table 3.1). The pre-interviews were conducted during the first phase of the study until theoretical saturation was deemed to have occurred since the topics began to repeat themselves (Guest et al., 2006; Saunders et al., 2018). Thereafter, changes were made to the pre-interview questions. At the point that any further changes no longer yielded any new insights the researchers stopped conducting pre-interviews and instead focused on the more specific main interviews. Therefore, this research did not have a specific sample size and instead relied on theoretical saturation.

Table 3.1: List of respondents.

#	Role of respondent(s)	Type of interview	Date	Duration
1	M&A	Pre-interview	01.02.23	47 min
2	R&D Manager	Pre-interview	02.02.23	51 min
3	R&D Manager	Pre-interview	03.02.23	35 min
4	Product Manager	Pre-interview	07.02.23	1 h 2 min
5	R&D Manager	Pre-interview	08.02.23	51min
6	Innovation Manager	Pre-interview	10.02.23	57 min
7	Innovation Manager	Pre-interview	17.02.23	31 min
8	R&D Manager	Pre-interview	20.02.23	1 h 3 min
9	R&D Manager	Pre-interview	21.02.23	54 min
10	2 R&D Manager	Pre-interview	21.02.23	55 min
11	Divisional CTO	Pre-interview	27.02.23	37 min
12	Business Area CTO	Pre-interview	27.02.23	41 min
13	Business Area CTO	Pre-interview	28.02.23	48 min
14	Product Management VP	Pre-interview	01.03.23	31 min
15	Innovation Management VP	Pre-interview	10.03.23	1 h 1 min
16	Innovation Manager	Pre-interview	13.03.23	40 min
17	Product Management Director	Pre-interview	15.03.23	55 min
18	Program Manager	Pre-interview	15.03.23	40 min
19	R&D Manager	Pre-interview	17.03.23	45 min
20	Divisional CTO	Main Interview	30.03.23	1 h 5 min
21	Divisional CTO	Main Interview	04.04.23	1 h 2 min
22	Divisional CTO	Main Interview	06.04.23	1 h 1 min
23	R&D Manager	Main Interview	06.04.23	1 h
24	Divisional CTO and CFO	Main Interview	06.04.23	41 min
25	Divisional CTO and CFO	Main Interview	12.04.23	1 h 11 min
26	Divisional CTO	Main Interview	17.04.23	56 min
27	R&D VP	Main Interview	18.04.23	47 min
28	R&D Manager	Main Interview	24.04.23	57 min
	Average duration			**51 min**

Secondary Data

Secondary data such as internal and public company documents (e.g., annual reports, press releases, and internal project and training documentation) was reviewed to gather data for the study and gain a better understanding of the current state of SwedCo's NPD processes. The findings that emerged during this analysis were then abstracted, related to prior and emerging theory, and included in this study. The review of these documents thus served as a complement to the empirical data from interviews in order triangulate findings and hypotheses that emerged from the literature review and interviews. In a similar manner, all findings from the documents were also discussed with SwedCo employees to avoid possible biases and increase credibility of the reviewed documents. Besides internal documents, the company's intranet was reviewed to gain knowledge of company best practices when it comes to innovation management, performance measurement, and other processes relating to NPD.

3.2.3 Data Analysis

Performing successful qualitative data analysis requires identifying themes, relationships among them, and using these to aid the understanding of the studied phenomena (Hilal & Alabri, 2013). Therefore, a thematic analysis was used for the qualitative analyses in this study, where common themes were identified by considering aspects such as repetitions, similarities and differences, and other relevant and important aspects considering the research questions (Bell et al., 2019; Braun & Clarke, 2006). As an aid in this process coding was utilized when reviewing the collected data. During the review of the empirical findings, which included primarily the transcripts from the main interviews, notes were taken separately by the researchers about significant remarks. These notes were later abstracted into codes to facilitate comparison and synthesis (Bell et al., 2019). Thereafter, codes were grouped into potential themes individually by each researcher and then reviewed together and discussed to determine which themes worked with the codes and overall data set. Researchers further reorganized and defined the empirical findings into seven emerging themes by consensus. Since thematic analysis also possibly can involve several layers of overarching themes containing groupings of themes into them, substantial attention was dedicated to this analysis of the material. The researchers were also wary of avoiding potential pitfalls of thematic analysis such as avoiding overlapping themes, or themes related to interview guide questions rather than the actual content provided by respondents as highlighted by Braun and Clarke (2006).

Throughout the course of the study, the researchers emphasized the simultaneous use of multiple data collection methods outlined above, coupled with the use of triangulation where possible to strengthen the findings and conclusions of this study (Bell et al., 2019). In cases where conflicting evidence emerged, these have been subjected to further investigation by comparing with additional literature and accounts by other sources to arrive at a conclusion of whether the results where reliable and to be included in this thesis. By remaining vigilant and adopting a critical stance towards theory and results used, the researchers have thus made a conscious ef-

fort to avoid incorporating uncorroborated findings in this study. How this was accomplished in practice is described in detail in the following subchapter.

3.3 Research Quality

Since qualitative research differs in its ontological and epistemological positioning from quantitative ditto, it is pertinent to assess its quality by means more suitable for this type of research rather than the ubiquitous reliability and validity criteria of quantitative research (Bell et al., 2019). Guba and Lincoln (1989) propose a trustworthiness criteria consisting of credibility, transferability, dependability, and confirmability to do so – each of which will be evaluated further below for this specific study.

3.3.1 Credibility

Several measures have been utilized to improve the credibility of the study. Firstly, prolonged engagement with substantial involvement in the studied environment was emphasized to counteract possible misinformation and to build trust and rapport with respondents in order to enhance the researchers' understanding of the studied concepts. Secondly, sufficient observation to enable identification of the most relevant characteristics and elements of the studied phenomena was prioritized by using multiple phases of interviews with a wide range of respondents to satisfy the persistent observation criteria proposed by Guba and Lincoln (1989). Respondent validation was also utilized by having respondents' accounts retold to them for confirming the validity of the findings. Finally, triangulation played a part in establishing the credibility of this study by ensuring that data was gathered from multiple sources, which enhances its credibility (Yilmaz, 2013). Among the methods used were the different types of interviews with multiple respondents from several parts of the organization, with differing roles and responsibilities, thus allowing for a broad perspective with various accounts of different aspects of the studied phenomena. Moreover, the interviews were conducted in different time periods of the study, with a purposive differentiation between informal pre-interviews and main semi-structured interviews to confirm the credibility of the findings that had emerged. Lastly, internal data from the organization was also utilized to corroborate and complement findings from interviews, as well as the use of scientific articles from numerous different sources and applicable areas of research during the literature review.

3.3.2 Transferability

By collecting data that is detailed and varied enough to provide a full and revealing picture of the phenomena studied, as well as including a detailed description of the case, the studied environment, concepts and an extensive literature review, the researchers have aimed to provide a rich description enabling transferability to some extent (Bell et al., 2019; Maxwell, 2008). However, the nature of qualitative case studies makes it inherently difficult to generalize to a large extent (Bell et al., 2019).

Instead, the aim of transferability of qualitative studies such as this one is rather to enable extension of the theory developed to other cases in future research (Maxwell, 2008).

3.3.3 Dependability

To enhance the dependability of this study, the researchers have performed thorough documentation with complete records of all stages of the research process. As a part of these measures the interview guide used is published annexed at the end of this document, which further strengthens dependability according to (Bell et al., 2019). However, because this study was conducted in a constantly changing environment, the extent of dependability is also potentially further limited by time constraints that were outside of the researchers' control.

3.3.4 Confirmability

Since the researchers' interpretation of the studied phenomena are a vital part of qualitative studies, complete confirmability is inherently difficult to achieve (Bell et al., 2019). However, to counteract any possible biases all analyses, conclusions, and emerging findings were developed jointly by both researchers. Opinions on these were also obtained from supervisors at both Chalmers and the case company. However, as these opinions could possibly also influence the study, the researchers had to be vigilant to counteract such tendencies when they occurred. Furthermore, awareness and prevention of biases also from other sources were vital for ensuring confirmability of the study. To mitigate such biases, the choice was made to interview many different persons in different roles and parts of the organization on the topic, as well as at several different time points, in order to counteract any individual person or part of the organization's possible biases.

3.4 Ethical Considerations

During a study of this type, the relationship and interactions between the researchers and participants can give rise to ethical considerations. Since the focus of the study was a real organization involving people, it was vital that the study was conducted in an ethically correct manner (Sutton & David, 2010). Therefore, the evaluation of the research quality needs to be complemented by ethical considerations (Hermerén, 2017). Bell et al. (2019) highlights the following ethical principles: avoidance of harm, informed consent, privacy, and preventing deception.

To avoid potential harm to research participants, confidentiality and anonymity are of high importance (Bell et al., 2019). When it comes to qualitative studies, the possible identification of people and organizations becomes an even bigger concern due to its delicate and possibly revealing nature. To mitigate this, all data that emerged was kept anonymous in this study, besides an anonymized representation of the respondents' approximate role descriptions in the interview Table 3.1. In addition, the interviews were also structured in such a way as to reduce potential

psychological harms such as stress and anxiety, and these considerations were also included in the interview guide development. Finally, case company representatives received a copy before publishing it to prevent any breaches of these guidelines.

All participants were moreover always informed about the study, its purpose, and the conditions of anonymity to be able to make an informed decision about their participation. This also included information about how the study is conducted and what observation techniques were used, all following the guidelines about informed consent described by Bell et al. (2019). Furthermore, any breaches of the conditions stated above could constitute an invasion of a participant's privacy (Bell et al., 2019). Therefore, to further strengthen the study in terms of mitigating ethical risks, all participants were informed that they could refuse participation, answering any particular questions if they felt uncomfortable, and terminate an interview at any point. Finally, to ensure complete ethical correctness it was deemed important to avoid deception in the study. This was enabled by never representing this study, its purpose, and goals as something other than what they were (Bell et al., 2019). One method used to fulfill this criterion in the study was the constant determination of the researchers about being open and sharing all necessary information with research participants involved. This was crucial to prevent any possible misrepresentation and deception.

4

Findings

This chapter outlines the findings resulting from the empirical data collection of this study. It has been partitioned thematically according to the seven topics that were most frequently described as important developments related to the effects of DT on NPD processes at SwedCo and contains the following subchapters: changing product nature; need for new NPD methods; need for new competences; increasing software development and its impacts; platforms and regulations; changing NPD cost; and business model innovation and partnerships. These will later be used in the discussion in an effort to answer the two research questions of this thesis.

4.1 Changing Product Nature

Over the past decade, SwedCo has increasingly shifted their focus to digital offerings, chief among them SM&CPs and mobile technologies. This has made visible tensions between new and legacy products in terms of the old technological foundations of the latter, which were not designed with connectivity in mind. Therefore, there has emerged a need to update and digitalize the product portfolio in order to stay relevant as technological and market needs are changing. This subchapter outlines these developments in more detail, according to the respondents' accounts from the empirical data collection during this study.

4.1.1 Move to Smart & Connected Products

SwedCo is currently experiencing that trends in the market today are moving more and more into digital and SM&CPs, and that this implies that they must change their own products accordingly in order to support this shift. One respondent described SM&CPs as one of the fastest growing parts of their business; growing from 12-15% of their product mix a decade ago to over 30% today. SM&CPs are therefore seen as a vital strategic growth driver for the firm, and it seems clear that this is the direction that developments will be headed in the future according to several respondents.

Another trend that is gaining pace is the increasing importance of mobile technologies, where cell phones and other connected devices can be utilized to control connected products remotely. This is described as a major shift by one respondent,

who foresees that products containing mobile technologies will eventually supplant other types of more traditional hardware-based products. The respondent further described this trend as being much less noticeable when SwedCo pioneered mobile solutions in their field over a decade ago. However, during the past five years or so, a number of major tech players have followed suit, which has accelerated the trend and will likely continue to do so in the future as well.

In sum, several respondents agreed that these developments are visible effects of DT on the products and technologies in their market, which are changing in nature over time. As one respondent put it:

> [...] if you look back to where we were 15 years ago, the heavy investment was really focused around hardware [...] it was all on-premise solutions and that's where the main bulk of the development was, because that was where you made your money [...] so the software was developed and seen as an enabler to for hardware sales [...] you made your money through the hardware, and so you were constantly investing in your in your hardware development.

Whereas today, that same respondent stated that DT has caused a shift towards for instance cloud-native products, SaaS, and software-based services. This has resulted in continuously increasing investments in the development of software, such that the opposite of the above quote is true today – with software representing the majority of NPD development investments currently in the respondent's division.

Another respondent agreed with this narrative and elaborated further that even though SwedCo was predominantly a mechanical-based company – which was their heritage, what they know best, and what they still are proud of – now the current market trends of increasing digitalization and importance of software development requires them to invest in those areas to stay relevant and in par or above their competitors.

Yet another respondent explained that the shift towards digital products is driven by a combination of both internal and external drivers (pertaining to technology and market influences). Even though IMFs can develop SM&CPs, there are many that still struggle to come up with the financial incentives for customers to pay for products and services they have not bought or perhaps even seen and thought about before. The respondent explained that there is much work involved teaching the customer on these matters, i.e., in selling those new values to the customer, and that they must be brought along on this journey on their own terms.

4.1.2 Legacy not Intended to be Connected

One respondent further described that: "[...] several decades ago, there was a conscious decision made as a company, that we would not be a software developer – it was not in our wheelhouse. We were going to be a products company, and that was going to be our expertise." However, since then much has changed, as the respondent

continued:

> [...] and I think we have come to realize over those years that [...] software development is very much an integral part of our strategy, and part of our story. In terms of leading the industry, in terms of innovation, you cannot divest yourself from that, or outsource that [...] you need to have the capabilities in-house.

In sum, SwedCo could according to this respondent gain a substantial competitive advantage if they:

> [...] stitch together products that should be talking to each other in an intelligent way that makes it useful and more convenient to the user. [...] Then you have moved from the product company we talked about 25 years ago to becoming a holistic solution provider.

Other respondents also support this direction regarding where SwedCo should be heading.

In fact, during several years, SwedCo has invested more and more in SM&CPs – both the connectivity in itself, dedicated hardware related to it, as well as the back-end systems dedicated to receiving the data from them. According to one respondent, this is the NPD investment category that has likely increased most over the past five years. But this also has some side effects regarding their legacy products, which were never intended to be connected at all. Therefore, there has emerged a need to consolidate the electro-mechanical platforms and control systems in their products, in order to decrease the number of components that need to be connected. "This is where the big shift in the DT is visible: the increasing amounts of software and electronics involved", as one respondent put it. Another respondent further expanded on this topic by mentioning that this in turn means that there are many more external factors affecting their products and development continuously – such as operating system updates, new security vulnerabilities that need to be patched and so on – which further increases demands put on the development teams, compared to the old hardware-focused products.

4.2 Need for Alternative New Product Development Methods

The increasing introduction of software development adds new layers of complexity and requirements to SwedCo's NPD processes. A major change is the more iterative and continuous approach to developing and maintaining products over their entire life cycle, in combination with shorter overall PLCs for software compared to hardware. As a result, there has emerged a need to adopt new development methodologies where the old ones were not well suited. This subchapter further describes how the respondents described SwedCo's reasoning regarding this shift, and how the adoption of these new methods have impacted their NPD processes.

4.2.1 Changing Technology Content

Several respondents agreed that one big difference between digital and mechanical products is that digital products undergo changes very often since technology is moving faster in the field of software. This has multiple implications regarding the development of SM&CPs, since technological changes necessitate more maintenance and continuous development after launching a product – in essence, you are never done with the development of software products. Instead, after a while it just becomes a cost of doing business rather than actual NPD to keep products with high degrees of software content up to date. Another reason for these developments is the large installed base and upfront investment in hardware that SwedCo's customers have – which becomes another reason why "hardware always outlasts software" as one respondent put it, who had seen electro-mechanical or hardware products that are 20-25 years old out in the field – stating that such a thing would never happen with software. Thus, the respondents agreed that the PLC and cycle times in the software domain is much shorter, with products being kept continuously updated by releasing new versions of them. However, one respondent expanded on this by stating that this would likely also cause shorter cycle times in hardware moving forward, as it is tied closer to the software in the product, and thus could experience constraints from computational hardware as functionality requirements increase with time.

Another respondent also mentioned that there are completely different levels of effort post-launch for software, and that:

> [...] earlier on we tried to manage software- and firmware-based products like they were mechanical, and we learned that lesson the hard way [...] you have to be willing to be in it for the long term, basically forever [...] until the product line is replaced by something.

This concurs with previous respondents regarding software products, that you are never finished developing. This also means that the PLC analysis is done differently today, as products are kept alive longer with continuous releases constantly improving the product – so that a couple of years down the line, the product has evolve into something completely different than it is today. However, the respondents made clear that this changing development nature pertaining to continuous improvements also has benefits in terms of providing opportunities for recurring monthly revenue – requiring the rethinking of business models utilized in the company.

Furthermore, customers have grown accustomed to this continuous technological development and the possibility of changing demands during product development itself (as there is no concept freeze in the same sense as in hardware development). This is especially true in consumer markets, where an effect of digitalization is that there are more requirements on coming out with new products seasonally compared to before. As one respondent put it: "[...] even if not much is changed each year, you still need to differentiate with a different look and feel somehow [...] to keep up with competitors and the changing landscape every year [...] and that drives cost in itself."

4.2.2 Changing Development Methods

The implications of the shift towards increasing software development has been discussed over the past decade – more specifically regarding the issue that the type of stage-gate model currently used for NPD project governance is not suited for software development. Over the past five years though, several divisions have moved away from stage-gate methods into more agile ways of working, predominantly by adopting SAFe – although some traditional old hardware type projects still follow the stage-gate process there as well. However, according to one respondent this does not mean that the stage-gate model is obsolete in all aspects, since it contributes with concepts that SAFe does not cover sufficiently, e.g., regarding governance of NPD efforts.

The respondents agreed that the agile way of working fits SwedCo much better today, since it facilitates the continuous and iterative development as per the trends described previously, as well as constant (re)prioritization regarding what areas are most important to improve in their products and portfolios. Previously, software development using the traditional stage-gate model could take 2-3 years until launch, with potential annual releases after that, according to one respondent – compared to as frequent as bi-weekly releases using agile methods today. However, since these new NPD methods are very different to those previously used, it has taken a huge shift in an R&D perspective to accommodate this transition. One respondent in a division that pioneered the introduction of agile methods described that it was difficult, at least initially, to gain traction for them in the company – mainly because the stage-gate methods were so ingrained in the company culture. However, it has also necessitated infrastructural changes to become more agile – with "CI/CD pipelines, DevOps teams, and the like" – but also regarding tools such as automated testing. In sum, it has caused a skill set and lead time change that has required the acquisition of competences in areas where SwedCo had none or limited previous experience.

Another difference mentioned that has impacted development methods used at SwedCo is the fact that there is a focus on keeping products up to date longer, and thus not letting them become "legacy products"; instead, there is a wish to rather have multiple releases with continuous improvements to the products. Taken together, these developments have resulted in SwedCo having fewer but bigger NPD projects than before, that are consisting of multiple iterations of continuous improvements and releases. This is a major change to previous methodologies, where such releases would rather have been seen as an entirely new product. Furthermore, several respondents mentioned that they are:

> [...] trying to adopt an agile approach to electronic- and mechanical developments too. Not all parts, like DevOps for instance [...] but rather taking some of the benefits of an agile, iterative design approach and see what they look like for a mechanical or electromechanical product.

Another part of agile methods that has caused a big shift in the mindset during

development is the focus on obtaining a working minimum viable product (MVP), in trying to get something to market as quickly as possible to start seeing a return on investment. Previously it would not have been a question that they would work towards having a full feature set before releasing a product. "However, this is difficult from a hardware perspective [since] a lot of hardware development is still entrenched within stage-gate methods, and the challenge going forward is how to become more agile in hardware delivery." That said, there are likely some mechanical projects that will only ever be strictly mechanical, as the respondents stressed that it does not make sense to change what is working well still. However, for highly integrated projects with interfunctional and multidisciplinary teams working at once in the same project, agile methods like SAFe have many benefits. One of the most prominent benefits cited by one respondent was the increased visibility in the development performance and shortened feedback loops that the agile methods have enabled – which helps them take corrective action faster and stay on the right path during development.

Finally, one respondent mentioned that even though agile methods and values have been introduced and the company is becoming more adept at them, there is still a long way to go when it comes to their implementation and in developing a culture that embraces them: "[...] as soon as one of these really agile companies move into our space, we are going to have issues", as the respondent put it.

4.3 Need for New Competences

The increasing importance of software and connectivity technologies in SM&CPs at SwedCo stresses the need for a new skillset as it is a completely different knowledge domain in comparison to traditional hardware development but are also in high demand by other firms undergoing DT. Moreover, the coexistence of different knowledge domains regarding different technologies also stresses the need for coordination roles. This subchapter will further dive deeper into the topic of new competence needs as discussed by respondents.

4.3.1 Expansion of Current Skillset

According to several respondents, the development of SM&CPs and the transition from on-premise solutions to cloud solutions require a whole set of new engineering disciplines. Traditionally, the development of the products could be accomplished by mechanical, electrical, and firmware engineers. However, the development of SM&CPs requires software, cloud, and quality assurance (QA) engineers to build and maintain the supporting infrastructure of SM&CPs. Moreover, iOS and Android engineers, as well as UI and UX designers, are also necessary to develop applications where customers can interact with SM&CPs. One respondent also pointed out that software engineers have increased the most in headcount over the last 5–10 years compared to all disciplines at SwedCo, indicating the ongoing expansion of competencies to support the development of SM&CPs. These new competencies also represent critical resources in NPD processes to be able to deliver SM&CPs to

end users.

4.3.2 Coordinating Roles and Highly Demanded Disciplines

The introduction of new knowledge domains to enable integration of digital technologies in the SM&CPs at SweCo has stressed the need for coordinating roles, such as software product owners, to ensure efficient collaboration between teams developing software and hardware parts for the SM&CPs. This is necessary to understand requirements from both the hardware and software perspectives before starting the development of firmware or the cloud. Moreover, as SM&CPs are often connected to the same digital platform, there is also a need to coordinate with platform managers, who supervise and ensure the continuous operations of SM&CPs. This is important to make sure that newly developed products can be integrated into the digital platform without impacting the operation of other products. Therefore, as concluded by several respondents, the development of SM&CPs requires more coordination effort even before starting development in comparison to traditional products.

The functionality requirements of the SM&CPs also influence the amount and time required from these new competences in development. A feature rich product will require more effort from all disciplines compared to a product that has one or a few features. One respondent further concluded that because of all these new competences required in the development of SM&CPs, the team size increases in comparison to traditional products.

One respondent also pointed out that these new disciplines are noticeably more expensive in comparison to mechanical and electrical engineers. Besides the fact that these competences are more expensive, another respondent also pointed out challenge to find and hire these competences as they are highly demanded also by other companies that makes transition into digital offerings and need these competences.

4.4 Increasing Software Development & its Impacts on New Product Development

Increasing software development and the way it is performed today through continuous development, integration, and deployment has impacted the NPD process by for instance increasing the importance of DevOps, disrupting traditional business cases, and requiring new ways of measuring and evaluating the NPD process. The impacts of increasing software development identified by respondents is further outlined in this subchapter.

4.4.1 Continuous Software Development

As mentioned previously, one of the major differences of having more software in NPD processes in comparison to pure hardware is that software does not launch once but has multiple releases and requires continuous support. One respondent described this transition as in following way:

> [...] historically when we looked at hardware based projects, when you launched a piece of hardware, you were done [...] and you could move on to another project and that product might live on for 20 years [...] In a digital world you are never done [...] If you have a firmware or software-based product, you are never finished [...].

Other respondents elaborated on this, by stating that software requires continuous support and development in terms of maintenance, security updates to address vulnerabilities, and feature enhancements. Maintenance includes for instance bug fixes, which can be found even several years after the initial release. This then requires immediate actions to correct, validate, and deploy a new version of software. In addition, new features are also added continuously, as another respondent explains. After releasing a minimally viable product (MVP), the functionality is added incrementally with new releases. Some divisions are doing all these activities on an ongoing basis by applying DevOps practices.

Several respondents also agreed that the involvement of more software development in NPD processes has resulted in an increased level of effort after launch. This can also be supported by another respondent's notion that activities related to continuous development and releases have doubled over the last five years, constituting 50% of activities performed nowadays in R&D. Furthermore, one respondent also pointed out that the size of the development team remains the same even after the launch of SM&CPs, and they work continuously to build and develop the product.

One respondent also highlighted that digital offerings are continuously developed and supported while using DevOps practices, including CI and CD. The respondent further delineated that at each planning interval (PI), the division allocates certain capacity for new feature development, technology debt, and enablers (architectural work). Depending on the product's development cycle, the allocated capacity can be adjusted. Old products require more attention regarding technical debt, while new products need more focus dedicated to enablers. Another respondent also highlighted that DevOps practices provide teams with end-to-end responsibility for products' development, launch, and maintenance.

Continuous software development and maintenance are also driven by other actors in ecosystems. For example, new versions of operating systems for iOS or Android create a continuous need for regression testing of updates to the digital offerings and their back-ends. This also results in an increasing effort that cannot be impacted by the company itself, and it increases with the size of the platform, additional features, and continuous launches of new digital offerings.

Lastly, one of the challenges identified by several respondents is the emerging grey area between new product development and continuous support in light of the ongoing adoption of continuous development practices such as DevOps. As SM&CPs require more continuous development of software, the NPD activities tend to merge with continuous support (maintenance) activities, making it challenging to differentiate these two activities. In the case of the traditional hardware product, as men-

tioned earlier in the introduction, the NPD is practically finished once the product is launched without requiring significant continuous support from R&D.

4.4.2 Impact of Increasing Software Development on Business Cases

As software development is becoming an indistinguishable part of the NPD process at SwedCo, several respondents indicated that changes may be needed in how business cases are written and evaluated as software is different in nature from hardware and old methods might not be applicable. The short timeframe used in business cases makes it challenging for software products to be business viable, as it takes time for software to scale and even 5 years is not enough, as one respondent pointed out. Another respondent highlights that software is also associated with recurring revenues and ongoing costs due to continuous development, which is not focused on in the traditional business case. Moreover, this change towards more software development during NPD can also require asking different questions when assessing the business case, and a lot of hardware industry managers do not have expertise in software, as pointed out by another respondent. This further creates challenges in business case assessment if software characteristics are considered in a proper way.

One respondent further discussed that instead of merely projecting sales as in traditional business cases, the scope should become wider and include aspects of understanding what drives the current business and where investment should be placed to be able to grow in the future. Another respondent highlighted that such strategic linking between NPD and overall strategy is well integrated in SAFe, where epics are clearly defined according to strategic objectives.

Another major implication for traditional business cases related to the more continuous, agile methods introduced in some divisions is that budgeting and financing NPD efforts no longer is decided on a project basis but rather on value streams, as one respondent describes:

> In the SAFe world, we don't pitch that we need this many millions for a project ending in November. Instead, we say: we need an organization, a team, that will have an MVP ready for launch by then [...] it is a big difference that we invest in development value streams instead of projects.

This was corroborated by another respondent that mentioned that traditional business cases have to some extent played out their role after selection and development of projects has commenced, since it makes more sense to evaluate business impact on the value stream level which can be done almost instantly. The respondent further mentioned that it had become more difficult to draft traditional business cases due to the evolutionary nature of software development and exemplified this by stating that "[...] it is very difficult to draft a business case on new features or epics in terms of additional revenues of X million."

A general challenge with business cases identified by another respondent is related to overinflation of the possible projected revenues. This is reportedly becoming more challenging also due to the difficulties of projecting future recurring revenues from digital offerings. Moreover, one respondent shared that overinflation in general can be related to a mindset of fearing that a project will not be approved without showing good figures in the business case. However, another respondent pointed out that management may have higher expectations than what is realistic to achieve. This is an especially relevant case for software-based products, which drives further the overinflation of business cases. It was also emphasized that it is important to extend the analysis beyond financials through portfolio management; for instance, if a project enhances the whole portfolio or is an enabler that supports improvements and drives sales for an overall platform of products.

4.4.3 Research & Development Measurement Changes

Several respondents highlighted that the tools used to assess efficiency differ between formal development practices and agile practices. As one respondent pointed out, the key difference in measurement between these two practices is the sampling frequency. In a stage-gate process, due to the few evaluation points, potential mistakes surface late in the process. This is not a problem for a smaller project. However, a larger project that has been ongoing for several years can face severe consequences, such as eroding potential profitability. In an agile environment, sampling happens constantly, enabling the rapid discovery of possible deviations from the planned path. Therefore, this environment is better suited for bigger projects, including software development. Respondents also indicated that KPIs from a more traditional environment do not work for software, as further problematized below.

SwedCo has been using the NSR metric for a while, but as software development has become an integral part of NPD process it faces some issues. The software is continuously developed, which means it will always count as a new product, over the whole life cycle. This makes the measurement to some extent obsolete in the current environment. Respondents also identified additional drawbacks with this metric. One of them is related to the definition of "newness", raising questions regarding whether a slightly improved product is a new product that should be included in NSR. The same respondent further reasons that one of the goals behind the NSR metric is also to drive the renewal of the product portfolio. However, as the respondent indicated, there are business areas that have a quite low NSR of 3-6% but still perform well in the market. This raises another question for the respondent of how managers should understand if they spend too much or too little on the development of SM&CPs current KPIs does not indicate that. Therefore, the same respondent does suggest complementing NSR metric with additional metrics to give a better overview of NPD performance, such as product's organic growth and contribution margin.

Another respondent pointed out that even if NSR is one of the key metrics used in SwedCo it is not really relevant to the measure efficiency of software development, as it is challenging to break it down to actionable insights. According to the same

respondent, in agile environment it is more relevant to measure the actual throughput of the teams and how well they are handling the backlog. Another consideration highlighted by another respondent is that software products are never handed over to operations or a sales organization. This can also impact the measurement of NSR as R&D function might have different practices in place resulting in different outcomes.

Moreover, there is another challenge related to measurement in an environment where different NPD practices coexist. As NPD practices can differ between business areas under the same division, it is challenging to aggregate the metrics and different KPIs. For example, larger business areas might be using SAFe but smaller business areas that originate from start-ups might not have any practices in place yet. Besides different methodologies, another respondent mentioned that different ERP systems are used in different regions and cannot be linked, making measurement and follow-up complicated. Several respondents further highlighted that because of these factors, it can be difficult to retrieve data on a project level from business areas.

The division that has implemented SAFe to the largest extent is conducting measurements in different ways. A respondent delineates that non-financial performance is measured during the PI cycle. This is done by monitoring how many stories the team completes in comparison to the plan. Metrics like velocity and predictability are used. Furthermore, as sprints are a maximum of 2 weeks long it implies more frequent measurements of progress. The same respondent further points out that financial performance in terms of revenue or profitability is not measured on each NPD process but on the value stream level. Moreover, the financial performance measurement happens regularly but with longer time frames, such as a quarter, in order to capture the outcome of continuous software development and deployment.

4.5 Emerging Platforms & Regulations

Platforms are becoming key enablers to renew legacy products and also increase the efficiency of the NPD process in a fast-paced environment. On the other hand, increasing the number of regulations related to security, privacy, and safety will require additional effort from NPD processes to stay compliant. The following effects identified by respondents on NPD processes will be further explored in this subchapter.

4.5.1 Increasing Importance of Platforms

Several respondents described that platforming for hardware and software are currently the largest initiatives in NPD and are enablers for the product portfolio upgrade, aiming to make mechanical and electromechanical products connected in order to support new digital offerings. This also increases the efficiency of NPD and makes products more easily adaptable to specific market needs and customizable to user requirements through different software and hardware modules. Platforms also

is beneficial for the continuous development and updates involved in agile methods. For instance, when a security vulnerability is identified, it can be directly addressed in that specific module that is used by multiple products. Consequently, the work is reduced by avoiding addressing each product individually. Moreover, to establish a platform for mechanical or electromechanical products thus requires an understanding of what modules should be developed, what interfaces should be incorporated in them, and whether products should also connect to other products and third-party systems.

One respondent provided an overview of the possibilities of a software platform: "[...] if we have multiple different software products, those software products are based on common core code modules that are reusable and that we can organize in different ways to support different types of applications."

A selection of software modules combined with hardware can enable different products to talk with each other and also provide possibilities for automation, resulting in a complete solution.

Some considerations regarding platform developments were highlighted by several respondents. It is important to choose the right level of platforming because it can become expensive and complex. This could be the case for a platform on a divisional level that has many different business areas and solutions, as stated by one respondent. Moreover, the establishment of platforms also initially takes more time and resources in comparison to discrete development projects. Another respondent also pointed out that the implementation of features into a platform that initially were not intended requires more effort in preparation, such as alignment of requirements between software and hardware modules. It also requires an overall understanding of how the feature will be used by the different products and what interfaces and standards should be used in order to allow communication with both other products and third-party modules, creating a need to interact and coordinate with platform managers, software platform owners, and product owners.

4.5.2 Emerging Regulations and Their Impact on New Product Development

Both software and hardware are facing increasing regulations that will have an impact on NPD processes. In the development of SM&CPs, the security aspects are becoming increasingly important in order to avoid situations where data or control of the product ends up in the wrong hands, as highlighted by several respondents. The emerging security regulations are trying to address these issues, as one respondent exemplified:

> Next year we have the Cyber Resilience Act coming for Europe and the Radio Equipment Directive, RED for Europe as well. That means every device that has a wireless transceiver will now be part of a new set of evaluations from a security standpoint.

Regulations further increase the focus on delivering secure devices, with continuous releases of firmware updates to address the constantly emerging vulnerabilities. As pointed out by the respondent, this cyber security aspect will remain forever, and both effort and time will increase to stay compliant. Another respondent pointed out that there are also increasing regulations on product documentation and sustainability initiatives from the EU, including energy consumption certification and documentation of what materials are used in the product.

In addition, there are also regulations requiring product certification, according to another respondent. This becomes increasingly relevant for SM&CPs that have connectivity technologies inside, such as radio technology to enable Wi-Fi connectivity. However, this requires certification from a Wi-Fi body, and as more technologies are incorporated, more certifications may be needed. Certification requirements also differ between countries, which require even more resources for certification if different markets are served.

Strict and extensive regulations can also be found for mechanical products in some industries where safety aspects are important, according to another respondent. These regulations are also becoming more challenging each year. Therefore, the same respondent further points out that more effort will also be devoted to mechanical product development to sort out new requirements and changes needed to be compliant.

The required effort will increase both on the software side and on the hardware side. However, a respondent pointed out that the required effort on the software side will be much higher due to embedded software in the electromechanical product. One respondent also viewed these developments as enhancing the value of the offering as it becomes more secure. In some cases, SwedCo is also enforcing on itself standards that do not apply in order to future-proof to some extent the products, which also provides a dimension of differentiation from competitors in cheaper market segments. However, this happens also at the expense of increased R&D effort.

4.6 Changing New Product Development Cost

The shift towards developing SM&CPs containing more software development is also visible in terms of increased costs during NPD efforts, primarily related to the new competences needed and the continuous nature of development it implies. According to the respondents, this is also visible due to some expenditures previously counted as operational cost now becoming part of R&D investments instead. This subchapter outlines how the respondents explained the impact they had seen in terms of NPD cost changes in more detail.

4.6.1 Increasing Software Development Costs

All the changes in product nature, development methods and competence needs have been described by respondents as the primary effects of DT on the case company.

But there are other areas of impact as well. For instance, one respondent has described how hardware development has seen a cost decrease and lead time reduction thanks to the possibilities enabled by additive manufacturing and 3D printing:

> [...] there was a massive time difference [earlier]. If you look at the way that you can prototype today with additive printing, you can [...] have a CAD design sent to the 3D printer to run overnight today, and then come in and have a physical thing in my hand [...] that people can look at and touch and feel. I think it has been a dramatic difference from a digitalization perspective in terms of the effect on cycle time and cost as well.

Cost is another area where SM&CPs differ substantially from non-digital products, and the continuous nature of software development is driving changes in NPD investment at SwedCo. Traditionally, calculating cost was a fairly straightforward process because you could count all the components and arrive at the total cost. With SM&CPs, the cost varies as the system scales. According to several respondents, additional services may have to be consumed when scaling if the system has not been architected properly – in that sense it is not a linear increase in costs as with non-digital products. Therefore, inefficiently developed software products can become very expensive to scale – which is why one respondent pays attention to the non-functional requirements when it comes to scaling digital services, since otherwise "[...] your costs can be out of control all of a sudden, or you may end up delivering very poor service and not meeting your availability targets or SLAs you may have committed to." On the other hand, if you develop your software architecture properly, these costs will likely be a smaller part of the equation compared to salaries for developers and other operating costs. Therefore, several respondents agree that while software may be more costly to develop initially, it may also be cheaper over the entire lifetime of the SM&CPs. It is clear however, that continuous software development and maintenance will affect NPD investment in terms of increasing costs with respect to previous development efforts, according to several respondents.

Several respondents elaborated on this by stating that the more advanced products you are developing, the more development funds are required as investment. This can be seen in that some of SwedCo's divisions have higher R&D spend, and that those are the ones geared more towards products with more software development and digital technologies involved. One respondent estimated the cost of development to "[...] at least double [...] R&D investment as a percentage of revenues traditionally would be around 2-3% [for pure mechanical] now we are going to have to double that. We are going to talk about 5-6% – in some divisions even more." Another respondent agreed and stated that there's a big difference between R&D investment figures at a born-digital software company – where it might be over 25-30% – and at an IMF like SwedCo, which may have a figure of 1-4% traditionally. The respondent continued: "[...] but now we are entering an entirely new era where parts of our business is becoming digital [...] and we are getting a completely different R&D investment that IMFs are not used to handle." This is a hard pill to swallow for

managers that are used to the traditional world of hardware development.

There are several new cost elements introduced by software development practices and connectivity technologies that are driving new costs related to increasing R&D investments. For instance, software development in SM&CPs requires a back-end solution, connectivity, and software licenses which did not exist before, and all add to the cost of development. Furthermore, the increasing regulatory and cybersecurity requirements that come with SM&CPs have been reported as "silent killers of time and energy" both for hardware and software development. Moreover, it is no longer blue-collar workers that are performing maintenance development of the products, but rather well-educated software and data engineers. This maintenance cost has thus shifted from being part of operational or supply chain-related costs to R&D investment since the same team is responsible for the SM&CPs during their entire PLCs.

These developments were described by respondents as one of the major reasons why R&D investment is increasing without NSR doing the same – because there now are fewer products where SwedCo is investing more money into digital platforms, back-ends, and maintaining and keeping them up to date in a more continuous fashion. Compared to what the business looked like 15 years ago, this has been a dramatic shift from investing heavily in hardware to investing heavily in software to keep up with competition, technological advances, changing customer behavior as well as enabling further hardware sales during the DT journey SwedCo has embarked on.

4.6.2 Shift from Operational Cost to Research & Development Cost

As described previously, one major difference due to the increasing amount of software development and SM&CPs that DT has caused is the increasing amount of maintenance and digital platform upkeep costs that is related to R&D teams' work. In traditional hardware development, such costs would instead be considered as a part of supply chain operations. However, one respondent thought that this is not necessarily something negative:

> [as it helps explain] that it is okay for your costs to go up if you want to play in the digital space [...] my concern regarding pulling it out of R&D would be that someone expects R&D spend [as a percentage of revenues] to be 2.5-3% when that is not really the case [...] you see, there is a cost to developing the [digital] product that was not there before.

As a result, one respondent mentioned that costs related to operations and distribution after products are launched will likely see a decrease as SM&CPs become more prevalent. Therefore, the respondent believes it will be important to look at the entire picture, and not only focus on the increasing NPD cost. However, the respondent mentioned that there is another aspect to consider in this regard as well, which is related to SwedCo's product portfolio and the fact that they are frequently acquiring other companies. This affects their portfolio in the sense that

it may introduce duplicate offerings within the company, which is not beneficial as it further increases maintenance costs on top of the developments outlined in this chapter regarding SM&CPs and their increasing software maintenance costs. Therefore, several respondents mentioned that it becomes increasingly important to perform effective portfolio management work in terms of assessing their product footprint to obtain slimmer portfolios with less "unnecessary" upkeep needs.

Finally, it has been reported that these increasing costs caused by DT may not be accurately reflected in the business cases for NPD projects, because "No one is willing to accept how expensive it really is to develop such software systems – so you fool yourself instead." Indeed, several respondents have mentioned the use of overly optimistic numbers to get projects approved, and that uncertainties regarding business case analyses are more prevalent regarding digital offerings.

4.7 Business Model Innovation & Partnerships

The changes in product nature and customer behavior due to DT is described by respondents as a major contributor to a focus shift towards developing offerings that can be sold as subscriptions or services to a larger extent than before. Furthermore, the shift towards SM&CPs increases the reliance on and need to interact with other partnering companies and their products. The following subchapter further describes the respondents' views on these developments and their implications for NPD at SwedCo.

4.7.1 Increasing Importance of Ecosystems & Partnerships

SM&CPs are increasingly important for SwedCo, not only to keep up with the changing environment they are in, but also due to the added benefits of the ecosystems approach that comes with SM&CPs. As one respondent put it: "We have realized that having connected products allows us to have a force multiplier for our sales team, because then it is not just our sales team selling it [the product] – it is the sales team of the connected partners too."

Respondents further highlighted that the emergence of ecosystems has increased the importance of partnerships with other actors. A major factor driving this development is the enhancement of SwedCo's offerings that is enabled by the interaction with other companies' products in the same ecosystem, which improves the user experience and increases the attractiveness of the offerings. Regarding NPD, this requires alignment of the interfaces of the products, which reportedly is relatively straightforward development-wise. However, as another respondent pointed out, it is difficult to assess the benefits of such partnership because it is challenging to measure the ROI on features that enable interaction with other products. Moreover, partners can also help during the development of digital offerings. This can be done if SwedCo develops a platform on which partners can add additional services and offerings to create a complete ecosystem of offerings for the end-user.

4.7.2 Shift Towards Service Provision & Recurring Revenue Opportunities

The change in product nature and customer behavior also opens up possibilities for business model innovation to capitalize on opportunities of introducing recurring monthly revenue; therefore, the current trend is moving towards service provision rather than selling stand-alone products. According to one respondent, this requires a new skill set for the sales team to effectively sell value propositions they (and sometimes the customers) are not used to. Indeed, another respondent described that many IMFs are still trying to understand how to accomplish this – how to convince customers to pay for something they never paid for before (e.g., software, which was previously seen as an enabler of hardware sales provided for free or against a one-time fee; today more and more software is sold on a subscription basis).

Simultaneously, there is a change in perception happening also on the customer side, as one respondent explained: "The customer also views those things a little differently [today] [...] they viewed our products 15-20 years ago as CAPEX, but as we move towards offering more SM&CPs, they are regarding them as OPEX." This opens the possibility of new value prospects to sell to customers, as they increasingly view the offerings as services instead of products.

The trend towards increasing focus on service provision was further described by several respondents as changing the nature and type of products they put on the market, with the objective of extracting as much revenue as possible. They agreed that the focus today is increasingly geared towards being a solution provider rather than a product provider since this enables the firm to lock in customers in some sense. In short, DT has forced SwedCo to change their approach and look at how they can design products that are licensable, where they can for instance package up security patches and firmware updates and sell it under a service agreement. An added benefit of this approach is that it can give the customer a greater level of freedom in terms of tailoring the product more for their purposes as well.

5

Discussion

The following chapter contains an analysis and discussion where the key empirical findings are elaborated upon and related to current literature in an effort to answer the two research questions of this study. It is organized based on these research questions and a thematic analysis of effects that were identified from the empirical findings. This discussion in synthesized form then forms the basis for the subsequent concluding chapter where impacts for firm management and further research are outlined.

5.1 Effects on New Product Development Processes Due to the Introduction of Digital Offerings Enabled by Digital Transformation

In this subchapter, the first research question regarding the effects of digital offerings (mainly SM&CPs) on NPD processes in IMFs is outlined. This is based on eight effects identified from a thematic analysis of the contents in the preceding empirical findings-chapter. These effects are then elaborated upon from a theoretical perspective based on the theories put forward in the theoretical framework. At the end of the subchapter, these effects are synthesized and summarized.

5.1.1 Increasing Software Content, Continuous Development & Coordination Required

One of the key findings regarding the effects of DT on NPD relates to the increasing time and focus devoted to software development as SwedCo is gearing development efforts toward SM&CPs. This is partly driven by external forces such as increasing competition and customer requirements, which requires SwedCo to increase their investments in these areas to be on par with or better compared to other firms. This further aligns with the reasoning of Teece (2007) on the importance of sensing, seizing and transforming the firm's current resource base in line with emerging events, among them exogenous technological developments. Furthermore, the scale of the potential investments could be explained by the ambition level derived from their strategic goals regarding DT, as highlighted by Matt et al. (2015). Depending on these ambitions and strategic goals it could strive towards being a firm setting

standards with new digital technologies in their industry or to build on standards established by others. The importance of clarifying the alignment of such actions with the firm's digital strategy is further emphasized by Ellström et al. (2021). By building such capabilities, there is a chance for the IMF to create valuable intangible resources that could possibly serve as a basis for sustained competitive advantage (Barney, 1991). Therefore, by making strategic objectives and ambitions related to DT explicit, SwedCo can make necessary investments in capabilities, such as new competencies or technological solutions.

Besides the increasing amount of software development, the NPD process is also impacted in the sense that it becomes continuous in nature due to the shift toward digital offerings. This also results in more development efforts post-launch at SwedCo as described in the empirical findings, in line with the argument that product development activities become an ongoing task for IMFs (Prokhin, 2020). As mentioned previously, increasing competition from more digitally mature firms also has an impact on development. This further accelerates the need for continuous development to stay ahead of competition as indicated by both Porter and Heppelmann (2015) and Aramand (2008). Therefore, there is an increasing need for establishing capabilities to accommodate continuous development and embrace the culture that can be found in software development companies. Creating a unified digital infrastructure in order to facilitate collaboration across business units and organizational learning, as well as obtaining management support have been reported in literature as ways of supporting such a transformation (Ellström et al., 2021; Teece, 2007).

The effects regarding increasing investments in SM&CPs and continuous software development further stress the need for the adoption of agile methods. SwedCo currently uses a variety of development methods, with stage-gate being the most frequently used. However, the empirical findings indicate that stage-gate is not well suited for software development, which has caused an ongoing and increasing adoption of agile/SAFe methods at SwedCo. Besides the organizational changes that come with adoption of SAFe, it also requires a shift in mindset to embrace the agile values according to Ebert and Paasivaara (2017). The simultaneous adoption of agile methodologies in some parts of SwedCo's organization, while formal development methods still coexist in other parts, can result in the emergence of different cultural views on NPD methods. This can complicate alignment on the NPD processes in the firm as a whole. Having different development practices in place can also complicate measurement and follow-up regarding NPD performance, which will be further discussed in upcoming subchapters.

Lastly, the development of SM&CPs involves both hardware and software, and thus requires more coordination between functions. Therefore, several researchers, such as Prokhin (2020), Vial (2019), and Björkdahl (2020), stress the need for using agile practices with cross-functional teams to increase collaboration across different business areas and improve agility in an environment with rapid changes. This is furthermore related to the increasing product complexity as described in the findings and by the theories of Björkdahl (2020) and Porter and Heppelmann (2015) on the

integration of different digital technologies in products contributing to increased complexity. The increased coordination needs in light of DT were also identified by Dąbrowska et al. (2022), who explain them as contributing towards firms' increasing overall costs which will be further elaborated upon in Subchapter 5.1.6.

5.1.2 Need to Acquire, Train and Retain In-Demand Competences

The findings further clarified that the development of SM&CPs enabled by DT at SwedCo also creates a need to acquire new competencies as investments in SM&CPs continue to increase; especially those related to software development as these were not part of their core competencies previously. The competence shift for IMFs undergoing DT was also highlighted by several researchers, such as Dąbrowska et al. (2022), Matt et al. (2015), Porter and Heppelmann (2015), Verhoef et al. (2021), and Vial (2019). Moreover, Porter and Heppelmann (2015) pointed out that as IMFs evolve to entities resembling a merger of a traditional product companies and software developers, they will also need to undergo a shift in culture and ways of working. One could argue that in such situations, friction between different parts of the company can emerge if the new culture is not embraced equally in the organization. This aligns with the theories put forward by Dąbrowska et al. (2022) and Matt et al. (2015), who imply the necessity of having management support in place to mitigate the potential frictions and create alignment between different functions. This is especially important for SwedCo as the company is rather decentralized, which could make it challenging to align all parts of the organization.

Vial (2019) further highlights the importance of assessing the current and future competence needs since some competences might be scarce and in high demand by many companies in the market, which is corroborated by the findings of this study. The increased challenges of hiring skilled employees could also warrant companies to focus also on the training of current employees to meet future needs. Moreover, as the importance of these in-demand competences increase with time and further investments in SM&CPs, IMFs should consider creating strategies to attract and retain employees possessing such competences, as they could provide an important intangible asset needed for attaining sustained competitive advantage in developing new digital offerings (Barney, 1991).

5.1.3 Platforming & Partnerships Become Critical Parts of New Product Development

As indicated in the empirical findings, hardware and software platforms can prove to be key enablers for IMFs in their efforts to digitalize mechanical and electromechanical product portfolios which were never intended to be connected. However, as highlighted by Porter and Heppelmann (2015) and Prokhin (2020), it may well be the case that legacy and new offerings will coexist for some time, requiring means to manage their coexistence and potential implications due to interdependencies between them. This is especially important for SwedCo, as they are dependent on a

large installed base of legacy products. Another consideration that emerged in the findings regarding platform development was the importance of choosing a suitable scope of said platforms to maximize the ROI. The platforms can become complex and expensive to develop and manage if they are aimed at addressing too many different solutions across different business areas. Therefore, IMFs should evaluate judiciously which parts of their product portfolio should utilize platforming to achieve a balance between increased R&D efficiency and increasing complexity.

Furthermore, findings from SwedCo indicate that the importance of product ecosystems and partnerships increases. Partnerships can increase the attractiveness of an IMFs offerings by enabling interaction with other companies' products in the same ecosystem and thus contribute to the increased value of the offering and improved customer experience (Verhoef et al., 2021). Being part of product ecosystems shared with other firms will also require finding ways to cooperate, share information, and improve interfirm relationships as highlighted by Dąbrowska et al. (2022), Verhoef et al. (2021), and Vial (2019), to facilitate co-creation and co-delivery of value. This is simultaneously a challenge and an opportunity, as it can enable IMFs to address a broader customer base, but at the same time (due to increasing interdependencies with other firms) they would be giving away part of their control and possibly also revenue to other firms.

The empirical findings also revealed that participating in an ecosystem can require more product maintenance, resulting in additional development efforts for the R&D department. This is mainly driven by externally imposed changes affecting all ecosystem participants, such as updates in smartphone operating systems as exemplified in findings. Such aspects of increased maintenance of SM&CPs due to the actions of partners are not covered in the reviewed literature. Therefore, the potential cost of maintaining an ecosystem can be challenging to predict and are at least partially out of the firm's control. This could arguably also depend on what role the company plays in the ecosystem, i.e., whether the company is an orchestrator or has a more contributing role such as being a supplier, assembler, or complementor (Dąbrowska et al., 2022; Dedehayir et al., 2018).

5.1.4 Agile Methods Require New Metrics and More Continuous Reporting

While there is an ongoing adoption of agile methods at SwedCo, NPD performance metrics have remained largely unchanged from stage-gate NPD methods. However, these do not suit software development well, as indicated by several respondents. This stresses the need for SwedCo to update NPD performance metrics in order to better reflect the new nature of developments including increasing software development. Kupiainen et al. (2015) also support these findings by outlining that agile methods do not favor extensive documentation or measurements as in formal development methods. Instead, agile methods focus on simple and virtually instantaneous metrics that support the iterative and continuous nature of software development (Kupiainen et al., 2015). This enables discovery of potential deviations in NPD

processes quicker, which also emerged in the findings of this study. One could also argue that such characteristics of metrics are not only beneficial for software development, but also for the hardware development in a digital world. Therefore, IMFs may need to consider adopting agile metrics across different NPD processes to react quicker to changes in the external environment and identify potential deviations from objectives more efficiently.

For instance, the NSR metric (which is a key NPD performance metric used at SwedCo) does not work well for software since software is always counted as new thanks to its continuous deployments and updates. This issue of newness was also mentioned by both Whiteley et al. (1998) and Shapiro (2006). To mitigate this issue, these authors suggest clear organization-wide criteria regarding newness. Therefore, IMFs might need to adjust the criteria as the nature of products is changing. Furthermore, they may also need to consider whether it is worth continuing to use the NSR metric in a fast-paced environment, as Cooper and Edgett (2012) pointed out that it does not reflect the true value of product performance due to possible cannibalization effect on existing products. Therefore, IMFs may need to evaluate the use of alternative metrics, which will be expanded more on in Subchapter 5.2.4, to better reflect the new nature of products that enable continuous value delivery and the constantly changing external environment.

Findings from SwedCo also indicate another challenge related to measurement in organizations with different business areas employing different development practices. This makes the aggregation of NPD metrics challenging and is further complicated in SwedCo due to the use of different non-integrated ERP systems in several parts of the organization, which makes it difficult to retrieve data at an aggregate level. As Björkdahl (2020) and Verhoef et al. (2021) pointed out, having full data accessibility is important for facilitating DT since other company functions can then leverage it. Therefore, if means are not established for enabling data sharing between different units in the organization, DT efforts, overall decision-making, and insight into the firm's NPD performance could be negatively impacted.

Moreover, Tzokas et al. (2004) suggested that documentation created by employing the stage-gate process enables learning and follow-up after project completion. However, as some divisions have moved away from these development methods towards SAFe, less focus ends up on documentation of this kind. This makes it more difficult to follow up on NPD processes and understand what has been done and if it was done according to plan. However, as shown in the findings, even when utilizing stage-gate NPD methods at SwedCo the documentation is not always stored systematically or used for organizational learning because other tasks are prioritized instead. Therefore, practice differs somewhat from theory in this case. In contrast, in an agile environment the measurements are happening continuously, thus leading to continuous learning if those measurements are regularly inspected and discussed. The ability to continuously create awareness for such metrics due to the increased frequency of measurement was indeed described as a major benefit of using SAFe methods according to one respondent.

5.1.5 Security, Privacy, & Safety Compliance Requires More Resources

The shift towards SM&CPs has also required additional considerations regarding security aspects. As vulnerabilities emerge continuously, continuous mitigation efforts are required. In addition, the increasing number of regulations regarding security, privacy, and safety for both software and hardware products are also affecting the NPD processes at IMFs as more time will be devoted to ensuring compliance.

The increasing importance of product security has also been highlighted by Porter and Heppelmann (2015) and Tomiyama et al. (2019), who expanded upon the threat of SM&CPs becoming targets for hacker attacks. Porter and Heppelmann (2015) further discuss SM&CPs' capabilities to monitor and collect data and raise questions about how such data is handled and used, which is receiving increasing attention from users and regulators as per the findings of this study. Therefore, IMFs must continuously prioritize security, privacy, and safety aspects to build and retain trust and reputation. It can also be concluded by the findings that it is likely only a matter of time before new regulations follow as new digital technologies emerge. Therefore, it is imperative to find means to how to manage new regulations in an efficient manner, which will be further explored in Subchapter 5.2.3.

5.1.6 Cost Structure Shift Towards Increasing Software Development & Maintenance Costs

As outlined in the empirical findings, SwedCo is experiencing increasing NPD costs. Its driving forces are multiple, with the most prominent being increasing software development the need for new, in-demand competences; increasing maintenance of platforms and products; and increasing importance of security, privacy and safety considerations. Moreover, the changing product nature also contributes through increasing complexity, connectivity, back-end solutions, and software licenses, on top of increasing development costs. In sum, it has emerged from the findings that pursuing more software development and providing digital offerings to a greater extent results in increasing NPD investments. In addition, as IMFs pursue DT they will increasingly turn into software companies, which have an R&D investment five to nine times higher than what IMFs typically have (Ahlawat et al., 2019). The trend for increasing R&D investments is also related to the ongoing cost of operating digital offerings as shown in the findings. Consequently, by introducing SM&CPs IMFs are expanding their industry boundaries, while moving into more software oriented areas contributing to higher R&D investments. It is also important to keep in mind that these categories are not exhaustive, and therefore, there could be other underlying forces driving the increasing NPD investments.

On the other hand, the literature on DT including Vial (2019) and Björkdahl (2020) has identified many benefits of DT, such as improved efficiency and cost savings at the organizational level. Some of these benefits were also identified in the findings in activities such as production and sales but not in the NPD processes. This discrepancy could be related to the fact that the DT research field is still nascent,

and that the NPD aspect of it has not been explored to the same extent as other parts.

There could be also additional explanations of increasing NPD investments related to the shift of activities that were previously considered parts of operations that are now becoming a part of NPD such as maintenance, continuous development of products and platform upkeep. In other words, there is a cost to put and keep digital offerings on the market and it increases as more SM&CPs are developed. Equivalents to these activities would be considered an operational cost for a non-digital product. However, the findings show that the corresponding operational costs will likely decrease as more SM&CPs and other digital offerings are introduced, making it more important to consider the sum of these changes rather than assessing them individually.

Lastly, the findings from SwedCo also indicate that intensive M&A activity can introduce duplicate offerings within a company, which further increases the aforementioned maintenance and software development costs related to SM&CPs. Therefore, there is an increasing importance of performing effective portfolio management with the aim of assessing product and system footprint and reducing redundancy of offerings to minimize the maintenance costs which was pointed out by respondents. However, Humble and Molesky (2011) mention that it could be challenging to decommission one system due to its potential interdependencies with other systems and products. Therefore, IMFs also need to manage linkages between products and systems to be able to efficiently decommission systems to ease the strain of maintaining them.

5.1.7 New Types of Offerings Require New Value Propositions & Sales Methods

Another effect that has wide-ranging implications on NPD processes is that the changing nature of products in light of DT also enables new ways of selling them. Digital offerings such as SM&CPs are continuously developed and improved, with new features constantly enhancing the user experience. This lays the groundwork for the introduction of subscription-based business models as a means to create recurring revenue, which enables firms to continuously capitalize on the continuous value delivered to customers and users. Therefore, current business models at IMFs may require substantial changes to efficiently capture the new continuous value proposition from digital offerings as pointed out by Correani et al. (2020), Verhoef et al. (2021), and Vial (2019).

Besides possible changes in terms of business models, it also emerged in the findings that customers might need education and directed sales efforts to explain in detail how these new types of value delivery via digital offerings work, as customers might be unfamiliar with them. This could be the case for key customers as they could be invested in current systems and show reluctance for change due to investments made in their installed base. However, it also emerged that some customers are already starting to view their purchases as OPEX rather than CAPEX, thus showing some

progress in accepting subscription-based business models. The following mindset shift at customers and possibilities for continuous value delivery from SM&CPs can allow IMFs to become solution providers and move further down in the value chain closer to the end-user. The increased customer proximity can also have positive implications for profitability as highlighted by Björkdahl (2020), which makes this an important strategic consideration for IMFs going forward regarding DT.

5.1.8 Development of Digital Offerings Require Changes to Business Case Evaluations

In the findings it emerged that the traditional business case used in NPD is no longer well suited in an iterative and continuous software development environment. The different characteristics of software compared to hardware also contribute to some further complications: first, software-based digital offerings require time to scale properly and secondly, there is always ongoing cost related to continuous development and maintenance even after product launch. These characteristics are currently not reflected in business cases in SwedCo. Furthermore, with increasing software development in NPD processes, another issue arises in regard to business case evaluation. According to the findings from SwedCo, managers trained and experienced in hardware product development might not have enough expertise in developing software. This could lead to the assessment of the business case not adequately considering all possible characteristics and aspects of software development and potentially leading to unrealistic expectations in terms of development costs and financial return. Another issue emerging from the findings in regard to business cases is the risk for overinflation of the potential financial value of the business cases. This is not a new issue, but the new software characteristics, potential lack of relevant expertise, and high expectations as previously discussed could further exacerbate this trend.

Some divisions at SwedCo have shifted towards a more evolutionary view of how the value creation and delivery in digital offerings takes place, in conjunction with their adoption of SAFe practices. Most divisions traditionally use formal business cases to plan development. However, the external environment and customer requirements can change several times before the initial delivery of the product in the digital world. This could have further implications such as not being able to match the value proposition with the one requested by the customers, potentially leading to market failure. In line with theories presented by Correani et al. (2020) and Björkdahl (2020), it could therefore become important to embrace a more entrepreneurial mindset to NPD processes and continuously adjust the value proposition and business case to such external changes.

5.1.9 Synthesis of Discussion on Research Question 1

The eight key effects from the first research are summarized in Table 5.1 below and will be briefly summarized in this synthesis to highlight the key differences between literature and findings as well as contributions to research. The discussion indicated

that most of the findings had been covered to some extent in the current literature. For instance, effects 1, 2, 4, and 7 as reported in the findings align closely with theory. However, the findings of this case study provided some nuances in this regard. This can be seen in effect 4, where differences between practice and theory emerged in regard to documentation practices that were not prioritized at SwedCo which could potentially impede organizational learning. Similarly, some nuances in comparison with theory can also be found in effect 7, where the findings highlight the potential need to educate customers as a consequence of employing new business models, which was not emphasized in the current literature.

There were also effects that were partially overlooked by extant literature, as in the cases of effects 3 and 5. Here, the findings of this study could serve to nuance the current state of research in these areas. Regarding effect number 3, the findings delineated platforms as key enablers to renew legacy products. However, the literature on DT has not emphasized product platforms. Instead, focus has been more on the ecosystems, which is also highlighted in the findings. Moreover, the literature has not provided arguments on how increased interdependencies in ecosystems could increase NPD efforts, which is evident from the findings. Regarding effect number 5, the literature did point out the importance of security, privacy, and safety, which was also in line with the findings. However, the literature did not link it to increasing NPD efforts, as findings from this study show.

Lastly, effects 6 and 8 were not at all covered by the literature reviewed and represent the most substantial contribution to current research from this study. Effect number 6 contributes from the perspective of the NPD cost structure shift towards increasing continuous software development and maintenance with the introduction of digital offerings. Additionally, effect number 8 contributes important insight regarding business case evaluations for digital offerings, which need changes to better represent software characteristics in a fast-changing external environment. Moreover, the non-existent literature coverage on these topics could be explained by the fact that DT research is a nascent field of research with gaps that need to be filled out and that provides promising grounds for further research.

Table 5.1: Summary of effects on NPD processes.

ID	Title of the effect on NPD	Alignment with literature
1	Increasing software content, continuous development and coordination required	Aramand (2008), Björkdahl (2020), Dąbrowska et al. (2022), Porter and Heppelmann (2015), Prokhin (2020), and Vial (2019)
2	Need to acquire, train and retain in-demand competences	Dąbrowska et al. (2022), Matt et al. (2015), Porter and Heppelmann (2015), Verhoef et al. (2021), and Vial (2019)
3	Platforming and partnerships become critical parts of NPD	Dąbrowska et al. (2022), Verhoef et al. (2021), and Vial (2019)
4	Agile methods require new metrics and more continuous reporting	Kupiainen et al. (2015) and Oza and Korkala (2012)
5	Security, privacy, and safety compliance requires more resources	Porter and Heppelmann (2015) and Tomiyama et al. (2019)
6	Cost structure shift towards increasing development and maintenance costs	
7	New types of offerings require new value propositions and sales methods	Correani et al. (2020), Verhoef et al. (2021), and Vial (2019)
8	Development of digital offerings require changes to business case evaluations	

5.2 Managing the Effects on New Product Development Processes That Result From the Introduction of Digital Offerings Enabled by Digital Transformation in Incumbent Manufacturing Firms

In this subchapter, the second research question regarding how IMFs can manage the effects on NPD processes as outlined in RQ1 is discussed. This is based on information identified from a thematic analysis of the empirical findings, as well as

the above analysis and discussion of RQ1. These contributions are then synthesized and summarized at the end of the subchapter.

5.2.1 Create Capabilities for Exploiting SM&CPs, Platforms & Partnerships

The long-term competitive advantage of IMFs like SwedCo will depend on increasing investments in software development to be able to deliver SM&CPs to stay relevant and on par with or above their competitors, as reported in the empirical findings. The competitive landscape is constantly changing with new players emerging, and consequently legacy products need to be updated in order to withstand the increasing competition and changing customer requirements. As Correani et al. (2020), Dąbrowska et al. (2022), and Vial (2019) highlight, DT can therefore both be interpreted as a threat to IMFs legacy business but also as an enabler to renew their offerings. Moreover, the findings reported a need to consolidate hardware platforms to enable more efficient renewal of legacy products. Therefore, IMFs should embrace DT by establishing new processes and capabilities for creating modular software and hardware platforms, while also utilizing DT to renew their product portfolios to increase their competitiveness.

Further investments in SM&CPs and other digital solutions are also enabling the exploitation of digital platforms and ecosystems. Verhoef et al. (2021) have pointed out that digital platforms have shown possibilities for exponential user growth as they are highly scalable and can take advantage of network effects, resulting in a higher financial return. Therefore, there is a prospect for building an ecosystem around digital platforms, which is already being pursued by SwedCo to some extent. Moreover, serving additional customers on a digital platform can be done at almost no additional cost, as it has been reported to be fairly resource-light to scale according to the empirical findings and Verhoef et al. (2021). The findings further indicate that as the importance of ecosystems increases, it creates a need to work efficiently with suitable partners, as pointed out by Verhoef et al. (2021). However, as partners become an integral part of the offerings and solutions provided to customers, the interdependencies between companies in the ecosystem increase. Therefore, it can arguably be beneficial to find partners with the same objectives and similar values to facilitate close collaboration and enable continuous development of ecosystem with mutual interest. This further aligns with the importance of selecting enterprise boundaries as part of establishing capabilities to seize opportunities in a changing environment (Teece, 2007). While building ecosystems in this manner is not in line with what SwedCo and other IMFs have traditionally done, the increasing importance of ecosystems and partnerships requires establishing such capabilities regarding building and managing relationships with other firms efficiently.

DT can also strengthen the competitive advantage of IMFs by delivering products and services that are better catering to customers' needs (Correani et al., 2020; Teece, 2007). There is also a need to clarify the technological ambitions of IMFs to

determine whether they are best suited to be first-movers or followers regarding DT, as suggested by Matt et al. (2015). This can help guide and motivate the needed strategic investments in both resources and capabilities. Relatedly, IMFs should also consider what role they would like to play in different ecosystems. As previously discussed in Subchapter 5.1.3, there are possibilities of having a controlling as orchestrator or a more contributing role as a complementor in ecosystems. The strategic objectives of IMFs could further guide this decision which becomes increasingly important as indicated by the findings and the reviewed literature (Ellström et al., 2021; Teece, 2007).

5.2.2 Increase Understanding of Recurring Revenue Models & Rigorous Cost Accounting

The increasing amount of continuous development and the fact that digital products are kept alive longer through continuous updating and maintenance create a different kind of cost structure for NPD efforts in the digital world. This has implications for IMFs' business models, especially regarding the need to focus more on recurring revenues as the value provided to the customer is continuous and potentially increasing with time as new features are added.

As emerged in the findings, business model changes can also require educating customers to counteract potential resistance or inertia against such changes. This results in a need for new capabilities in the sales function to create awareness and convince customers of the benefits of the new value delivery model. However, this impact is not specified by the current research on DT, besides the overall need for new competencies.

Moreover, it has been reported in the findings that NPD costs will increase, but at the same time a decrease in operational costs is expected. Therefore, IMFs need to look at the entire picture, and rethink the way cost accounting is performed during NPD to assess if the total cost is increasing or decreasing over the lifetime of the product or service. This may well require new types of metrics, as explained in Subchapter 5.1.4. Therefore, it is of increasing importance to renew organizational structures to facilitate data sharing and search for new metrics that can provide a better picture on cost related to different NPD efforts.

5.2.3 Accommodate Need for Continuous Software Development & Maintenance, Multiple Development Methodologies & Efficient Regulatory Compliance Procedures

Another important way for IMFs to manage the impact of DT on NPD that was exhibited at SwedCo is the use of DevOps and CI/CD practices to accommodate the need for continuous software development and maintenance that comes with DT. This is in line with the arguments of Vial (2019) regarding the increasing need for cooperation between functions, which is reflected in the use of the above-mentioned

practices at SwedCo. These practices serve to increase the collaboration between R&D and IT, while adopting digital technologies in NPD processes to deliver new products. Besides increased efficiency in delivering and launching new offerings, the utilization of continuous development practices by IMFs can shift towards continuous value delivery and enabling business model innovation.

Moreover, it has been reported that while several divisions at SwedCo are increasingly using agile methods for developing software, there are still some cases where stage-gate methods are considered to be more suitable. It is therefore important for IMFs to establish clear support and a culture that can accommodate the coexistence of multiple development methods simultaneously, and clearly outline the appropriate use cases for each of them. However, the current literature does not provide any theories or recommendations regarding the simultaneous accommodation of different development methods which stresses the need for further research in this area.

Finally, the increasing number of regulations and certifications regarding digital offerings reported in the findings imply a need to establish efficient processes for working in highly regulated environments, such that regulatory compliance and certification processes do not slow down development processes. Even though some researchers (e.g., Porter & Heppelmann, 2015) indicated the potential emergence of regulations in light of DT, it is not explained in more detail in the literature how IMFs could handle them. This stresses the need for more research in this area as the number of regulations is likely to continue to increase. The findings from SwedCo also emphasize the need for awareness of regulations and their impact on NPD processes. However, one possible way of managing them can be traced back to the general suggestions of both Björkdahl (2020) and Correani et al. (2020) for processes at IMFs to be agile and lean to enable rapid adaptation to fast-changing environment. Similar principles could be utilized in NPD by building in more flexibility in processes, and therefore IMFs might need to work more closely with regulators to be able to anticipate and accommodate new regulations.

5.2.4 Adapt Business Cases & Performance Measurement Practices to Agile Methods

As outlined previously, there is a need to adapt performance metrics to an agile/SAFe environment to account for its iterative and continuous nature. As emerged in the findings, metrics related to a product's user base growth and contribution margins could be used to complement the traditional NSR metric that is not as well-suited for the digital world. Even though literature by Kupiainen et al. (2015) and Oza and Korkala (2012) highlight the differences between formal and agile methods in terms of measurement, it does not provide guidance on how measurement should be pursued in an environment where different development practices coexist and how the metrics could be aligned to measure similar aspects of development in order to guide decision-making in such NPD processes. Therefore, there are prospects for further research in this area, which is becoming increasingly important for IMFs undergoing DT.

Besides performance measurement in NPD, the business cases also require adaptation to this new environment. Business cases have historically been focused on a longer time perspective, whose feedback loops are too long for agile development methods as the external environment changes continuously. Furthermore, the difference in how business cases are formulated in NPD processes depending on development methods is not discussed in the literature. Findings from SwedCo also indicate that the use of business cases as performed when using formal development methods is not appropriate for the development of digital offerings.

Finally, it was also found that it is difficult to follow up on NPD investment and business cases at SwedCo since they are sometimes not sufficiently tracked. In addition, different divisions use different systems to measure NPD investments depending on the development methods and ERP systems utilized, thus making comparisons difficult. Moving forward, establishing a common system for reporting data related to NPD processes independently of what development practices are used could be of great use for IMFs like SwedCo to increase transparency, accountability and learning in the organization.

5.2.5 Synthesis of Discussion on Research Question 2

The focus areas for managing the effects on NPD processes are summarized below in Table 5.2 below and will be briefly summarized in this synthesis to highlight the key differences between literature and findings and contribution to research. In this discussion, it emerged that current literature does not address management of the majority of the identified effects on NPD processes sufficiently. This could be due to the fact that DT is still a nascent theoretical field and there are many perspectives to be explored. However, focus area 1 was partially covered by the DT literature, as it is foundational for DT itself (without digital technologies, there would be no DT).

When it comes to focus areas 2 and 3, some parts of the literature cover adjacent areas of research, such as the need for new business models. However, in both cases, the literature does not cover specifics on how IMFs should handle the effects brought forward in this case study. For instance, regarding focus area 3, the importance of being able to handle the coexistence of different development methodologies emerged, but the findings and literature did not have any concrete suggestions on this matter. This is also the case for the emerging regulations, where no concrete actions were identified besides raising awareness among managers in IMFs regarding their potential consequences. This stresses the importance of conducting further research to find effective means of managing both concurrent utilization of multiple NPD methods and managing the increasing number of regulations affecting NPD processes.

Lastly, the reviewed literature also showed limited coverage regarding focus area 4. The findings highlighted the importance of rethinking how business cases are made for NPD processes, as the way of how value is delivered to customers is changing. This stresses the need for further research into how business cases should be per-

formed in this new environment. The findings also highlighted the importance of updating NPD performance measurement to better match changing development methods, the nature of the product, and the external environment. This also requires further research regarding what new metrics should be implemented and how they should be used in NPD processes.

Table 5.2: Focus areas related to the identified effects of DT on NPD processes.

ID	Focus Area	Alignment with literature
1	Create capabilities for exploiting SM&CPs, platforms and partnerships	Correani et al. (2020), Dąbrowska et al. (2022), Verhoef et al. (2021), and Vial (2019)
2	Increase understanding of recurring revenue models and rigorous cost accounting	
3	Accommodate need for continuous software development and maintenance, multiple development methodologies and efficient regulatory compliance procedures	Björkdahl (2020), Correani et al. (2020), and Vial (2019)
4	Adapt business cases and performance measurement practices to agile	

6

Conclusion

This chapter briefly summarizes the conclusions regarding the research questions answered in this thesis, followed by a short discussion on its practical and theoretical implications, as well as its limitations and possibilities for further research. The purpose of this study was to investigate what the effects of DT are on NPD processes for IMFs and how IMFs can manage these effects. Therefore, a single case study a Sweden-based IMF (SwedCo) was performed. During the research process, 28 interviews with R&D managers and other relevant experts in the related field were conducted at SwedCo. The collected data was thematically analyzed and presented in the chapter on empirical findings. These findings were then discussed, summarized and grouped to answer the two research questions that were formulated to fulfill the purpose of this study. The key insights will be briefly summarized below for each research question.

Regarding the first research question (RQ1: How does the introduction of digital offerings enabled by DT affect NPD processes within R&D in IMFs in practice?), focus was put on understanding the effects on NPD processes at IMFs when digital offerings enabled by DT are introduced. In the findings from SwedCo, several main effects emerged in this regard, which are summarized in Table 6.1 (not ordered in terms of importance or scale of impact). Moreover, as discussed in Chapter 5, some of the effects were not extensively covered by literature today. However, it cannot be concluded that the list of effects is exhaustive. There could also be other effects on NPD processes that were not covered in interviews due to the specific case chosen, other delimitations, or respondents not being aware of all underlying effects.

Table 6.1: Summary of the identified effects of DT on NPD processes.

ID	Effects on NPD Processes
1	Increasing software content, continuous development and coordination required
2	Need to acquire, train and retain in-demand competences
3	Platforming and partnerships become critical parts of NPD
4	Agile methods require new metrics and more continuous reporting
5	Security, privacy, and safety compliance requires more resources
6	Cost structure shift towards increasing development and maintenance costs
7	New types of offerings require new value propositions and sales methods
8	Development of digital offerings require changes to business case evaluations

For the second research question (RQ2: How can IMFs manage the effects on NPD processes within R&D that result from the introduction of digital offerings enabled by DT?), focus lay on exploring how IMFs could manage these effects. It emerged that there are four key areas that IMFs such as SwedCo should focus on in light of DT. These four areas are summarized in Table 6.2. Due to the limitations of this study this is not an exhaustive list of focus areas that could be considered. Furthermore, the reviewed literature exhibited limited coverage regarding this research question. This stresses the need for further research in this area, as will be discussed later on in this chapter.

Table 6.2: Summary of focus areas to manage the identified effects.

ID	Focus Areas to Manage Effects on NPD Processes
1	Create capabilities for exploiting SM&CPs, platforms and partnerships
2	Increase understanding of recurring revenue models and rigorous cost accounting
3	Accommodate need for continuous software development and maintenance, multiple development methodologies and efficient regulatory compliance procedures
4	Adapt business cases and performance measurement practices to agile

6.1 Practical Implications

According to the empirical findings of this study, it appears that DT has affected the NPD processes within R&D in several ways, as concluded in Table 6.1. The findings also indicate that managers at SwedCo are aware of these effects to some extent. However, similar to other large IMFs, SwedCo is prone to inertia due to their legacy. Therefore, this stresses the need of establishing capabilities and processes to manage the identified effects in order to sustain their competitive advantage. Furthermore, some of the identified effects are not mutually exclusive, such as effects number 1 and 6 (where increasing software development leads to increasing cost of development and maintenance), and may even be interlinked with each other, such as the case of effect number 1 having linkages to all remaining effects.

By reviewing the focus areas for management in Table 6.2, IMFs could design prioritized actions to mitigate the emerging effects on NPD processes and gain an upper hand against competitors. While neither the reviewed literature nor the findings showed explicit, tried and tested ways to manage these effects, they are certainly areas of interest for management and practitioners at IMFs as well as researchers to investigate further.

First, to sustain and build competitive advantage in the industry, it is important to continue to invest in SM&CPs but also create capabilities for exploiting platforms and partnerships. This is a big shift for SwedCo and R&D managers. Previously, NPD efforts could stay within the walls of the R&D department without interacting with external actors. The shift towards SM&CPs has torn down these walls, creating new interaction points with internal and external actors, such as partners in ecosystems and regulators. This has also increased the interdependencies with other actors when the solution delivered to customers becomes dependent on contributions from all partners in an ecosystem. As an extension of this, IMFs no longer have the same control over the effort and cost related to NPD processes. This is further exacerbated by emerging regulations and changes imposed by external partners and other actors in the ecosystem over which the individual IMF may have little influence. Therefore, if an IMF could establish capabilities for exploiting SM&CPs, platforms and partnerships, this may result in increased competitiveness, awareness and new ways of managing interdependencies and interactions efficiently. In turn, this may make them better prepared for undergoing DT and capitalize on its benefits.

Secondly, DT has also changed the concept of value delivery with the introduction of SM&CPs, from one-time sales to continuous value delivery. In the findings it also emerged that there is a need to understand how this continuous value could be captured. Therefore, IMFs should continue innovating with recurring revenue models but also increase awareness about them on the customer side. Customers might not be familiar with these new business models and could be reluctant to change as identified by the findings. Moreover, increasing continuous development and maintenance are also contributing factors towards increasing NPD costs. This requires managers to apply a wider view in terms of analyzing NPD costs, as DT also affects other parts of the value chain (such as operational cost decreases in

conjunction with increasing NPD costs).

Thirdly, the increasing need for IMFs to handle continuous software development by implementing DevOps practices is highlighted by both findings and literature. Therefore, their capabilities should be strengthened in this area moving forward. Another implication is that legacy businesses will not disappear in the near future, as pointed out by both findings and literature. Both the need for renewal of legacy products as well as remaining demand for non-digital products may consequently result in development methods coexisting in the organization. This requires creating support and a culture able to accommodate different development practices being utilized simultaneously. Moreover, the findings also indicate that the increasing number of regulations regarding security, privacy, and safety aspects of SM&CPs creates additional effort in the NPD efforts. Managers at IMFs could increase awareness about emerging regulations by monitoring the environment, working closer to regulators, and creating flexibility in NPD processes to adapt, as mentioned previously.

Lastly, due to the changing product nature and development methods there are implications for NPD process performance measurement and the way business cases are made. Some of the key performance metrics are no longer suitable in this new environment, such as NSR at SwedCo. Managers should therefore look for new metrics that could complement the NSR in an environment with an increasing number of digital offerings, such as user-base growth or contribution margins as proposed by respondents. Moreover, as the value delivery for the customer becomes continuous, it creates a need to make the business case more adaptable to both changing requirements as well as new business models.

6.2 Theoretical Implications

This study identified the research gap between ongoing DT at IMFs and the effects on NPD processes within R&D as digital offerings are introduced. Current research has not thoroughly explored the intersection of these subjects. Therefore, this study sheds light on and contributes to this research gap as current developments make it increasingly important for IMFs to understand the effects of DT on NPD processes and how these could be managed. This study has contributed to research by identifying effects on NPD processes that were not identified by the current literature. This was the case for the three of eight identified effects in Table 6.1.

The first of these was that security, privacy, and safety regulatory compliance require more resources from NPD. The current literature also stated the increasing importance of security and emerging regulations for SM&CPs, but it did not elaborate further on its potential impacts on NPD processes as it emerged from the findings of this study. The second effect is related to the cost structure shift towards increasing development and maintenance cost. As discussed in Chapter 5, this is a combination of several of the effects and it is not highlighted by the current literature. Lastly, the development of digital offerings requires changes in business case evaluations. As

discussed previously, software characteristics are not reflected in the business cases used in formal NPD methods. This effect is not highlighted by current research either. All three of these effects are new contributions to the research, as they are consequences of both the changing nature of the product and the adoption of agile development practices due to DT.

It has also emerged in Chapter 5 that current literature does not explore ways for IMFs like SwedCo to manage the effects on NPD processes due to DT. However, in the findings from SwedCo, four areas emerged where capabilities should be established and strengthened, as shown in Table 6.2. Therefore, it can also be concluded that this subject was not well researched from a theoretical standpoint, and each focus area for management that emerged from the findings contributes to the identified research gap as discussed previously.

6.3 Limitations & Future Research

This study outlined the effects of DT on NPD processes at IMFs and the management thereof. As mentioned previously, both the delimitations and research strategy employed in this study contribute towards a somewhat limited generalizability and transferability inherent in case study research of this kind. Therefore, the researchers urge for cautious applications of the findings in this regard, as transferability and generalizability were not the primary goals of this study. Since DT is a relatively new field of study, it is lacking empirical studies in some regards – for instance regarding its impact on NPD. In addition to this study's contribution, there are more areas to explore and questions to consider for future research. Overall, the researchers would like to highlight a few subjects for future research in more detail.

First, some of the identified effects were not covered by literature, such as the shifting cost structure towards continuous development and maintenance and the required change in business case evaluations (effects 6 and 8). This should be further investigated to provide more detailed answers to the findings of this study but also shed light for practitioners. As discussed in this research contribution, current literature also does not explore areas of how to manage the identified effects, which should be further investigated to provide more concrete suggestions for IMFs going forward in DT.

Second, as emerged in the findings, ensuring compliance with existing and upcoming regulations and certifications related to security, privacy, and safety is becoming increasingly resource-intensive from an NPD standpoint. Therefore, it would be interesting to pose a question for further research regarding how these regulations can be managed most efficiently with minimal impacts on NPD processes.

Third, the adoption of agile development methods has changed the way NPD performance is measured compared to formal development methods. The NPD processes have become continuous and iterative, which is making it difficult to assess the possible return on investment beforehand. Thus, it should be further explored how

financial governance could be applied for this new development environment, as well as whether and in that case which new tools and metrics are necessary.

Fourth, the importance of new business models increases with the introduction of digital offerings. However, some legacy products will likely remain also in the future. This results in a situation for IMFs where new business models need to be developed while at the same time serving customers according to old models. Therefore, a question could be asked about how IMFs can efficiently manage different business models while undergoing DT.

Apart from the aforementioned limitations regarding the scope and setting where the research was conducted, it is believed that the findings and conclusions contribute to both current and future research as well as actionable information for both practitioners and academics interested in the field of study. However, more research in this context is welcomed to investigate any possible similarities and to investigate the generalizability and transferability of this study, for instance using longitudinal and comparative multiple case studies including also born-digital firms.

References

Ahlawat, P., Krause, T., Pagano, E., Banerjee, S., Jarvis, F., Justin, J., Premo, R., & Emerson, G. (2019). *How Software Companies Can Get More Bang for Their R&D Buck*. Retrieved January 25, 2023, from https://web-assets.bcg.com/img-src/BCG-How-Software-Companies-Can-Get-More-Bang-for-Their-R-D-Buck-Nov-2019-R_tcm9-234379.pdf

Anquetil, N., de Oliveira, K. M., de Sousa, K. D., & Batista Dias, M. G. (2007). Software maintenance seen as a knowledge management issue. *Information and Software Technology*, *49*(5), 515–529. https://doi.org/10.1016/j.infsof.2006.07.007

Aramand, M. (2008). Software products and services are high tech? New product development strategy for software products and services. *Technovation*, *28*(3), 154–160. https://doi.org/https://doi.org/10.1016/j.technovation.2007.10.004

Baines, T., Lightfoot, H., Benedettini, O., & Kay, J. (2009). The servitization of manufacturing: A review of literature and reflection on future challenges. *Journal of Manufacturing Technology Management*, *20*(5), 547–567.

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99. https://search.ebscohost.com/login.aspx?direct=true&db=bsu&AN=5978921&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Beck, K., Grenning, J., Martin, R. C., Beedle, M., Highsmith, J., Mellor, S., van Bennekum, A., Hunt, A., Schwaber, K., Cockburn, A., Jeffries, R., Sutherland, J., Cunningham, W., Kern, J., Thomas, D., Fowler, M., & Marick, B. (2001). *Manifesto for Agile Software Development*. Retrieved March 15, 2023, from http://agilemanifesto.org/

Bell, E., Bryman, A., Bryman, A., & Harley, B. (2019). *Business Research Methods*. Oxford University Press.

Björkdahl, J. (2020). Strategies for Digitalization in Manufacturing Firms. *California Management Review*, *62*(4), 17–36. https://search.ebscohost.com/login.

aspx?direct=true&db=bsu&AN=145035770&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Bloom, N., Jones, C. I., Van Reenen, J., & Webb, M. (2020). Are Ideas Getting Harder to Find? *American Economic Review*, *110*(4), 1104–44. https://doi.org/10.1257/aer.20180338

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brown, N., Cai, Y., Guo, Y., Kazman, R., Kim, M., Kruchten, P., Lim, E., MacCormack, A., Nord, R., Ozkaya, I., Sangwan, R., Seaman, C., Sullivan, K., & Zazworka, N. (2010). Managing Technical Debt in Software-Reliant Systems. *Proceedings of the FSE/SDP Workshop on Future of Software Engineering Research*, 47–52. https://doi.org/10.1145/1882362.1882373

Cooper, R. G., & Edgett, S. J. (2012). Best Practices in the Idea-to-Launch Process and Its Governance. *Research-Technology Management*, *55*(2), 43–54. https://doi.org/10.5437/08956308X5502022

Cooper, R. G., & Kleinschmidt, E. J. (1991). New product processes at leading industrial firms. *Industrial Marketing Management*, *20*(2), 137–147. https://doi.org/10.1016/0019-8501(91)90032-B

Cooper, R. G., & Sommer, A. F. (2016). The Agile–Stage-Gate Hybrid Model: A Promising New Approach and a New Research Opportunity. *Journal of Product Innovation Management*, *33*(5), 513–526. https://doi.org/https://doi.org/10.1111/jpim.12314

Correani, A., De Massis, A., Frattini, F., Petruzzelli, A. M., & Natalicchio, A. (2020). Implementing a Digital Strategy: Learning from the Experience of Three Digital Transformation Projects. *California Management Review*, *62*(4), 37–56. https://search.ebscohost.com/login.aspx?direct=true&db=bsu&AN=145035774&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Dąbrowska, J., Almpanopoulou, A., Brem, A., Chesbrough, H., Cucino, V., Di Minin, A., Giones, F., Hakala, H., Marullo, C., Mention, A.-L., Mortara, L., Nørskov, S., Nylund, P. A., Oddo, C. M., Radziwon, A., & Ritala, P. (2022). Digital transformation, for better or worse: a critical multi-level research agenda. *R&D Management*, *52*(5), 930–954. https://doi.org/10.1111/radm.12531

Dedehayir, O., Mäkinen, S. J., & Roland Ortt, J. (2018). Roles during innovation ecosystem genesis: A literature review. *Technological Forecasting and Social Change*, *136*, 18–29. https://doi.org/https://doi.org/10.1016/j.techfore.2016.11.028

Dubois, A., & Gadde, L.-E. (2002). Systematic combining: an abductive approach to case research [Markets as Networks]. *Journal of Business Research*, *55*(7), 553–560. https://doi.org/https://doi.org/10.1016/S0148-2963(00)00195-8

Dybå, T., & Dingsøyr, T. (2008). Empirical studies of agile software development: A systematic review. *Information and Software Technology*, *50*(9), 833–859. https://doi.org/https://doi.org/10.1016/j.infsof.2008.01.006

Ebert, C., Gallardo, G., Hernantes, J., & Serrano, N. (2016). DevOps. *IEEE Software*, *33*(3), 94–100. https://doi.org/10.1109/MS.2016.68

Ebert, C., & Paasivaara, M. (2017). Scaling Agile. *IEEE Software*, *34*(6), 98–103. https://doi.org/10.1109/MS.2017.4121226

Eger, T., Eckert, C., & Clarkson, P. J. (2005). The Role of Design Freeze in Product Development. *Proceedings ICED 05, the 15th International Conference on Engineering Design*.

Elkins, D. A., Huang, N., & Alden, J. M. (2004). Agile manufacturing systems in the automotive industry. *International Journal of Production Economics*, *91*(3), 201–214. https://doi.org/https://doi.org/10.1016/j.ijpe.2003.07.006

Ellström, D., Holtström, J., Berg, E., & Josefsson, C. (2021). Dynamic capabilities for digital transformation. *Journal of Strategy and Management*, *15*(2), 272–286. https://doi.org/10.1108/JSMA-04-2021-0089

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11

Fitzgerald, B., & Stol, K.-J. (2017). Continuous software engineering: A roadmap and agenda. *Journal of Systems and Software*, *123*, 176–189. https://doi.org/https://doi.org/10.1016/j.jss.2015.06.063

Flick, U., von Kardoff, E., & Steinke, I. (2004). *A Companion to Qualitative Research*. Sage.

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, *12*(2), 219–245. https://doi.org/10.1177/1077800405284363

Fricker, S. A. (2012). Software Product Management. In A. Maedche, A. Botzenhardt, & L. Neer (Eds.), *Software for People: Fundamentals, Trends and Best Practices* (pp. 53–81). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-31371-4_4

Furr, N., & Shipilov, A. (2019). Digital doesn't have to be disruptive: the best results can come from adaptation rather than reinvention. *Harvard Business Review*, *97*(4).

Gavin, R., Harrizon, L., Plotkin, C. L., Spillecke, D., & Stanley, J. (2020). *The B2B digital inflection point: How sales have changed during COVID-19*. Retrieved January 24, 2023, from https://www.mckinsey.com/capabilities/growth-marketing-and-sales/our-insights/the-b2b-digital-inflection-point-how-sales-have-changed-during-covid-19

Guba, E. G., & Lincoln, Y. S. (1989). *Fourth Generation Evaluation*. Sage.

Guest, G., Bunce, A., & Johnson, L. (2006). How Many Interviews Are Enough?: An Experiment with Data Saturation and Variability. *Field Methods*, *18*(1), 59–82.

Hermerén, G. (2017). *Good Research Practice*. Retrieved February 14, 2023, from https://www.vr.se/download/18.5639980c162791bbfe697882/1555334908942/Good-Research-Practice_VR_2017.pdf

Highsmith, J., & Cockburn, A. (2001). Agile Software Development: The Business of Innovation. *Computer*, *34*(9), 120–127. https://doi.org/10.1109/2.947100

Hilal, A. H., & Alabri, S. S. (2013). Using NVivo for Data Analysis in Qualitative Research. *International Interdisciplinary Journal of Education*, *2*(2), 181–186.

Hossain, E., Babar, M. A., & Paik, H.-y. (2009). Using Scrum in Global Software Development: A Systematic Literature Review. *2009 Fourth IEEE International Conference on Global Software Engineering*, 175–184. https://doi.org/10.1109/ICGSE.2009.25

Humble, J., & Molesky, J. (2011). Why enterprises must adopt devops to enable continuous delivery. *Cutter IT Journal*, *24*, 6–12.

Iansiti, M. (1995). Shooting the Rapids: Managing Product Development in Turbulent Environments. *California Management Review*, *38*(1), 37–58. https://search.ebscohost.com/login.aspx?direct=true&db=bsu&AN=9512123298&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds

Kerssens-van Drongelen, I. C., & Cooke, A. (1997). Design principles for the development of measurement systems for research and development processes. *R&D Management*, *27*(4), 345–357. https://doi.org/https://doi.org/10.1111/1467-9310.00070

Kim, J., & Wilemon, D. (2002). Focusing the fuzzy front–end in new product development. *R&D Management*, *32*(4), 269–279. https://doi.org/https://doi.org/10.1111/1467-9310.00259

Kupiainen, E., Mäntylä, M. V., & Itkonen, J. (2014). Why Are Industrial Agile Teams Using Metrics and How Do They Use Them? *Proceedings of the 5th In-*

ternational Workshop on Emerging Trends in Software Metrics, 23–29. https://doi.org/10.1145/2593868.2593873

Kupiainen, E., Mäntylä, M. V., & Itkonen, J. (2015). Using metrics in Agile and Lean Software Development – A systematic literature review of industrial studies. *Information and Software Technology*, *62*, 143–163. https://doi.org/10.1016/j.infsof.2015.02.005

LaBerge, L., O'Toole, C., Schneider, J., & Smaje, K. (2020). *How COVID-19 has pushed companies over the technology tipping point—and transformed business forever*. Retrieved January 24, 2023, from https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever

Lyytinen, K., Yoo, Y., & Boland Jr., R. J. (2016). Digital product innovation within four classes of innovation networks. *Information Systems Journal*, *26*(1), 47–75. https://doi.org/https://doi.org/10.1111/isj.12093

Mantere, S., & Ketokivi, M. (2013). Reasoning in Organization Science. *Academy of Management Review*, *38*(1), 70–89. https://doi.org/10.5465/amr.2011.0188

Marxt, C., & Hacklin, F. (2005). Design, product development, innovation: all the same in the end? A short discussion on terminology†. *Journal of Engineering Design*, *16*(4), 413–421.

Mathiassen, L. (2017). Designing Engaged Scholarship: From Real-World Problems to Research Publications. *Engaged Management Review*, *1*(1), 2. https://doi.org/10.28953/2375-8643.1000

Matt, C., Hess, T., & Benlian, A. (2015). Digital Transformation Strategies. *Business & Information System Engineering*, *57*(5), 339–343. https://doi.org/10.1007/s12599-015-0401-5

Maxwell, J. A. (2008). Designing a Qualitative Study. The SAGE Handbook of Applied Social Research Methods.

Meyer, M. H., & Lopez, L. (1995). Technology Strategy in a Software Products Company. *Journal of Product Innovation Management*, *12*(4), 294–306. https://doi.org/10.1111/1540-5885.1240294

Meyer, M. H., & Seliger, R. (1998). Product Platforms in Software Development. *Sloan Management Review*, *40*(1), 61–74.

Olsson, H. H., Alahyari, H., & Bosch, J. (2012). Climbing the "Stairway to Heaven" – A Mulitiple-Case Study Exploring Barriers in the Transition from Agile Development towards Continuous Deployment of Software. *2012 38th Euromi-*

cro Conference on Software Engineering and Advanced Applications, 392–399. https://doi.org/10.1109/SEAA.2012.54

Oza, N., & Korkala, M. (2012). Lessons Learned In Implementing Agile Software Development Metrics. *UK Academy for Information Systems Conference Proceedings 2012*. https://aisel.aisnet.org/ukais2012/38

Padmini, K. V. J., Dilum Bandara, H. M. N., & Perera, I. (2015). Use of Software Metrics in Agile Software Development Process. *2015 Moratuwa Engineering Research Conference (MERCon)*, 312–317. https://doi.org/10.1109/MERCon.2015.7112365

Pernstål, J., Feldt, R., & Gorschek, T. (2013). The lean gap: A review of lean approaches to large-scale software systems development. *Journal of Systems and Software*, *86*(11), 2797–2821. https://doi.org/https://doi.org/10.1016/j.jss.2013.06.035

Persson, M., & Åhlström, P. (2006). Managerial issues in modularising complex products. *Technovation*, *26*(11), 1201–1209. https://doi.org/10.1016/j.technovation.2005.09.020

Porter, M. E., & Heppelmann, J. E. (2014). How Smart, Connected Products Are Transforming Competition. *Harvard Business Review*, *92*(11), 64–88.

Porter, M. E., & Heppelmann, J. E. (2015). How Smart, Connected Products are Transforming Companies. *Harvard Business Review*, *93*(10), 96–114.

Prokhin, E. (2020). Digital Transformation of Industrial Companies: What is Management 4.0? *2020 The 11th International Conference on E-Business, Management and Economics*, 131–138. https://doi.org/10.1145/3414752.3414779

Rising, L., & Janoff, N. (2000). The Scrum software development process for small teams. *IEEE Software*, *17*(4), 26–32. https://doi.org/10.1109/52.854065

Saunders, B., Sim, J., Kingstone, T., Baker, S., Waterfield, J., Bartlam, B., & Burroughs, H. (2018). Saturation in qualitative research: exploring its conceptualization and operationalization. *Quality and Quantity*, *52*(4), 1893.

Scaled Agile. (2023a). *Development Value Streams*. Retrieved March 25, 2023, from https://scaledagileframework.com/development-value-streams/

Scaled Agile. (2023b). *Portfolio SAFe*. Retrieved March 25, 2023, from https://scaledagileframework.com/portfolio/

Scaled Agile. (2023c). *Strategic Themes*. Retrieved March 25, 2023, from https://scaledagileframework.com/strategic-themes/

Schmidt, C. (2004). The Analysis of Semi-Structured Interviews. In *A Companion to Qualitative Research* (pp. 253–258).

Shapiro, A. R. (2006). Measuring Innovation: Beyond Revenue from New Products. *Research Technology Management*, *49*(6), 42–51. Retrieved June 5, 2023, from http://www.jstor.org/stable/24134972

Srivastava, M., Franklin, A., & Martinette, L. (2013). Building a Sustainable Competitive Advantage. *Journal of Technology Management & Innovation*, *8*(2), 47–60.

Stake, R. E. (1995). *The Art of Case Study Research*. Sage.

Straehle, O., Bron, A., & Crabbe, D. (2022). *The Hardware Paradox: Machinery Must Expand beyond Machines*. Retrieved January 25, 2023, from https://www.bain.com/insights/hardware-paradox-global-machinery-and-equipment-report-2022/

Sutton, C., & David, M. (2010). *Social Research: An Introduction*. Sage.

Svahn, F., Mathiassen, L., & Lindgren, R. (2017). Embracing Digital Innovation in Incumbent Firms: How Volvo Cars Managed Competing Concerns. *MIS Quarterly*, *41*(1), pp. 239–254. Retrieved June 4, 2023, from https://www.jstor.org/stable/26629645

Teece, D. J. (2007). Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance. *Strategic Management Journal*, *28*(13), 1319–1350. https://doi.org/https://doi.org/10.1002/smj.640

Tom, E., Aurum, A., & Vidgen, R. (2013). An exploration of technical debt. *Journal of Systems and Software*, *86*(6), 1498–1516. https://doi.org/10.1016/j.jss.2012.12.052

Tomiyama, T., Lutters, E., Stark, R., & Abramovici, M. (2019). Development capabilities for smart products. *CIRP Annals*, *68*(2), 727–750. https://doi.org/10.1016/j.cirp.2019.05.010

Turetken, O., Stojanov, I., & Trienekens, J. J. M. (2017). Assessing the adoption level of scaled agile development: a maturity model for Scaled Agile Framework. *Journal of Software: Evolution and Process*, *29*(6), e1796. https://doi.org/https://doi.org/10.1002/smr.1796

Tzokas, N., Hultink, E. J., & Hart, S. (2004). Navigating the new product development process. *Industrial Marketing Management*, *33*(7), 619–626.

Van de Ven, A. H. (2007). *Engaged Scholarship : A Guide for Organizational and Social Research.* Oxford University Press, Incorporated.

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, *122*, 889–901. https://doi.org/10.1016/j.jbusres.2019.09.022

Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, *28*(2), 118–144. https://doi.org/10.1016/j.jsis.2019.01.003

Wallén, G. (1996). *Vetenskapsteori och forskningsmetodik*. Studentlitteratur.

Whiteley, R., Parish, T., Dressler, R., & Nicholson, G. (1998). R&D Metrics: Evaluating R&D Performance Using the New Sales Ratio. *Research-Technology Management*, *41*(5), 20–22. https://doi.org/10.1080/08956308.1998.11671232

Wortmann, F., & Flüchter, K. (2015). Internet of Things. *Business & Information Systems Engineering*, *57*(3), 221–224. https://doi.org/10.1007/s12599-015-0383-3

Yilmaz, K. (2013). Comparison of Quantitative and Qualitative Research Traditions: epistemological, theoretical, and methodological differences. *European Journal of Education*, *48*(2), 311–325. https://doi.org/https://doi.org/10.1111/ejed.12014

Yin, R. K. (2003). *Case Study Research: Design and Methods*. Sage.

Yin, R. K. (2009). *Case Study Research: Design and Methods*. Sage.

A

Interview Guide for Main Interviews

Brief Introduction of Your Role and Team

- Could you briefly introduce yourself and your role at SwedCo?
- What does your team do?
  - What is your role in the overall R&D/Innovation process?

Digitalization of New Product Development (NPD) Projects

- Which product areas are most heavily invested in? Has this changed over time - i.e., is DT visible in a shift of R&D cost across product categories?
  - How many and what types of projects do you conduct, and how has it changed over time?
- What share of projects is new product development, and what is incremental/maintenance of existing products? Has it changed?
  - What is the ratio of projects that is PPI/NPI/CPI?
- Is there a discernible difference in project headcounts/person years of activity and lead time?
  - Between digitally mature (high degree of SW development in the project) and less digitally mature projects?

NPD Cost Structure and Cost Drivers (In Light of Digital Transformation)

- Are there visible differences in total cost & cost structure of digital vs non-digital projects?
- Has the character of NPD costs changed over time?

  - What activities/processes in NPD accounts for greatest cost? (are there differences between digital and non-digital projects?)

  - Do we see increases in new types and numbers resources and capabilities required? (e.g., specific R&D personnel/roles required) due to DT?

- Is there any indication of an increase in cost over product lifetime or longer duration of NPD phase for digital products?

  - Are there any differences in projected/planned length of product life cycles/time in market for digital products? How does this affect cost visavi "legacy" products?

NPD Project Governance and Follow-up/Possible Perceived Barriers to Digital Transformation

- Are there verifiable barriers to investment in digital technologies in e.g., incentive structures or market split considerations (e.g., less value in global investment if the mandate is geographically limited)?

  - If they exist, are there opportunities for collaboration and knowledge-sharing to overcome such barriers?

- How is all internal evaluation data reported/stored/followed up on?

  - What policies are there regarding this reporting?

  - What metrics are used?

  - Does the reporting differ between different phases of projects? (e.g., before/after GW4/product launch) and digital vs standalone projects?

- Do alliances, standards/protocols or emerging digital ecosystems have implications for NPD cost?

Should Subsequent "Maintenance" and/or Upgrades of Digital Products be Included in R&D/NPD Cost?

- Are maintenance/upgrades for existing digital products classified as operative expenses (e.g., sales of services) or R&D (NPI/CPI)? Is this possible to distinguish and track?

Management of Identified Effects on NPD Processes

- How can the effects on NPD processes be managed as result from the introduction of digital offerings enabled by DT?

- What new capabilities and resources are required in order to manage these identified effects on NPD processes?

Further Interviews

- Who would you recommend that we talk to next, to get other perspectives/insights?
- Could we reach out to you again if needed?

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF ENTREPRENEURSHIP AND STRATEGY
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden
www.chalmers.se

CHALMERS
UNIVERSITY OF TECHNOLOGY