Agile R&D Units' Organization in Physical Product Development – An Empirical Investigation

TECHNISCHE UNIVERSITÄT DARMSTADT

Vom Fachbereich Rechts- und Wirtschaftswissenschaften
der Technischen Universität Darmstadt

zur Erlangung des akademischen Grades
Doctor rerum politicarum (Dr. rer. pol.) genehmigte

Dissertation

von

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Darmstadt 2022

Meier, Andre: *Agile R&D Units' Organization in Physical Product Development – An Empirical Investigation*
Darmstadt, Technische Universität Darmstadt
Jahr der Veröffentlichung der Dissertation auf TUprints: 2022
URN: urn:nbn:de:tuda-tuprints-216123
Tag der mündlichen Prüfung: 27.06.2022

Kurzzusammenfassung

Während Softwareunternehmen in ihren Entwicklungsprozessen zunehmend auf agile Methoden setzen und sich damit zu komplett agilen Unternehmen transformieren, verlagerte sich diese Bewegung in letzter Zeit auch in den Bereich der physischen Produktentwicklung. Insbesondere setzen auch traditionelle Maschinenbauunternehmen zunehmend auf agil organisierte Einheiten in Forschung und Entwicklung (F&E), um den erhöhten Innovationsbedarf des heutigen Geschäftsumfeldes in noch kürzeren Zeitintervallen zu bewältigen. Aufgrund der Tatsache, dass bestehende Agilitätsforschung jedoch hauptsächlich aus den Bereichen Informationssysteme und Produktionsmanagement stammt, nimmt die Agilitätsforschung in der F&E- und Innovationsmanagementliteratur zwar zu, ist jedoch immer noch selten. Dies führte zu einer unzureichenden Erforschung des Konzeptes in diesem Zusammenhang. Darüber hinaus teilt die existierende Forschung die allgemeinen Mängel der Agilitätsliteratur, z. B. einen starken Fokus auf die Unternehmens- oder Projektebene und die Softwareentwicklung. Darüber hinaus konzentriert sich die Literatur in hohem Maße auf die Ergebnisperspektive des Konzepts, d. h. erhöhte Anpassungsfähigkeit, anstatt zu erläutern wie man sich agil organisiert, d. h. die Fähigkeitenperspektive. Aufgrund dieser Mängel wurde in der aktuellen Literatur das praktisch hochrelevante Phänomen agiler F&E-Einheiten, insbesondere deren Organisation, die sie in der Produktentwicklung so anpassungsfähig macht, vernachlässigt. Diese Dissertation adressiert dieses Defizit, indem sie Erkenntnisse aus der Agilitätsforschung, der F&E- und Innovationsmanagementliteratur und der Organisationstheorie verknüpft. Basierend auf einem Interviewdatensatz von zwölf Agilitätsexpert:innen und drei Umfragedatensätzen von 178 F&E-Manager:innen, 110 F&E-Projektleiter:innen und 454 F&E-Projektmitarbeitenden führt diese Dissertation vier Untersuchungen in Form von separaten Forschungsstudien durch. Durch den Zusammenschluss der Studien verdeutlicht die Dissertation erstmals, was die Organisation agiler F&E-Einheiten (ARDO) ganzheitlich kennzeichnet und zeigt die Auswirkungen von ARDO auf die Gesamtleistung der F&E-Einheiten, sowie auf die einzelnen in den F&E-Einheiten tätigen Mitarbeitenden. Darüber hinaus trägt diese Dissertation zur Literatur über Agilität, F&E und Innovationsmanagement sowie zur Organisationstheorie im Allgemeinen bei. Erstens indem das Agilitätskonzept in einem neuen Kontext, mittels einer neuen Analyseeinheit und aus einem neuen Blickwinkel betrachtet wird, wodurch die vernachlässigte Fähigkeitenperspektive der Agilität abschließend und ganzheitlich konzeptualisiert wird. Zweitens wird ein besseres

Verständnis des Zusammenspiels von Agilität und Innovationsleistung geschaffen, insbesondere durch die weitere Verknüpfung des Konzeptes mit dem Frontend der Innovation. Drittens erweitern die Identifikation und Operationalisierung von ARDO als eine solche Kompetenz die Theorie der dynamischen Fähigkeiten und ermöglichen zukünftige quantitative Forschung zu einer dynamischen Fähigkeit im Kontext von F&E und zu agilen F&E-Einheiten in der physischen Produktentwicklung im Allgemeinen.

Abstract

While software firms increasingly rely on agile methods in their development processes and consequently transform to entirely agile firms, this movement lately also transferred to the domain of physical product development. More specifically, even traditional mechanical engineering firms increasingly rely on agilely organized Research and Development (R&D) units to cope with the current business environment's increased demands for innovations at even shorter time intervals. However, since extant agility research primarily stems from the information systems and operations management fields, agility research in R&D and innovation management literature is rising but still scarce, resulting in the concept's insufficient exploration in this context. Moreover, extant research shares agility literature's general flaws, such as a strong focus on the firm or project level and software development. Moreover, literature highly focuses on the concept's outcome perspective, i.e., increased adaptiveness, instead of elucidating how to organize to be agile, i.e., the capability perspective. As a result of these shortcomings, extant literature has neglected the practically highly relevant phenomenon of agile R&D units, particularly their organization, which makes them so adaptive in new product development (NPD). This dissertation addresses this shortcoming by linking insights from agility research, R&D and innovation management literature, and organizational theory. Based on an interview data set from twelve agility experts and three survey data sets from 178 R&D managers, 110 R&D project managers, and 454 R&D project employees, this dissertation conducts four investigations in the form of separate research studies. By the studies' alignment, the dissertation, for the first time, elucidates what holistically constitutes agile R&D units' organization (ARDO) and reveals ARDO's consequences on the R&D units' overall performance and the individual employees nested in the R&D units. Moreover, this dissertation contributes to agility, R&D and innovation management literature, as well as organizational theory in general, first by approaching the agility concept in a new context, via a new unit of analysis, and from a new angle, thus finally and holistically conceptualizing agility's neglected capability perspective. Second, by providing a better understanding of agility's and innovation performance's interplay, particularly by further linking the concept to innovation's front end. Third, ARDO's identification and operationalization as such a competence advance dynamic capabilities theory, which facilitates future quantitative research on a dynamic capability in the context of R&D and on agile R&D units in physical product development in general.

Agile R&D Units' Organization in Physical Product Development – An Empirical Investigation

Content Overview

Table of Content

List of Figures

List of Tables

1 Introduction

“Innovation is what agile is all about” (Rigby et al., 2016, p. 42). Such statements in journals like the *Harvard Business Review* attract managers' interest since they promise a solution to deal with today’s markets’ increased uncertainty and the constant need for innovations (Bennett & Lemoine, 2014; Little, 2005). Contrary, others consider the concept only the latest management fashion (Cram & Newell, 2016). Despite these diverse views on agility, agile methods’ success and prevalence have so far been unbridled (Abrahamsson et al., 2009; Conboy, 2009; Hobbs & Petit, 2017). Thus, more and more firms rely on such development approaches and the corresponding restructuring of their business areas (Hobbs & Petit, 2017; Rigby et al., 2016; Rigby et al., 2018), which also explains academic research’s interest on the topic (Christofi et al., 2021; Potdar et al., 2017; Tallon & Pinsonneault, 2011). Nevertheless, the concept still needs to be fully explored in the field of Research and Development (R&D) and innovation management (Bianchi et al., 2020), to which this dissertation contributes.

1.1 Motivation and Background

Nowadays, companies face the constant challenge of bringing more innovative products to the market at even shorter time intervals (Saviotti & Pyka, 2004). In addition, increased volatility, uncertainty, complexity, and ambiguity characterize the current business environment. In this setting, often referred to as the VUCA world, development projects’ planning and linear completion are difficult (Bennett & Lemoine, 2014). Thus, there is a need for increased adaptability, flexibility, and responsiveness in the development process (Bennett & Lemoine, 2014; Rigby et al., 2016).

As a result of these needs, more and more companies consider the concept of agility as an opportunity to meet these requirements and integrate agile methods into their development processes (Hobbs & Petit, 2017; Rigby et al., 2016). Agile methods divide the development process into iterations to react to changing requirements during development faster and have been explicitly developed to better handle uncertainty (Cooper, 2016; Strode et al., 2011). Particularly in the software industry, these development approaches are quite popular, almost state of the art, and thus widespread in well-known companies such as Microsoft, Google, Facebook, Spotify, or Riot Games (Denning, 2016).

From the software industry on, agile approaches such as Scrum or Extreme Programming (XP) continued to diffuse into companies such as Apple or Cisco Systems, which, in addition to software, also manufacture hardware components (Chen et al., 2016; Denning, 2016; Hobbs & Petit, 2017). Nowadays, also more and more established manufacturing companies rely on agile development methods, with considerable success (Cooper, 2016; Cooper & Sommer, 2016; Rigby et al., 2016; Rigby et al., 2018). For example, John Deere, a global agricultural engineering company, reduced its development cycle times by up to 75% and increased team productivity by up to 200% in some cases by using agile methods. The company managed to develop a new machine type's fully operatable functional prototype in eight months, which would have been possible in a reference study with classical development methods at best in one and a half years (Rigby et al., 2016). The toy manufacturer LEGO echoes similar positive experiences, whereby the company uses a hybrid form of agile development methods and the classic, linear stage-gate model (Cooper & Sommer, 2016). The number of manufacturing companies that rely on agile methods and a corresponding organizational structure is continuously increasing, and also other firms such as BOSCH, 3M, or Saab are additional notable and well-known representatives of this movement in physical product development (Rigby et al., 2018).

Such phenomena in practice and the associated success stories aroused academic research's interest, thus, many scientific studies from various research fields deal with agility (Christofi et al., 2021). In a recent literature review in the information systems field, Tallon et al. (2019) identified 169 different studies on IT-supported agility from 2000 to mid-2018. In the operations management field, Potdar et al. (2017) even analyzed nearly 300 research articles on agile manufacturing published between 1993 and 2016, which illustrates academic research's high affinity with agility. Regarding the concept's origin, however, there are two fundamental assumptions, represented by the two most prominent research fields dealing with agility, the operations management and information systems fields (Conboy, 2009; Gunasekaran, 1998; Potdar et al., 2017; Rigby et al., 2016; Tallon et al., 2019).

In 1991, scholars at the Iacocca Institute at Lehigh University recognized the need for adaptable and flexible manufacturing systems due to increased competitive pressure and observed a corresponding change in practice (Gunasekaran, 1998; Yusuf et al., 1999). In a comprehensive study based on the involvement of many executives from leading US companies, it was the researchers' goal to describe the most relevant and beneficial manufacturing practices at that

time (Yusuf et al., 1999). The US government-sponsored initiative (Gunasekaran, 1998) resulted in two comprehensive reports on manufacturing companies' strategies in the 21st century (Iacocca Institute, 1991a, 1991b) and had the overarching premise to support the United States of America in regaining its supremacy in manufacturing (Yusuf et al., 1999). In detail, the reports addressed the agile manufacturing company's components, processes, and necessary infrastructure. Furthermore, for the first time in literature, these works characterize agility in the manufacturing context and essential agility-favoring elements (Iacocca Institute, 1991a, 1991b; Yusuf et al., 1999). In addition to their high popularity in practice and politics, the reports simultaneously are important pioneer work for academia since they for the first time use the term agile manufacturing, the later declared manufacturing paradigm of the 21st century (Yusuf et al., 1999). In doing so, the reports established one of agility's main research streams and the basis for further ground laying work in this field (Yusuf et al., 1999). For instance, the reports' results served both Gunasekaran (1998) and Yusuf et al. (1999) as motivation and basis to create the first conceptual frameworks of agile manufacturing and to identify its attributes, drivers, and first implementation approaches (Gunasekaran, 1998; Yusuf et al., 1999).

Contrary, many scholars and practitioners see agility's origin in software development (Abrahamsson et al., 2009; Cooper & Sommer, 2016), more precisely in the Agile Manifesto from 2001 (Beck et al., 2001). Seventeen software developers came together in Snowbird, Utah, to create new software development approaches and thus replace existing methods, such as the waterfall model (Rigby et al., 2016). The latter provides satisfactory results in stable markets and project environments but has significant weaknesses in volatile and uncertain development settings (Boehm, 1988; Boehm & Turner, 2005; Rigby et al., 2016). In the waterfall model, the software requirements and the steps for implementing them are defined in detail at the project start and then processed sequentially like a waterfall, giving the methodology its name (Rigby et al., 2016). Particularly in the event of frequent changes or unforeseen obstacles during development, such linear methods quickly reach their limits due to their rigidity and cause high bureaucratic efforts (Boehm, 1988; Boehm & Turner, 2005; Rigby et al., 2016). Moreover, the increased reaction time needed to respond to any changes often makes the software and the corresponding customer requirements obsolete at delivery (Rigby et al., 2016). Therefore, the movement around the Agile Manifesto focused on redefining software development's values and principles to better address today's turbulent business environment (Bose, 2008; Rigby et al., 2016).

From the two original and most extensive research streams, the agility concept also diffused into other disciplines (Christofi et al., 2021; Conboy, 2009). For example, the project management community (Conforto & Amaral, 2010; Hobbs & Petit, 2017; Sheffield & Lemétayer, 2013), the general management literature (Doz & Kosonen, 2010; Teece et al., 2016), and the innovation management literature (Kester et al., 2011; Kester et al., 2014; Kock & Gemünden, 2016) discuss agility from their scientific angles and consequently form new agility research streams.

A more content-related perspective on extant agility research elucidates that the concept is primarily associated with the corresponding methods, which also literature's large extent addressing these approaches shows (Abrahamsson et al., 2009; Chan & Thong, 2009; Fitzgerald et al., 2006; Hong et al., 2011; Maruping et al., 2009; Wang et al., 2012). While a large number of this scholarly work originates from the information systems field, meanwhile also the project management community recognized the advantages of agile methods as project management approaches (Conforto et al., 2014; Conforto & Amaral, 2010; Hobbs & Petit, 2017; Kaufmann et al., 2020; Serrador & Pinto, 2015; Stettina & Hörz, 2015; Sweetman & Conboy, 2018).

While agile methods' implementation in a single team or small project is less problematic, introducing such approaches in larger projects or multiple teams can create serious challenges (Boehm & Turner, 2005; Hobbs & Petit, 2017; Nerur et al., 2005). A large part of extant agility literature thus deals with scaling the agile ways of working from an individual team to several teams, if not the entire organization, or from small to large projects (Hobbs & Petit, 2017). In the course of this research, scholars examined the prerequisites for agility more closely and developed several frameworks to support the process of implementing agile methods in larger contexts, i.e., scaling agile (Ebert & Paasivaara, 2017; Reifer et al., 2003; Rigby et al., 2018; Swafford et al., 2006a; Tallon et al., 2019).

Such scaling frameworks' successful implementation would result in an entirely agile organization, another important field of existing agility research (Kettunen, 2009). Agile companies can handle unexpected changes more quickly and even regard them as opportunities, which they leverage with their strong innovation capacities (Lu & Ramamurthy, 2011). In the context of agile manufacturing, Yusuf et al. (1999) characterized such an agile manufacturing company for the first time, which Bottani (2010) even proved empirically. Nowadays, research even addresses the whole supply chain (Gligor et al., 2015; Swafford et al., 2006b, 2006a).

Several studies also examined agility's outcomes, in particular its impact on business performance (Gemino et al., 2021; Gligor et al., 2015; Kester et al., 2014; Raschke, 2010; Ravichandran, 2018; Shuradze et al., 2018; Tallon et al., 2019; Tam et al., 2020; Vázquez-Bustelo et al., 2007).

These remarks show agility's high relevance for practice and academia. However, extant agility and innovation management literature share certain limitations, which this dissertation discusses in more detail in the next chapter, and whose coexistence caused that research by now left the phenomenon of agile R&D units in physical product development unaddressed so far.

1.2 Research Gap and Research Questions

This chapter aims to present shortcomings in extant agility literature and to develop this dissertation's overall three research questions, which the thesis addresses in four separate research studies.

Agility's high relevance for practice (Rigby et al., 2016; Rigby et al., 2018) and its multifaceted nature (Sarker et al., 2009) allow applying various perspectives on the concept, which results in many academic contributions on agility in different research disciplines. However, due to the already long engagement with the concept, extant research's majority is primarily located in the information systems and operations management fields, even dating back to the late 1990s (Gunasekaran, 1998; Yusuf et al., 1999). Over two decades later, the R&D and innovation management literature started to investigate the concept of agility from its scientific angle, and first notable academic contributions evolved (Kester et al., 2011; Kester et al., 2014; Kock & Gemünden, 2016). Due to this asymmetry compared to agility's main research streams, agility research in R&D and innovation management is rising but still scarce (Christofi et al., 2021). Consequently, many aspects of the concept's application in this context are left unexplored, for example, agility's thorough conceptualization as present in other research fields such as information systems (Conboy, 2009), operations management (Yusuf et al., 1999), or project management (Conforto et al., 2016). Extant agility research in R&D and innovation management, besides a sole focus on the corresponding methods which extant agility research no matter from which research field is liable to, also manifests in a high proportion of studies of qualitative nature or based on anecdotal evidence (Beaumont et al., 2017; Brock et al., 2020;

Cooper & Sommer, 2016; Grass et al., 2020). Moreover, additional shortcomings, which refer to extant agility research in general, further contribute to the concept's insufficient disclosure in R&D and innovation management (Bianchi et al., 2020).

First, extant research only addressed a limited set of analysis levels (Christofi et al., 2021). Most studies are either located on the firm level (Gligor et al., 2015; Lu & Ramamurthy, 2011; Swafford et al., 2006a; Tallon et al., 2019; Tallon & Pinsonneault, 2011) or investigate single projects applying the concept (Conforto & Amaral, 2010; Serrador & Pinto, 2015; Sweetman & Conboy, 2018). Also latest literature reviews and studies in the field fault the neglected micro perspectives on the concept as well as the lack of understanding about underlying processes and mechanisms, thus encouraging future studies to address these shortcomings and focus on new units of analysis (Christofi et al., 2021; Dabić et al., 2021).

Second, extant agility research's large share in the information systems field caused that literature primarily investigates the concept in the context of software development (Bianchi et al., 2020; Fitzgerald et al., 2006; Lu & Ramamurthy, 2011; Sheffield & Lemétayer, 2013; Tallon et al., 2019). However, with more and more traditional engineering firms embracing the concept (Cooper, 2016; Cooper & Sommer, 2016, 2018), future research needs to investigate agility's application in physical product development (Conforto et al., 2014). While there are already some notable initial studies addressing this issue, these are solely qualitative or anecdotal by nature (Cooper, 2016; Cooper & Sommer, 2016; Salvato & Laplume, 2020). Particularly, deeper empirical analyses are missing, showing that research has not thoroughly elucidated the concept in this context. Thus, latest research calls for future studies to investigate agility in industries other than the software industry (Conforto et al., 2014; Cooper & Sommer, 2016).

Third, present studies' more prominent perspective on the concept solely addresses agility's outcome view (Bouwman et al., 2018). When analyzing extant research by its conceptualization of agility, it becomes evident that most studies regard the concept solely as increased adaptiveness and responsiveness to changes of any kind, such as changing market conditions, customer requirements, environmental threads, and new technologies (Cai et al., 2019; Kester et al., 2011; Kester et al., 2014; Kock & Gemünden, 2016; Swafford et al., 2006a). Applying this agility conceptualization, these scholarly works analyze how the increased adaptiveness relates to more downstream outcomes such as increased monetary success, customer

satisfaction, etc. (Gligor et al., 2015; Kester et al., 2014; Shuradze et al., 2018; Tallon et al., 2019). While such investigations elucidate how an increased agility influences firm performance, present research fails to thoroughly answer the question of how to become agile in the first place and consequently leverage this increased adaptiveness (Bouwman et al., 2018). However, even though less prominent and not fully elucidated yet, some scarce studies in extant research are nevertheless aware of this capability perspective on agility. For instance, Bouwman et al. (2018) state that "[w]e approach agility from two different perspectives: agility as an outcome, and agility as a way of working in the design or innovation process" (p. 152). Likewise, Cooper and Sommer (2016) refer to agility's capability perspective as *Agile* and consider it a project management approach facilitating increased agility, speed, and adaptiveness in product development. Building on these works addressing agility's dichotomous perception, more research on agility's neglected capability is vital to better understand how to organize to be agile. However, thorough analyses pointing in this direction are missing to date, particularly concerning quantitative studies (Bianchi et al., 2020).

Fourth, research linking agility and the early innovation phases, often referred to as the front end (Eling & Herstatt, 2017), is scarce, except for some notable initial studies, which however also share above addressed flaws of extant agility literature (Brock et al., 2020; Gonzalez, 2014; Hoonsopon & Puriwat, 2019). The front end of innovation involves all activities from an innovation idea's initial generation until its further development's approval (Kim & Wilemon, 2002; Murphy & Kumar, 1997). Due to the front end's role for all subsequent development activities, firms need to increase efficiency and effectiveness in the early innovation phase since it highly contributes to firm's overall success (Brentani & Reid, 2012; Kock et al., 2016; Verworn et al., 2008; Verworn, 2009; Zhang & Doll, 2001). To be successful in the front end relies on generating a large number of innovation ideas, effectively sort out the high potential ones, and then efficiently further process these (Bertels et al., 2011; Ho & Tsai, 2011; Martinsuo & Poskela, 2011; Verworn et al., 2008). Nevertheless, this task is hard to do since compared to the more formal new product development (NPD) process, in the innovation's early stages, market and customer requirements, and potential technologies are unknown or highly volatile. This ambiguity results in ill-defined product concepts which nevertheless need to be evaluated and constantly updated (Brentani & Reid, 2012; Khanagha et al., 2018; Kim & Wilemon, 2002; March, 1991; Murphy & Kumar, 1997; Schoenherr & Wagner, 2016). This increased ambiguity and less information at hand make the front end the ideal setting for agility's application since the concept explicitly addresses uncertainty and complexity in the development process and

facilitates testing many product ideas in short time intervals (Cooper, 2016; Cooper & Sommer, 2016; Gonzalez, 2014; Strode et al., 2011). Thus, it is surprising that, even though agility and the front end are well-researched individually, research linking both fields is scarce, even though agility's advantage for managing the fuzzy front end is quite evident (Gonzalez, 2014).

In summary, due to the lack of agility research in the innovation management field, particularly concerning the front end, along with agility research's strong focus on the firm level, software development, and the concept's outcome perspective, research overlooked the phenomenon of agile R&D units in physical product development. Considering that it is the R&D units who are responsible for bringing innovations to market and thus highly contribute to a firm's overall success (Markham, 2013; Schrauder et al., 2018), extant research's oversight on this practically highly relevant topic is surprising. Of particular interest is those R&D units' agile organization, which makes them adaptive and responsive to change. Their increased responsiveness also favors success in the fuzzy front end, in which agile R&D units initially operate and in which they generate and test first product ideas (Schrauder et al., 2018).

This dissertation thus aims to fill this gap in extant literature and addresses three specific questions regarding agile R&D units' organization (ARDO). In doing so, the present work helps to better understand this phenomenon and addresses crucial shortcomings of extant agility and R&D and innovation management literature, thus further linking both fields.

First, since research by now has totally neglected agilely organized R&D units, it remains unclear what constitutes agile R&D units and their organization. Thus, it is first of all crucial to understand what characteristics and aspects define ARDO to better understand the phenomenon. Moreover, this clarification would allow identifying agilely organized R&D units and conducting further research. Investigating ARDO is an opportunity to introduce agilely organized R&D units to literature and in progress to finally conceptualize agility's neglected capability perspective holistically (Bouwman et al., 2018; Cooper & Sommer, 2016). Some studies already apply such a capability perspective on the concept. However, they often conceptualize or measure agility with only one dimension, e.g., the iterative methods (Mishra et al., 2017; Vijayasarathy & Turk, 2012), or at the most bidimensionally, e.g., autonomy and diversity (Lee & Xia, 2010).

Interestingly, other studies exclusively focus on other aspects such as the customer relationship (Roberts & Grover, 2012) or the Agile Manifesto's principles (Sheffield & Lemétayer, 2013), which corroborates prior research stating that agility is a multifaceted concept (Lee & Xia, 2010; Sarker et al., 2009; Yusuf et al., 1999). However, no study has holistically assessed agility's neglected capability perspective by now (Bianchi et al., 2020). Consequently, thoroughly conceptualizing ARDO would not only for the first time investigate agile R&D units but also thoroughly conceptualize agility's neglected capability perspective, as extant literature calls for (Bianchi et al., 2020). This conceptualization would finally answer the question of which structure, processes, capabilities, and culture to possess to become agile. Following extant agility literature's view that agility is not vacuum-encapsulated (Tallon et al., 2019), it is also essential to consider additional factors that might influence ARDO's and thus agility's capability perspective's existence. Consequently, this dissertation applies a system perspective on ARDO, resulting in the first overall research question of this thesis:

Research Question 1: By taking a holistic view, what constitutes agile R&D units' organization?

Second, being aware of what ARDO constitutes and which aspects further characterize and thus identify agilely organized R&D units, applying such a system perspective would subsequently lead to the questions of what outcomes such an agile organization in R&D holds. If an R&D unit transitions to ARDO, it should affect various factors in their environment, particularly their performance, if agility advocates' claim holds true (Rigby et al., 2016). However, since research by now has totally neglected agile R&D units and their organization, empirical insights on this phenomenon's organizational consequences are lacking. In general, taking a holistic view on the concept also shows that there are various studies relating agility's outcome perspective, i.e., an increased adaptiveness, to performance (Gligor et al., 2015; Kester et al., 2014; Shuradze et al., 2018; Tallon et al., 2019). However, extant agility literature did not thoroughly investigate agility's capability perspective and its relation to performance. Relating ARDO to different performance outcomes and investigating the relationships at hand however would provide a better understanding of the mechanisms at play, i.e., of how agility actually leads to increased performance. Moreover, it would empirically support this dissertation's assumption that several factors constitute agility's capability perspective, which indeed leads to increased adaptiveness and performance, as agility advocates suggest (Cooper & Sommer, 2016, 2018; Rigby et al., 2016). Thus, this dissertation's second overall research question is:

Research Question 2: What are the organizational consequences of agile R&D units' organization?

Third, while focusing on organizational outcomes is vital to show that implementing ARDO pays off, this dissertation keeps with prior work and aims at also investigating ARDO's consequences on the individual (Christofi et al., 2021; Dabić et al., 2021). Particularly, it would be interesting to know how the R&D unit's transition toward an agile organization affects its employees. For example, if agility advocates' claim holds true and the increased performance and enhanced employee welfare go hand in hand, resulting in a win-win situation for both parties (Cooper, 2016; Rigby et al., 2016) or if the increased adaptiveness and performance comes at the employees' expense (McHugh et al., 2011). Reflecting on extant agility literature, it becomes evident that research regarding the concept's influence on the employees applying it is scarce (Christofi et al., 2021; Dabić et al., 2021). Grass et al. (2020) also recognized extant research's strong method focus and noted that the individual's neglect is surprising considering the Agile Manifesto's key statement that individuals and their interactions are more valuable than processes and tools (Beck et al., 2001). Notable exceptions to this neglect are some initial studies that, however, solely focus on agile methods' effects on employees in software development. Moreover, they fail to thoroughly elucidate contingencies of agility's effect on the individual (Benlian, 2021; Gupta et al., 2019; McHugh et al., 2011; Tripp et al., 2016), implicating a necessity for additional studies addressing the human aspects of agility more thoroughly and in new contexts. Thus, investigating ARDO's individual consequences would also help get more insights on how agility affects the individual employees. This dissertation's last overall research question is thus defined as followed:

Research Question 3: What are the individual consequences of agile R&D units' organization?

1.3 Alignment of Dissertation

This chapter clarifies the dissertation's alignment regarding content, applied theories, utilized data, and methods. Subchapter 1.3.1 addresses the dissertation's overall research design manifesting in four research studies and presents each of these studies' content and overall contextual alignment in greater depth. Moreover, subchapter 1.3.2 focuses on the studies'

theoretical foundations while subchapter 1.3.3 presents the studies' empirical and methodological foundations. Figure 1 gives an overview of the dissertation's research studies and their alignment.

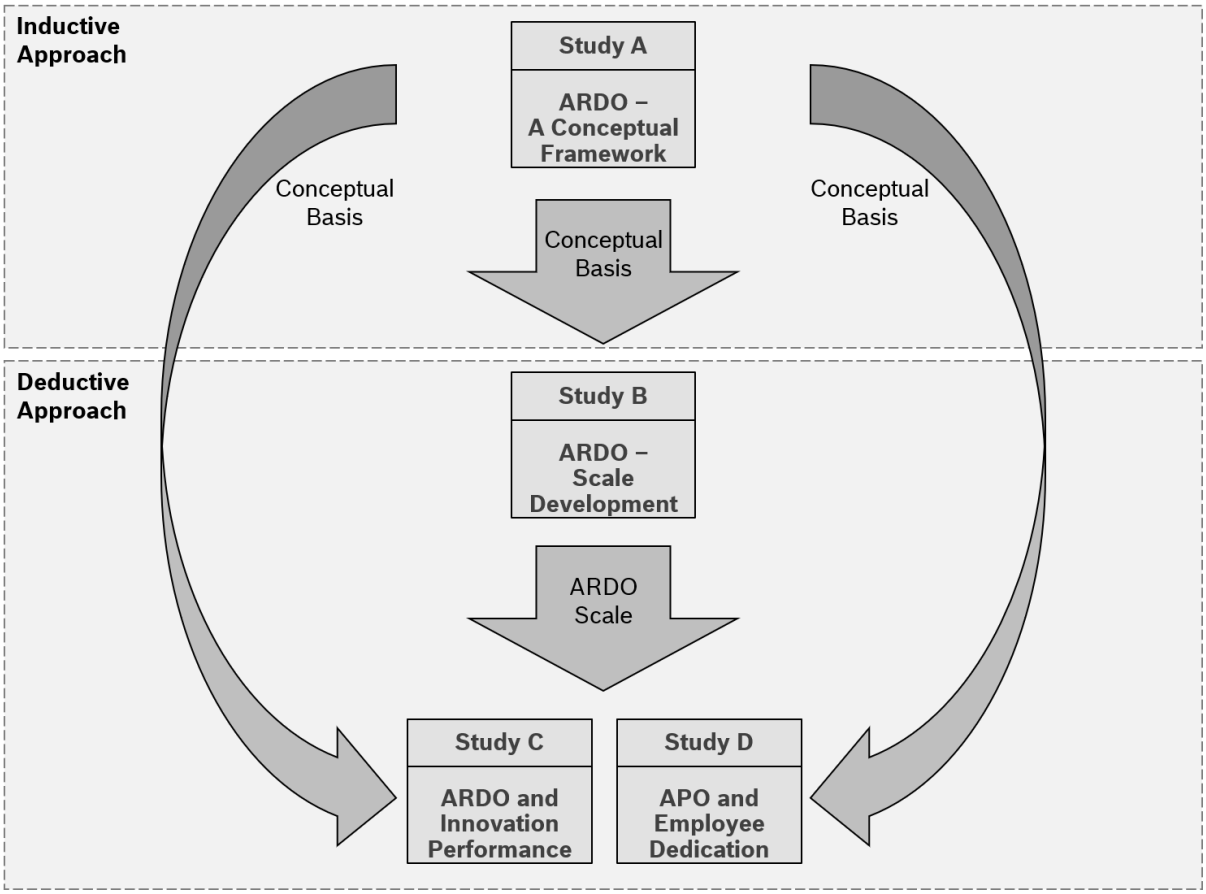

Figure 1: Overview of the dissertation's studies and their alignment

1.3.1 Alignment of Content and Research Studies

The present work combines extant knowledge on agility from different research fields with new empirical findings to provide a holistic view on ARDO and thus explores this organizational form's characteristics and consequences in physical product development. This dissertation applies a four-stage multimethod research design to address the overall research questions derived in Chapter 1.2, considering distinct units of analysis and contingency factors. The overall research design transfers into four separate research studies (see Figure 1). The first study provides a holistic conceptual framework for ARDO. Study B validates a measurement model for ARDO with quantitative data. Study C and D apply study B's novel measure to test

study A's propositions about ARDO's organizational and individual consequences with empirical data. I discuss each study's content and their contextual alignment in more detail in the following. In addition, I present the applied theories, collected data sets, and applied methods, whose analysis and integration into existing literature facilitates various implications for theory and practice.

In an explorative-qualitative interview study, **research study A,** for the first time, investigates agilely organized R&D units and develops a conceptual framework for ARDO. Extant research neglected agility's capability perspective, a specific way of working to become agile (Bouwman et al., 2018; Cooper & Sommer, 2016), thus leaving the question unaddressed of how to organize to reach increased agility in NPD. In addition, research primarily addressed the firm level (Christofi et al., 2021; Gligor et al., 2015; Tallon et al., 2019), thus neglecting the R&D unit level where NPD endeavors are carried out (Schrauder et al., 2018). Extant agility studies also widely focused on software development instead of physical product development (Conforto et al., 2014; Tallon et al., 2019). As a result of these oversights, research left agilely organized R&D units and their organization, which finally provides increased agility, speed, and responsiveness, unstudied. Research study A addresses this shortcoming, aiming to explore ARDO for the first time and provide a better understanding of the phenomenon. More specifically, by applying a system perspective on agility, the study seeks to elucidate ARDO's characteristics, favoring or hindering antecedents, and its consequences.

As a popular theory-building approach to explore phenomena, study A follows an inductive research approach and conducts a qualitative-explorative interview study at a global technology-oriented firm (Gephart, 2004). Twelve semi-structured interviews with agility-advocating R&D managers and agility experts, such as agile coaches and scrum masters, resulted in approximately nine hours of taped interview material which reveals in-depth insights on agilely organized R&D units in practice. Study A relies on the approach of Gioia et al. (2013) to analyze the transcribed interview data, firstly by tagging the informants' relevant statements with keywords. Subsequently, we continuously aggregate these codes to second-order categories and finally to aggregate dimensions, which refer to the highest level of aspects describing a phenomenon (Gioia et al., 2013). For ARDO, these aggregate dimensions are ARDO's characteristics, enablers, barriers, and consequences. As a result of this coding scheme, four Gioia tables, one each for ARDO's characteristics, enablers, barriers, and consequences, evolve. Besides enabling ARDO's holistic conceptualization, each Gioia table's

second-order and the more detailed first-order codes provide additional in-depth insights into each ARDO characteristic, enabler, barrier, and outcome. In addition, the study's results section presents each derived second-order theme in more detail and provides a concluding representative interview quote for each discussed aspect. By finally integrating the interview data into extant literature, inter alia by discussing similarities and differences between extant theory and the interviews' findings, a theoretically and practically validated conceptual framework evolves, allowing a holistic view on the phenomenon of agilely organized R&D units.

The framework elucidates that six dimensions characterize ARDO: a culture based on agile values and failure tolerance, customer integration, an iterative work method, autonomy, cross-functional capabilities, and flat hierarchies. In terms of ARDO's antecedents, top management support, success stories, a servant leadership style, resource availability, employee involvement, and a structured implementation approach seem to favor ARDO. Contrary, internal and external incompatibility, fear of change, classic human resources (HR) systems, the executive staff, and agility's misapplication inhibit R&D units' agile organization. The framework further reveals that ARDO favors these units' NPD success, effectiveness, efficiency, uncertainty reduction, customer satisfaction, and employees' welfare if implemented successfully. Concerning this dissertation, study A for the first time provides a better understanding of the characteristics, antecedents, and consequences of ARDO and thus lays the conceptual foundation for all subsequent studies.

Based on study A's conceptual work, **research study B** empirically validates ARDO's conceptualization as a six-dimensional higher-order construct and develops a multidimensional scale to measure ARDO. Since extant literature by now neglected agilely R&D units and their organization, empirical analyses and the ability to quantify ARDO are lacking. Also in light of the broader agility literature, it becomes evident that scales to measure agility widely follow its outcome perspective: increased adaptiveness and responsiveness to change (Kester et al., 2014; Kock & Gemünden, 2016). Even though initial scales to measure agility's neglected capability exist, these measures are mostly one or two-dimensional (Lee & Xia, 2010; Sheffield & Lemétayer, 2013; Vijayasarathy & Turk, 2012). This narrow conceptualization interferes with extant literature and research article A's perception of agility as a multidimensional construct, which besides iterative working manifests in several additional aspects such as autonomy, cross-functionality, or customer focus (Lee & Xia, 2010; Recker et al., 2017; Sarker et al.,

2009). Consequently, developing a scale to measure ARDO also means the opportunity to measure agility's neglected capability perspective (Bouwman et al., 2018; Cooper & Sommer, 2016). Thus, research article B aims to elucidate ARDO's characteristics empirically and develops a measure to quantify ARDO's dimensions and thus ARDO.

The six ARDO characteristics of study A's analyses are the basis for article B's research objective. The qualitative-explorative study's findings of aspects identifying agile R&D units and what in greater depth describes these six characteristics help create an initial pool of survey items. To assess each ARDO dimension thoroughly, we rely on established scales in literature or, if unavailable, develop several own survey items based on common procedures (Churchill, 1979; DeVellis, 2016). By transferring study A's interview insights on the ARDO dimensions into multi-item Likert scales, we finally make ARDO, represented by these dimensions' overall mean, quantifiable and thus identifiable (DeVellis, 2016; Hinkin, 1995).

Research study B validates the new scale in three separate steps to ensure its content, structural, and nomological validity (DeVellis, 2016; Hinkin, 1995; Worthington & Whittaker, 2006). The empirical data stems from a survey among 175 R&D managers and 454 R&D project employees at a global mechanical engineering firm. Research study A's ARDO framework evolved from interviews with renowned agility experts from practice and an intense engagement with literature, initially ensuring ARDO's practical and theoretical content validity (DeVellis, 2016; Hinkin, 1995; Nunnally & Bernstein, 1994). However, we take three additional content validity measures (Ruvio et al., 2014; Worthington & Whittaker, 2006). First, we separately discuss the item pool with four practitioners of the focal firm and four academics. Second, we extensively pretest the scale with 15 practitioners and hold follow-up interviews with nine of them, thus evaluating potential for improvements, ensuring clarity, and the items contextual fit to the corresponding ARDO dimension (Bianchi et al., 2020; Ruvio et al., 2014; Worthington & Whittaker, 2006).

Subsequently, we ensure the scale's structural validity, that is that the items on the one hand correctly load on the intended ARDO dimension and that on the other hand, these dimensions represent one distinct ARDO characteristic (DeVellis, 2016; Hinkin, 1995; Nunnally & Bernstein, 1994; Schwab, 1980; Worthington & Whittaker, 2006). As suggested by extant literature (DeVellis, 2016; Worthington & Whittaker, 2006), we assess the measure's structural validity by applying exploratory factor analysis (EFA) and confirmatory factor analysis (CFA)

on the R&D managers' and R&D employees' survey data. Both informants evaluated in an online questionnaire to which extent the ARDO dimensions are present in their unit or project. EFA and CFA confirm ARDO's conceptualization as a higher-order six-dimensional construct, even though we need to remove seven of the initial 27 items because of cross-loadings (DeVellis, 2016; Worthington & Whittaker, 2006). For cross-validation, we, in addition to the R&D manager sample, also perform the CFA on the R&D project employees sample, arriving at similar results (DeVellis, 2016; Hornsby et al., 2013). In addition, we assess each dimension's scale reliability by calculating Cronbach's alpha, McDonald's omega, the average variance extracted, and the composite reliability (DeVellis, 2016; Hayes & Coutts, 2020; Trizano-Hermosilla & Alvarado, 2016; Worthington & Whittaker, 2006).

Last, we ensure ARDO's nomological validity by showing that it behaves to theoretically related constructs and outcome variables as proposed (Hinkin, 1998; Hornsby et al., 2013; Moon et al., 2015; Schwab, 1980). As expected, the novel ARDO measure and its dimensions show moderate to high correlations with agility and increased front-end success. We perform the analysis on the R&D manager survey data by calculating the correlation patterns of all variables (Hinkin, 1998; Hornsby et al., 2013).

In sum, we validate the ARDO measure in three separate analyses, ensuring content, structural, and nomological validity and cross validate the new scale on a different hierarchical level. The validated novel measurement model helps empirically assess ARDO and thus facilitates this dissertation's quantitative studies.

Research study C applies the newly developed scale to identify agile R&D units and examine their organization's influence on the units' innovation success. By mainly focusing on agility's outcome perspective, research failed to investigate agilely organized R&D units' performance outcomes and empirically elucidate agility's neglected capability perspective's relationship with innovation success (Kester et al., 2014; Shuradze et al., 2018). Nevertheless, addressing this shortcoming would finally elucidate how to organize to increase responsiveness and success in NPD. In addition, research linking agility and the early innovations phases is mostly conceptual by nature (Brock et al., 2020; Gonzalez, 2014). Thus, the second quantitative analysis of this dissertation investigates how R&D units' agile organization influences innovation performance, particularly front-end and NPD success. Considering both agility perspectives (Bouwman et al., 2018), we hypothesize that ARDO leads to increased agility,

favoring success in the fuzzy front end and NPD success. Moreover, we expect agility's positive effect on front-end success to be even stronger when market and technological turbulence are high.

We test our hypotheses via structural equation modeling with a sample of 162 R&D managers of a global mechanical engineering firm. Confirming our hypotheses, ARDO is positively related to increased agility, which in turn positively relates to front-end success, thus proving prior conceptual work (Gonzalez, 2014). In line with prior research and supporting our mediated model, front-end success also positively relates to NPD success (Markham, 2013; Verworn, 2009). Results also show a direct positive effect of ARDO on front-end success. We further find significant indirect effects of ARDO on front-end success and between agility and NPD success. Concerning moderating effects, agility's positive effect on front-end success increases when market turbulence is high. For technological turbulence, our results do not show similar effects.

This investigation provides a better understanding of the mechanisms at play of how agile R&D units favor performance and the relationships among several performance-relevant outcomes such as increased adaptability, front-end success, and NPD success. In doing so, the study helps explain why, on average and compared to non-agile ones, agile R&D units have higher adaptiveness and success in their innovation activities. Moreover, the study investigates an increased turbulence's role as a contingency factor of agility's positive effect on front-end success. Study C's conceptual basis again stems from study A's propositions, which initially identified front-end and NPD success as ARDO's success factors and suggested that the increased agility provided by ARDO positively influences these outcomes.

While study C's survey data shows ARDO's relationship with performance-related success factors, this dissertation's third quantitative study, **research study D**, applies a more micro-perspective on the concept and investigates an agile project organization's (APO) effect on the project employees' dedication. Extant agility research highly focuses on the concept's performance outcomes (Gligor et al., 2015; Tallon et al., 2019), leaving its influence on the individual widely unexplored (Christofi et al., 2021; Dabić et al., 2021). Moreover, notable initial studies in this direction solely focus on agile methods, the context of software development, and leave agility's interplay with employee dedication unexplored (McHugh et al., 2011; Tripp et al., 2016). This neglect is surprising considering dedication's performance-

relevance (van Scotter & Motowidlo, 1996). Consequently, it remains unclear how a holistic agile project organization influences the project team members' individual dedication. Study D addresses this issue and also reveals this relationship's contingency factors since extant studies on agility's individual consequences widely fail to apply such a contingency perspective (Gupta et al., 2019; Tripp et al., 2016). We hypothesize that APO positively relates to each team member's individual dedication. Moreover, we expect individual perceptions such as clear career paths to positively moderate this relationship while employees' fear of agility mitigates this effect. Regarding contingencies on the project level, we propose that APO's structured implementation approach and employees' involvement further strengthen APO's effect on employee dedication. The same applies to contingency factors on the organizational level, more specifically, the projects' larger organizational unit's clear ideation strategy and entrepreneurial orientation (Anderson et al., 2015).

To test these hypotheses, study D converts the ARDO scale developed in study B from the unit to the project level and applies it to projects running in the R&D units of study C to identify projects with an agile organization. The data stems from 70 R&D projects of a large mechanical engineering firm containing 286 project team members, their project manager, and superior R&D unit manager. The project team members and the project manager assessed their project's agile organization, while the project team members also reported on their dedication, fear of agility, and career paths' clarity in their work environment. The project managers further reported on the approach to implement the agile ways of working in their project and how employees have participated. Finally, the R&D unit managers assessed the larger organizational unit's entrepreneurial orientation and ideation strategy's clarity. We apply random effects regressions with the project as the grouping variable to simultaneously consider these individual, project, and organizational factors.

Results show that, on average, employees in projects with an agile project organization are more dedicated. Moreover, clear career paths, APO's structured implementation approach, employees' involvement, and the larger organizational unit's clear ideation strategy and entrepreneurial orientation strengthen this relationship. Surprisingly, we do not find contingency effects for employees' fear of agility and clear career paths. Nevertheless, the study examines the socio-psychological effects of ARDO on the project level and, in combination with the other studies, elucidate this phenomenon's consequences holistically.

1.3.2 Alignment of Applied Theories

This work builds on dynamic capabilities (Eisenhardt & Martin, 2000; Teece et al., 1997; Teece, 2007; Teece et al., 2016) and self-determination theory (Coccia, 2019b; Gagné & Deci, 2005; Ryan & Deci, 2000) as guiding theories to underline the dissertation's and the corresponding research studies' analysis theoretically.

Following the in-depth literature review by Tallon et al. (2019), dynamic capabilities are among the most applied theoretical lenses on agility and refer to companies' ability to quickly address changes in their environment by integrating, building, and reconfiguring internal and external resources and competences (Teece et al., 1997). Recently, even renowned dynamic capabilities theory scholars recognized and addressed its relatedness with agility (Teece et al., 2016). When discussing the interviews' findings in light of extant literature, study A for the first time addresses the high similarities between the ARDO dimensions and the ways of working that Teece et al. (2016) identify as relevant for dynamic capabilities' sensing, seizing, and transforming dimensions (Teece et al., 1997; Teece, 2007). For instance, Teece et al. (2016) regard iterative working and a strong focus on customers' problems as vital for sensing, which is about hypothesizing market developments, testing these assumptions, and learning about the business constantly. Moreover, autonomy, a corresponding flat organizational structure, and cross-divisional cooperation support sensing and thus to implement proactive actions efficiently (Teece et al., 2016). In addition, the authors stress the need for an open-minded, change-embracing, and failure-tolerating culture, which, along with iterative working's constant prototype delivery, is important for transforming and reconfiguring (Teece et al., 2016). Finally, Teece et al. (2016) regard dynamic capabilities, just like ARDO, as a vehicle for achieving organizational agility, which further strengthens the present work's studies' proposition that also ARDO is a dynamic capability. Figure 2 displays the proposed relationship between ARDO and dynamic capabilities theory.

Study B builds on study A's initial propositions and utilizes dynamic capabilities theory as the theoretical foundation for ARDO's conceptualization and operationalization in the scale development process. The study inter alia discusses each ARDO dimension in terms of dynamic capabilities theory and elucidates in greater depth how it relates to sensing, seizing, and transforming (Teece et al., 2016). Moreover, the study uses dynamic capabilities theory as the theoretical rationale for ARDO's structural and nomological validation (DeVellis, 2016; Hinkin, 1998; Schwab, 1980). On the one hand, it regards ARDO, just like a dynamic capability

with its sensing, seizing, and transforming activities (Teece et al., 1997), as a higher-order latent construct represented by six dimensions and statistically corroborates this assumption. On the other hand, Study B uses Teece et al.'s (2016) recognition that dynamic capabilities, like ARDO, facilitate organizational agility to show ARDO's relatedness with increased adaptiveness empirically. In doing so, we validate the ARDO measure nomologically, i.e., that it behaves to outcome variables as expected (Hinkin, 1998; Hornsby et al., 2013; Schwab, 1980). Similarly, study C transfers the recognitions of Teece et al. (2016) to the context of agile R&D to illustrate its propositions about ARDO's positive effect on several performance outcomes and the relationships among these.

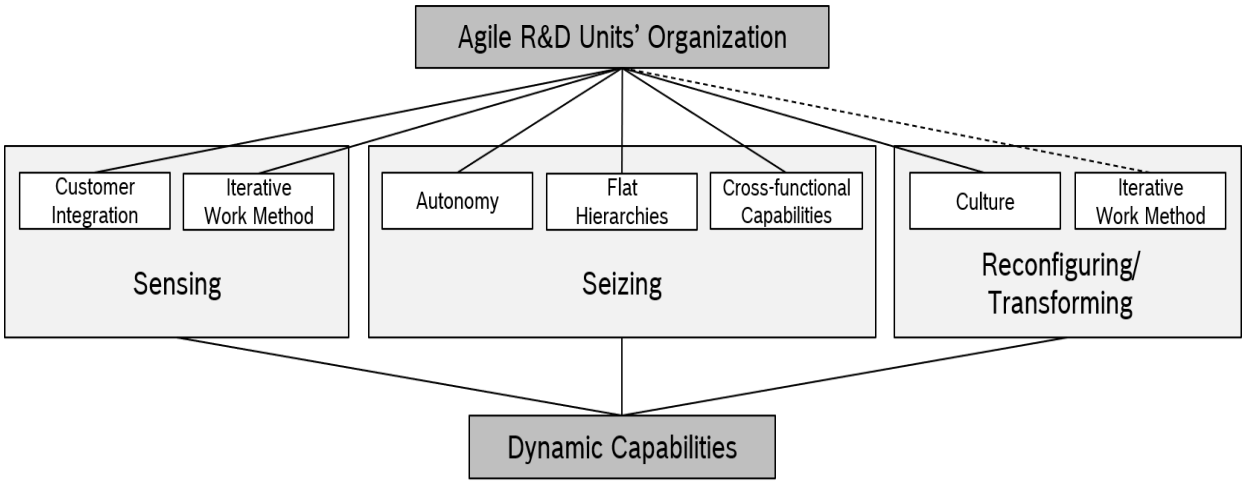

Figure 2: Relationship between agile R&D units' organization and dynamic capabilities (Source: Own figure building on Teece et al. 2016)

In addition to dynamic capabilities theory, study B further relies on self-determination theory (Coccia, 2019b; Gagné & Deci, 2005; Ryan & Deci, 2000) for ARDO's conceptualization. Self-determination theory is a widely used psychological approach to explain individuals' motivation, social development, and well-being (Ryan & Deci, 2000). Research applies the theory to various domains, such as the education and healthcare system, sports, and to explain employees' behavior in organizations (Coccia, 2019b; Gagné & Deci, 2005). According to self-determination theory, employees' intrinsic motivation, personal and social development, and behavioral self-regulation result from the concurrent perception of a feeling of autonomy, relatedness, and competence (Coccia, 2019b; Ryan & Deci, 2000). Self-determination theory thus helps explain employees' and firms' increased performance as well as employees' well-being and individual perceptions (Coccia, 2019a, 2019b; Ryan & Deci, 2000). Consequently,

the theory aligns well with this dissertation's aim to investigate ARDO's performance and individual consequences.

Study B builds on self-determination theory to explain ARDO's autonomy dimension's relevance for an agile organization, employee motivation, and thus ARDO's performance-relevance. Moreover, self-determination theory is a commonly applied theoretical lens in dedication research (Grant, 2008). The threefold concept of autonomy, relatedness, and competence equals lately discovered dedication's antecedents, such as autonomy itself, positive feedback, which is highly related to a feeling of competence, or tasks' perception as being significant, ultimately fostering employees' relatedness with their work (Grant, 2008; Maden-Eyiusta, 2016). Based on this link between self-determination theory and dedication and study B's initial insights, study D relies on self-determination theory as its guiding theory. By inter alia explaining how each APO dimension makes employees feel more autonomous, related, and competent in their daily work, self-determination helps better understand how APO influences employee dedication (Gagné & Deci, 2005). Moreover, study D shows how employees' fear of agility, clear career paths, a structured implementation approach, employees' involvement, strategic clarity, and entrepreneurial orientation do or do not address aspects of self-determination theory's threefold concept (Coccia, 2019b; Gagné & Deci, 2005; Ryan & Deci, 2000) and thus potentially increase or decrease an APO's effect on employee dedication (Salanova et al., 2005; van Scotter & Motowidlo, 1996). Thus, self-determination theory also explicates the boundary conditions of APO's relationship with employee dedication.

In sum, dynamic capabilities and self-determination theory build this dissertation's theoretical rationale and help explain ARDO's conceptualization and consequences. Combined with the applied methods and data presented in the next chapter, the theories thus help answer this work's overall research questions.

1.3.3 Alignment of Used Methods and Data

I collected four different data sets during this dissertation to achieve the set research objectives and enable this dissertation's research design. The first data set includes interview material with 12 agility experts and R&D group leaders of a global technology-oriented company. I collected the data sets two to four via a questionnaire survey among R&D managers, R&D project

managers, and R&D project employees in a large mechanical engineering company. This subchapter presents the data sets and data collection procedures in more detail.

I obtained the interview data set in 2019 via an explorative-qualitative study at a global electronics and engineering company, which possesses technological leadership in various industries. The company generates annual sales revenues of almost 80 billion Euros and employs almost half a million associates in over 60 countries. The firm possesses over 100 engineering locations worldwide and is among practitioners and scholars renowned for its innovativeness and numerous patents throughout its history. The explorative-qualitative investigation comprised twelve semi-structured interviews, all of which I conducted six with R&D managers whose R&D units use agile approaches in their daily innovation activities. In addition, I held another six interviews with renowned agility experts, among others agile coaches, change experts, and organizational development consultants with a specific R&D expertise. This sample composition, which I achieved by considering common practices (Corbin & Strauss, 1990; Glaser & Strauss, 1967; Strauss & Corbin, 1998), guaranteed valuable insights regarding the interplay of R&D and agility. The company in focus possesses a group-like structure and several independent business units operating in various engineering industries such as automotive, factory automation, hydraulics, building technology, or household electronics. Furthermore, study participants belonged to different business units. Therefore, study A gained insights regarding agile R&D units that develop various technologies in diverse markets.

Before data collection, I designed and pretested a structured interview protocol to ensure the question's clarity and avoid biased responses of the interview partners, e.g., through the interview content's ambiguity (Glaser & Strauss, 1967). This clarity was ensured by gaining extensive insights into the company's R&D activities, inter alia via participation in daily stand-ups, sprint plannings, and retrospectives of agilely organized R&D units. Furthermore, I attended several workshops of agile coaches and consultants supporting various business units of every agility level in their transition toward an agile organization. These insights further strengthened the understanding of the company's characteristics in agile work methods. Moreover, I ensured clarity and validity of each interview question via their content's review with experts from academia and practitioners from the focal company (Corbin & Strauss, 1990; Glaser & Strauss, 1967; Strauss & Corbin, 1998). This pretest led to minor adjustments of the questionnaire, a procedure also executed after every conducted interview to constantly specify

the interview content and gain more specific insights on the phenomenon under investigation (Glaser & Strauss, 1967). The applied sampling technique evolved from initial purposeful sampling to snowball sampling, where interviewed experts recommended other possible interview candidates, and concluded with theoretical sampling (Corbin & Strauss, 1990; Glaser & Strauss, 1967; Patton, 1990). The latter refers to a point where sampling continues until the scientific content of the interviews starts to resemble, and no further insights evolve (Strauss & Corbin, 1998). The initial set of informants resulted from a meeting with practitioners from the focal firm proposing the firm's most experienced agility experts. The interviews lasted on average 45 minutes, were taped, and subsequently transcribed following suggestions in extant literature (Eisenhardt & Martin, 2000; Strauss & Corbin, 1998).

Study A analyzes the interview data with the approach of Gioia et al. (2013), which identifies over 100 first-order codes describing relevant interview content. The analysis further clusters the various low-level codes to several ARDO characteristics, antecedents, and outcomes, resulting in a conceptual framework to better understand ARDO (Gioia et al., 2013).

I obtained the three data sets of the quantitative studies in a survey conducted in 2019 among R&D managers, R&D project managers, and R&D project team members of a multinational mechanical engineering company. In the year of the study, the company employed more than 32,000 people in around 80 countries worldwide and generated revenues of ca. 6.2 billion Euros. Investing 5.5% of its annual revenues in R&D, the focal company possesses a strong innovation orientation. The focal company consists of ten business units developing various products in different markets and countries, ensuring sufficient heterogeneity of all three samples. In addition, the level of agile methods' and a corresponding agile work organization's implementation highly varied between the business units. Some business units were early adopters and advanced in their transition from linear product development to an agile work organization. Other business units just initiated such change activities, while others rejected agile methods due to incompatibility with their product portfolio and customers. Holding job titles such as R&D group or department heads, the R&D managers were responsible for all of the unit's front-end activities, which are clearly distinct from the subsequent more formal development activities in the focal firm. The survey explicitly addressed the R&D unit level and innovation's front end. With 175 usable questionnaires, the response rate was 89%, although voluntary participation and without incentives' provision.

Like the R&D managers, I also surveyed the informants at the project level by an online questionnaire. Based on a list of the current project portfolio provided by the company's R&D coordinator, I contacted the project managers of the company's ongoing or recently completed R&D projects. Selecting projects from nine business units operating in various industries and countries ensured the sample's necessary heterogeneity. In addition to assessing their own questionnaire, the project managers received a second e-mail containing an additional survey link for their project team, which they should forward. Out of 123 selected projects, 110 project managers and 485 team members took part in the survey.

For all three informant types, the questionnaires' structure was similar and focused on the work organization, innovation performance, and strategic, cultural, and market conditions of the unit/project. In addition, the R&D project team members also assessed questions about their dedication. Participants were assured of confidentiality and anonymity. Before generating and distributing the questionnaire, I had the opportunity to gain in-depth insights into the R&D units' structures and processes, e.g., via access to internal secondary data or participation in meetings and coaching workshops on an agile work organization. This information, along with constant exchange with the firm's staff, ensured a comprehensive understanding of the R&D units' development activities, work organization, and culture (DeVellis, 2016). The procedure enabled the creation of three high-quality surveys, one for each informant group, which facilitated empirical analyses on ARDO for the first time and thus helped answer this dissertation's research questions.

Study B uses the R&D manager survey data to validate the newly developed ARDO measure and the R&D project employees survey data to cross validate the novel measure on another hierarchy level. Likewise study B, study C applies structural equation modeling on the R&D manager sample to better understand how ARDO affects innovation performance and under which kind of turbulence agility particularly favors front-end success. Finally, study D combines all three quantitative data sets for random effects regressions with the project as the grouping variable to investigate how ARDO on the project level influences employee dedication and how organizational, project, and individual-level factors affect this relationship.

Table 1 summarizes the dissertation's overall structure, alignment, and the research studies' basic information.

Table 1: Overview of this dissertation's research studies

Study	*Title*	*Contributing to Overall Research Question*	*Theory*	*Method*	*Data*
A (Chapter 2)	Characteristics, Antecedents, and Consequences of Agile R&D Units' Organization – A Conceptual Framework	1,2,3	Dynamic Capabilities Theory	Qualitative: Gioia Methodology	Expert Interviews Data (12 Interviews)
B (Chapter 3)	Agile R&D Units' Organization Beyond Software—Developing and Validating a Multidimensional Scale in an Engineering Context	1,2	Dynamic Capabilities Theory & Self-determination Theory	Quantitative: Structural Equation Modeling	R&D Managers Survey Data (175 Observations) & R&D Project Employees Survey Data (454 Observations)
C (Chapter 4)	Agile R&D Units' Organization and its Relationship With Innovation Performance	2	Dynamic Capabilities Theory	Quantitative: Structural Equation Modeling	R&D Managers Survey Data (162 Observations)
D (Chapter 5)	What About the People? Agile Project Organization and Team Member Dedication	3	Self-determination Theory	Quantitative: Random Effects Regressions	R&D Projects Survey Data (70 projects with each project's manager, superior line manager, and in total 286 project team members)

2 Research Study A: Characteristics, Antecedents, and Consequences of Agile R&D Units' Organization – A Conceptual Framework

Abstract:

The information systems and operations management fields have exhaustively investigated the concept of agility. However, innovation management literature has almost neglected the topic, particularly agile R&D units, on which large industrial companies increasingly rely. To investigate this practically relevant but academically under-explored phenomenon's characteristics, antecedents, and consequences, we conducted an explorative-qualitative study with R&D managers and agility experts. Our findings' integration in extant literature provides a holistic framework of agile R&D units' organization (ARDO). The results reveal the complementary capabilities to gain agility and facilitate future empirical investigations, thus advancing scarce research on agility's capability perspective in innovation management.

Classification in terms of this dissertation:

- *Method:* Qualitative: Gioia Methodology
- *Data*: Expert interviews data (12 interviews)
- *Study contributing to overall research question*: 1, 2, 3

Publication and conferences:

Meier, A., & Kock, A. (2021). Characteristics, Antecedents, and Consequences of Agile R&D Units' Organization – A Conceptual Framework. Journal of Competences, Strategy & Management (11), 1–20.

An earlier version of this paper has been presented at the R&D Management Conference 2019, Paris, France, and the 11th SKM Symposium Agile Organisation 2019, Stuttgart, Germany.

3 Research Study B: Agile R&D Units' Organization Beyond Software—Developing and Validating a Multidimensional Scale in an Engineering Context

Abstract:

Previous literature addressed organizations' adaptiveness to ever-changing business environments and investigated the concept of agility. However, extant agility research primarily covers the corporate and project levels and is typically located in the information systems and operations management fields. Relatively little quantitative research in innovation management literature exists, and those studies approached the concept solely from an outcome perspective (i.e., increased adaptiveness) instead of elucidating how organizations should organize themselves to be agile (i.e., a capability perspective). This article addresses these shortcomings and adopts a capability perspective since no empirical studies have examined agile R&D units' organization (ARDO). Drawing on dynamic capabilities theory, we develop a measure of ARDO, conceptualizing it as a second-order construct, consisting of six dimensions: a culture of agile values, customer integration, autonomy, an iterative work method, cross-functional capabilities, and flat hierarchies. We validated the measurement by conducting three studies to ensure content, structural, and nomological validity. We applied structural equation modeling on a sample of 175 R&D managers and cross validated our findings on different hierarchical levels via a sample of 454 R&D employees. The results confirm the second-order nature of the ARDO measure and provide evidence of its positive relationship with front-end success. We advance scarce quantitative research on agility's neglected capability perspective and contribute to the innovation management field by facilitating further empirical research on agile R&D units' antecedents and outcomes in the context of physical product development.

Classification with respect to this dissertation:

- *Method:* Quantitative: Structural equation modeling
- *Data*: R&D managers (n = 175) & R&D project employees (n = 454) survey data
- *Study contributing to overall research question*: 1, 2

Publication and conference:

Meier, A., & Kock, A. (2021). Agile R&D Units' Organization Beyond Software—Developing and Validating a Multidimensional Scale in an Engineering Context. *IEEE Transactions on Engineering Management*. In Press. DOI: 10.1109/TEM.2021.3108343

An earlier version of this paper has been presented at the European Academy of Management 2020 Online Conference, virtual.

4 Research Study C: Agile R&D Units' Organization and its Relationship With Innovation Performance

Abstract:

Research initially investigated agility's effect on innovation performance. However, most studies focus on a corporate or project level, only consider software development, and neglect innovation's front end. Finally, literature approached the concept from an outcome perspective instead of elucidating how to organize to be agile and successful in new product development (NPD). Consequently, research failed to investigate how the organization of agile R&D units in physical NPD affects innovation performance. We apply structural equation modeling on a set of 162 R&D units in a large industrial firm and provide a better understanding regarding the interplay of agile R&D units' organization (ARDO), the resulting agility, front-end success, and NPD success. Moreover, we elucidate contingencies in a turbulent market environment. The study extends research on agility's neglected capability perspective in innovation management, thus providing a better understanding of agility's relationship with innovation performance and showing managers how to increase their unit's NPD success.

Classification with respect to this dissertation:

- *Method:* Quantitative: Structural equation modeling
- *Data*: R&D managers survey data (n = 162)
- *Study contributing to overall research question*: 2

Publication and conference:

Meier, A., & Kock, A. (2022). Agile R&D Units' Organization and its Relationship With Innovation Performance. Under review.

An earlier version of this paper has been presented at the 27th Innovation and Product Development Management Conference 2020, virtual.

4.1 Introduction

As a response to increased volatility and uncertainty in today's markets (Bennett & Lemoine, 2014), agile development approaches are almost state of the art in software development firms (Abrahamsson et al., 2009; Conboy, 2009). Even traditional mechanical engineering firms increasingly integrate agility in their development processes (Cooper & Sommer, 2016; Rigby et al., 2016; Rigby et al., 2018). Consequently, research in the field of information systems (Tallon et al., 2019; Tallon & Pinsonneault, 2011), operations management (Gligor et al., 2015; Vinodh et al., 2012), and project management (Kaufmann et al., 2020; Serrador & Pinto, 2015) investigated agility's outcomes.

Also the innovation management literature started to investigate agility's effect on innovation performance (Kester et al., 2014; Shuradze et al., 2018). However, previous research defined agility solely from an outcome perspective, meaning increased adaptiveness toward threats and changing customer needs, or technologies (Kester et al., 2011; Kock & Gemünden, 2016). Questioning this exclusive focus on the outcome, Bouwman et al. (2018) argue for a capability perspective that sees agility as a specific way of working and investigates how to structure and organize to be agile. Likewise, Cooper and Sommer (2016) acknowledge agility's twofoldness and thus differ between *Agile* as a management approach and the resulting agility and adaptability. Building on this twofold perception of the concept, extant innovation literature provided us with a good understanding of increased adaptiveness' influence on new product development (NPD) success (Kester et al., 2014; Shuradze et al., 2018). In addition, notable initial empirical studies applied the concept's less prominent capability perspective and showed how single agile practices favor innovation success (Bianchi et al., 2020; Kaufmann et al., 2020; Recker et al., 2017). However, since they neglected important aspects of the concepts such as increased autonomy, diversity, cultural traits, or the relationship with the customer (Grass et al., 2020; Lee & Xia, 2010; Lill et al., 2020; Madi et al., 2011; Meier & Kock, 2021a, 2021b; Yusuf et al., 1999), they failed to address agility's multidimensionality, which prior research suggests (Lee & Xia, 2010; Meier & Kock, 2021a; Sarker et al., 2009). In addition, these works strongly focus on software development and the firm level (Bianchi et al., 2020; Recker et al., 2017). Like their outcome-view-based counterparts, these studies are thus liable to neglect the concept's micro perspectives and underlying processes (Christofi et al., 2021; Dabić et al., 2021), thus leaving the question open of how to organize to be agile and successful in product

development. Moreover, they fail to investigate agility in new contexts, such as physical product development (Conforto et al., 2014; Cooper & Sommer, 2016).

Recently, Meier and Kock (2021a) recognized these shortcomings and operationalized agility's neglected capability perspective, which they refer to as agile R&D units' organization (ARDO). ARDO encompasses structure, processes, and cultural traits relevant to agility (the capability) that also relate to increased agility (the outcome) (Meier & Kock, 2021a). However, although ARDO's consequences for innovation success have been proposed based on qualitative work (Meier & Kock, 2021b), empirical evidence for these propositions is missing. A comprehensive analysis of ARDO's relationship with NPD success, including potential contingencies, would (1) more thoroughly elucidate ARDO's consequences, (2) show the mediating mechanisms at play of how ARDO affects NPD success, (3) thoroughly elucidate agility's relationship with innovation performance by combining capability and outcome perspective and showing how to be both adaptive and successful in NPD.

We are not aware of any study that has thoroughly quantitatively investigated ARDO's relationship with innovation performance, particularly its interplay with front-end and NPD success. Our study addresses these shortcomings and sets out to provide a broader understanding regarding the interplay of agility's neglected capability perspective, i.e., ARDO, and eventual innovation success. Thus, we formulate our study's research question:

How does agile R&D units' organization (ARDO) relate to innovation performance, specifically front-end and NPD success?

We conceptualize ARDO as a dynamic capability with six dimensions: (1) a culture based on agile values, (2) customer integration, (3) autonomy, (4) iterative working, (5) cross-functional collaborations, and (6) flat hierarchies (Meier & Kock, 2021a). Dynamic capabilities describe "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece et al., 1997, p. 516). Following Teece et al. (2016), dynamic capabilities foster organizational agility and enable firms to constantly adapt and innovate in uncertain environments. We argue that ARDO is such a capability and rely on dynamic capabilities to explain its relationship with innovation success (Meier & Kock, 2021a, 2021b; Teece et al., 2016). Our framework combines agility's capability and outcome perspectives (Bouwman et al., 2018; Meier & Kock, 2021a, 2021b) and considers contingency

effects (Busse et al., 2017; Sousa & Voss, 2008) because agility might be more beneficial in turbulent environments (Gonzalez, 2014; Poskela & Martinsuo, 2009). Following prior conceptual work (Meier & Kock, 2021b), we hypothesize that ARDO increases an R&D unit's agility, front-end success, and NPD performance. We validate these hypotheses on a sample of 162 R&D units of a global mechanical engineering firm.

This study contributes to agility, innovation management, and organizational theory literature. First, we empirically demonstrate agile R&D units' organization's performance outcomes, such as NPD success, thus showing how ARDO affects innovation performance and illustrating its relevance for physical NPD in practice. In doing so, our study empirically complements prior conceptual work (Meier & Kock, 2021b) and follows the call to approach agility in new contexts and from new perspectives (Meier & Kock, 2021a, 2021b). In doing so, this study contributes to agility literature by also counteracting extant research's firm-level (Gligor et al., 2015; Tallon & Pinsonneault, 2011), software development (Conboy, 2009; Tallon et al., 2019), and outcome focus (Bouwman et al., 2018).

More importantly, our results comprehensively elucidate agility's relationship with innovation performance by integrating agility's capability perspective (ARDO), its outcome view (increased adaptiveness), and front-end and NPD success in one analysis. We thus advance prior work on adaptiveness's relationship with NPD success (Kester et al., 2014; Shuradze et al., 2018) by elucidating how to become responsive in NPD via ARDO and by clarifying that agility's positive effect on NPD success results from an increased front-end performance. Moreover, our study contributes to the discussion on how to successfully manage innovation's front end (Jörgensen et al., 2011; Kock et al., 2015; Schrauder et al., 2018; Schweitzer & Gabriel, 2012). Specifically, we empirically link agility's capability and outcome perspective to front-end effectiveness and efficiency. Thus, we explore new antecedents to front-end success, complementing prior conceptual work (Gonzalez, 2014) and scarce research linking agility and the front end of innovation (Brock et al., 2020). Overall, our study's findings introduce ARDO as a new means for superior innovation performance (Liu et al., 2015; Markham, 2013; Patanakul et al., 2012; Sivasubramaniam et al., 2012), further linking agility research and innovation management (Kester et al., 2011; Kester et al., 2014; Kock & Gemünden, 2016).

Finally, this study contributes to contingency research in both fields (Ashrafi et al., 2019; Kock et al., 2016; Najafi Tavani et al., 2013). We investigate market and technology turbulence as potential boundary conditions of the relationship between agility and front-end success and demonstrate that ARDO is more beneficial in turbulent environments, thus proving prior conceptual work (Gonzalez, 2014; Meier & Kock, 2021b). Thus, the study also contributes to dynamic capabilities theory, providing empirical evidence that ARDO is a dynamic capability (Meier & Kock, 2021a, 2021b; Teece et al., 1997; Teece et al., 2016).

4.2 Theoretical Framework

4.2.1 The six Dimensions of Agile R&D Units' Organization

Investigating ARDO's relationship with innovation performance requires a comprehensive conceptualization of the construct. Following Meier and Kock (2021a, 2021b), we define ARDO as a second-order construct capturing an R&D unit's culture, structure, as well as processes along the six dimensions (1) culture, (2) customer integration, (3) autonomy, (4) iterative work method, (5) cross-functional capabilities and (6) flat hierarchies. We now present these dimensions in more detail.

The culture of agilely organized R&D units reflects the often-described agile values, including a high personal commitment, the sole focus on the set goals, and openness regarding tasks and project status. In addition, mutual respect, courage, and failure tolerance are crucial cultural elements (Madi et al., 2011; Meier & Kock, 2021a, 2021b). ARDO also implies a pronounced customer integration (Meier & Kock, 2021a, 2021b) as satisfying the customer is one of agility's primary objectives (Gunasekaran, 1998). Moreover, ARDO entails increased autonomy, ensuring allocating the needed resources and encouraging trial- and error experimentation (Meier & Kock, 2021a, 2021b; Zhang & Bartol, 2010). Autonomy also ensures that the appropriate employees make decisions and change-responding measures quickly (Meier & Kock, 2021b; Yusuf et al., 1999). In addition, ARDO is characterized by flat hierarchies, referring to drastically reduced hierarchical layers in the R&D units (Meier & Kock, 2021a, 2021b), which contribute to faster decision making (Sweetman & Conboy, 2018). ARDO's work method is iterative and feedback-driven in sprints. Every iteration suggests the

delivery of a product increment to present to the customer (Meier & Kock, 2021a, 2021b). In addition, the iterative approaches allow constantly adjusting the objectives and continuous learning (Cooper & Sommer, 2016, 2018; Meier & Kock, 2021b; Rigby et al., 2016). Cross-functionality is also a relevant dimension of agility and ARDO (Meier & Kock, 2021a, 2021b; Yusuf et al., 1999), as it contributes to shorter development cycles (Bunduchi, 2009; Stettina & Hörz, 2015). Members of agilely organized R&D units possess in-depth expertise in a specific field and widespread general understanding in related areas (Meier & Kock, 2021a, 2021b), a characteristic often referred to as T-Shapedness (Hansen, 2001).

4.2.2 The Front End of Innovation

The front end is the early phase of the innovation process and comprises all activities before the actual NPD process (Koen et al., 2001). It is, therefore, the innovation phase from an idea's creation until its further development's approval (Kim & Wilemon, 2002; Murphy & Kumar, 1997). Key front-end activities are idea generation and evaluation, product concept generation and an innovation project's initial planning (Brentani & Reid, 2012; Haase & Laursen, 2018; Khurana & Rosenthal, 1998). The front end is a major determinant of a firm's innovation performance and overall success (Bacon et al., 1994; Verworn, 2009; Zhang & Doll, 2001). Front-end activities are challenging because firms must constantly generate innovative but marketable ideas (Martinsuo & Poskela, 2011). At the same time, they need to perform idea generation, evaluation, and concept generation efficiently and quickly (Ho & Tsai, 2011; Verworn et al., 2008). Consequently, front-end success is often conceptualized by effectiveness and efficiency (Ho & Tsai, 2011; Kock et al., 2015). Front-end effectiveness assesses the ideas and implementable concept studies of an R&D unit in terms of quantity and quality (Ho & Tsai, 2011; Kock et al., 2015). Front-end efficiency depicts the speed of screening ideas and translating these into concepts while also considering the costs of these processes (Kock et al., 2015).

This early innovation stage is often vaguely defined, and decisions are made in an ad-hoc manner without clear objectives (Kim & Wilemon, 2002; Murphy & Kumar, 1997; Schoenherr & Wagner, 2016). The explorative nature paired with less formality than in the subsequent NPD process increases uncertainty (Khanagha et al., 2018; March, 1991). Therefore, an agile

organization of the R&D units and the resulting agility might be particularly relevant in the front end (Gonzalez, 2014; Meier & Kock, 2021a, 2021b).

4.2.3 Agility and Innovation Performance

Companies face the constant challenge of introducing more and more innovative products in even shorter intervals (Saviotti & Pyka, 2004; Teece et al., 1997). In addition, complexity and uncertainty increasingly characterize the modern business environment (Bennett & Lemoine, 2014). Consequently, firms introduce agile methods in their innovation processes to deal with these challenges (Beaumont et al., 2017; Cooper & Sommer, 2016; Rigby et al., 2016; Rigby et al., 2018). Compared to research investigating agility in the fields of information systems (Tallon et al., 2019) or operations management (Gligor et al., 2015; Poskela & Martinsuo, 2009), studies linking agility and performance in the innovation management literature are scarce and mostly conceptual or qualitative (Cooper, 2016; Gonzalez, 2014). For example, Cooper and Sommer (2016, 2018) found that combining agile methods with traditional development approaches in an industrial setting leads to increased productivity in NPD. Also in the early stages of the innovation process, agile project management has been proposed to contribute to increased effectiveness and efficiency (Gonzalez, 2014).

Besides this qualitative work, the study of Shuradze et al. (2018) provides empirical evidence for the positive relationship between organizational agility and innovation performance. They find that organizational agility mediates the relationship between data analytic capabilities and a firm's explorative and exploitive innovation endeavors (Shuradze et al., 2018). Portfolio agility positively related to the strategic alignment, maximal value and balance of the innovation portfolio, and consequently to the firm's NPD success (Cooper et al., 1999, 2000; Kester et al., 2014).

However, these studies have only considered agility's outcome perspective (i.e., increased adaptiveness), showing that adaptiveness positively relates to innovation success (Kester et al., 2014; Shuradze et al., 2018). Contrary, research from a capability perspective—focusing on how to attain adaptiveness (Bouwman et al., 2018)—is lacking, despite some notable attempts that, however, fail to address agility's multidimensionality, which prior research shows (Lee & Xia, 2010; Meier & Kock, 2021a, 2021b; Sarker et al., 2009). For instance, Recker et al. (2017)

showed how single agile practices affect customer responsiveness and development success, while Bianchi et al. (2020) investigated how agile methods' alignment with more traditional stage-gate approaches affect development performance. However, Meier and Kock (2021a, 2021b) note that agility's capability perspective means more than just agile methods' artefacts and that research should adopt a lower level of analysis, as opposed to the current literature's strong focus on the corporate level (Christofi et al., 2021). The authors conducted an explorative-qualitative study to thoroughly conceptualize agility's neglected capability perspective in the context of physical product development, which they refer to as agile R&D units' organization (ARDO) (Meier & Kock, 2021b) and developed a measure to assess ARDO (Meier & Kock, 2021a). The current study builds on this foundation to investigate if ARDO favors innovation performance and thoroughly elucidate how agility affects innovation performance.

4.3 Hypotheses

4.3.1 Overview

Figure 8 presents our study's research framework and hypotheses. Overall, we hypothesize that ARDO positively relates to NPD success, mediated by agility and front-end success. In addition, we expect that market and technology turbulence positively moderate the relationship between agility and front-end success. We now argue for the hypotheses in more detail.

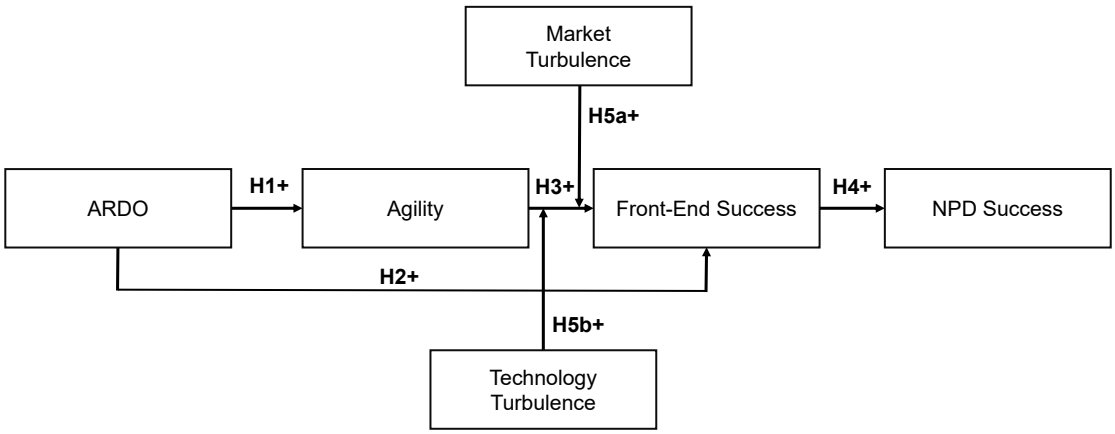

Figure 8: Framework (Research study C)

4.3.2 Agile R&D Units' Organization and Agility

To comprehensively elucidate agility's relationship with innovation performance, we integrate both agility perspectives in our framework (Bouwman et al., 2018). In our framework, ARDO represents agility's capability perspective, while agility itself refers to an R&D unit's increased adaptability and change-resilience, the outcome perspective (Meier & Kock, 2021a). Following Teece et al. (2016) that dynamic capabilities enable agility, we follow prior work suggesting that also ARDO is such a capability since several ARDO dimensions contribute to sensing, seizing, and transforming and consequently to agility (Meier & Kock, 2021a, 2021b).

For instance, the increased autonomy enables R&D units to make faster decisions and take the necessary change-responding actions more quickly (Meier & Kock, 2021a, 2021b; Yusuf et al., 1999). Flat hierarchical structures contribute to shorter information paths and decision making on the appropriate hierarchical level (Meier & Kock, 2021a, 2021b; Sweetman & Conboy, 2018). However, when provided with decision-making opportunities, individuals must possess the courage, commitment, and failure tolerance to do so (Teece et al., 2016). ARDO provides such a culture and, consequently, employees in agile R&D units are confident to make appropriate decisions more quickly (Meier & Kock, 2021a, 2021b), resulting in overall increased agility (Kester et al., 2011; Kock & Gemünden, 2016). The cross-functional capabilities further contribute to increased agility since all unit members possess in-depth knowledge in their field of expertise, paired with wide-range knowledge in other fields (Meier & Kock, 2021a, 2021b), often referred to as T-shapedness (Hansen, 2001). Thus, the unit members can replace each other functionally and keep the unit operational and agile in the event of environmental turbulences and unforeseen challenges (Hansen, 2001; Meier & Kock, 2021a, 2021b; Yusuf et al., 1999). Cross-functionality also favors holistic thinking, resulting in earlier threat detection and better task prioritization (Bunduchi, 2009; Schweitzer & Gabriel, 2012). Moreover, working in sprints enables R&D units to adapt their objectives and actions almost weekly, enabling them to react to changes in the market environment faster (Meier & Kock, 2021b). In addition, retrospectives and sprint reviews reflect on every sprint, which facilitates learning from failures and reacting to challenging situations in the future (Cooper & Sommer, 2016, 2018; Meier & Kock, 2021b; Rigby et al., 2016). A strong customer integration increases customer understanding and anticipation of future needs and requests (Lu & Ramamurthy, 2011; Meier & Kock, 2021b; Sambamurthy et al., 2003). In sum, since every dimension of ARDO provides various benefits for the R&D unit's agility, the collective construct should

have a positive significant effect on agility (Meier & Kock, 2021a, 2021b). Consequently, we formulate our first hypothesis as follows:

Hypothesis 1: ARDO positively relates to an R&D units' agility.

4.3.3 Agile R&D Units' Organization and Front-end Success

Following Teece et al. (2016) and Meier and Kock (2021a), we propose that ARDO enables units to sense and seize market opportunities and transform these into value-offering products. ARDO's high degree of autonomy (Meier & Kock, 2021a, 2021b) encourages employees to be creative and provides them with the necessary freedom to innovate (Zhang & Bartol, 2010). ARDO further allows the employees, who are at the heart of the problem, to address issues with their own approach, instead of being simply told by management, limiting the range of solutions (Atuahene-Gima, 2003). To be successful in the front end, a climate of psychological safety and support for new ideas is needed (Bertels et al., 2011). ARDO's increased open-mindedness, the courage and commitment to try out new ideas, as well as a failure resilience favoring experimentation provide such a supportive climate to succeed in the fuzzy front end (Meier & Kock, 2021a, 2021b), which also relies on generating numerous creative ideas (Kim & Wilemon, 2002; Nienaber et al., 2015). In addition, cross-functionality, as also present in agile R&D units (Meier & Kock, 2021a, 2021b), has been associated with increased creativity (Bunduchi, 2009) and is a promising way to manage the fuzzy front end successfully (Jörgensen et al., 2011; Schweitzer & Gabriel, 2012). The early integration of other functions and departments also leads to a better evaluation and prioritization of the generated ideas and concepts (Kester et al., 2011). Moreover, the iterative approach allows the R&D units to try out many potential product ideas, as they can quickly test and adapt concepts (Meier & Kock, 2021a, 2021b). Iteration enables a constant evaluation if the project is on the right track (Vaculík et al., 2018) and favors increased front-end success (Gonzalez, 2014), because dismissing or changing a concept in late project phases is associated with high costs (Thomke, 1998). The thus facilitated projects' early termination and the continuous learning through sprint-reviews also preserves valuable resources and detects waste (Meier & Kock, 2021b; Vaculík et al., 2018). In line with prior research, which has shown that customer orientation helps reduce uncertainty in the front end (Schweitzer & Gabriel, 2012), we further argue that the close customer proximity enables R&D units to develop exactly those product concepts that

the customer requires instead of concepts with irrelevant features (Meier & Kock, 2021b). Since the front end's resources are constrained (Ho & Tsai, 2011; Verworn, 2009), such customer orientation increases a unit's efficiency and overall success (Meier & Kock, 2021b). A unit's flat hierarchies further support efficiency because they facilitate resource allocation and processing of ideas to concept studies (Ho & Tsai, 2011; Meier & Kock, 2021b; Verworn et al., 2008):

Hypothesis 2: ARDO positively relates to front-end success.

4.3.4 Agility and Front-end Success

Agility means that R&D units more quickly recognize and respond to changes in their environment, such as technological challenges, new customer needs or market opportunities (Kester et al., 2014; Kock & Gemünden, 2016; Meier & Kock, 2021a, 2021b). This positively influences their front-end performance as the main objective in the front end is to generate and pursue those ideas with the highest market potential (Bertels et al., 2011; Markham, 2013). Agility allows quickly unlocking new market potential instead of merely reacting to changes in the market with a time lag (Kester et al., 2011; Kester et al., 2014). Even in established markets, agility enables R&D units to respond to customer requests or threats in a faster way (Meier & Kock, 2021b). An R&D units' agility also affects its internal processes and daily work routines (Meier & Kock, 2021b). Since agility implies a flexibility and speed component, it ensures the needed resources' quick allocation and further allows the generated concept s' quick adaption (Kester et al., 2011; Kester et al., 2014). Due to the increased responsiveness, the unit's development results can remain open-ended until the late stages of the project (Meier & Kock, 2021b). The speed obtained by agility also makes the generated ideas progress more quickly for further development (Börjesson et al., 2006; Gonzalez, 2014). In addition, Kester et al. (2014) and Vaculík et al. (2018) stress that agility also enables the termination of unsuitable projects in the firms' innovation portfolio. Concluding, we argue:

Hypothesis 3: Agility positively relates to front-end success.

4.3.5 Front-end Success and NPD success

Following Brown and Eisenhardt (1995), product development is a problem-solving process in which measuring process performance is vital. However, in addition to the NPD process itself, NPD performance also relies on the quality of the ideas generated and refined in the front end (Markham, 2013). A strong performance in the front end is key since the decisions made in this phase are the basis for all subsequent development processes, and mistakes are either costly or irreversible (Khurana & Rosenthal, 1998; Thomke, 1998). Primarily, the creation of a marketable idea takes place in the front end, which is necessary for any subsequent development process (Brentani & Reid, 2012; Khurana & Rosenthal, 1998; Koen et al., 2001). However, front-end tasks such as idea evaluation and the formulation of value-offering project proposals are also vital for NPD success (Markham, 2013). In addition, also the first executive reviews are conducted (Khurana & Rosenthal, 1998). Therefore, we suggest that these front-end tasks' strong execution by the R&D units increases respective units' NPD performance (Kock et al., 2016). Overall, we argue that ARDO increases the agility and consequently the front-end success of an R&D unit, favoring the unit's overall NPD success (Meier & Kock, 2021b). Thus, in line with prior findings (Markham, 2013; Verworn, 2009) and to complete our overall framework elucidating agility's interplay with innovation performance, we state:

Hypothesis 4: Front-end success positively relates to NPD success.

4.3.6 The Moderating Influence of Market and Technology Turbulence

While environmental turbulence is generally a vital contextual factor for performance (Kohli & Jaworski, 1990), this specifically refers to NPD (Calantone et al., 2003) and its front end (Kock et al., 2015; Poskela & Martinsuo, 2009). In turbulent market environments, the scope of development projects is often vaguely defined and constantly changing, and ambiguity complicates decision making (Kock & Gemünden, 2016; Zhang & Doll, 2001). Such an environment characterized by turbulence and uncertainty calls for increased agility (Clauss et al., 2019; Dess & Beard, 1984). Hence, we suggest that while agility alone is favorable for front-end success, this relationship becomes stronger when market and technology turbulences are high. The speed and flexibility that agility implies (Kester et al., 2011; Kester et al., 2014) support agile R&D units coping with changing market situations, customer demands or technological changes in their front-end activities (Meier & Kock, 2021b). In addition, agility

favors quickly incorporating new technologies into products as well as terminating obsolete projects, which is particularly relevant in environments where the technologies are constantly changing and hard to predict (Kester et al., 2011; Kester et al., 2014). The increased agility enables R&D units to react to these changes by considering new technological developments in their front-end activities (Meier & Kock, 2021b). Therefore, we argue that especially under changing market and technological conditions, agile R&D units can adjust their front-end activities accordingly, resulting in higher success:

Hypothesis 5a: Agility and market turbulence interact to predict front-end success, such that agility results in a higher front-end success when market turbulence is high.

Hypothesis 5b: Agility and technology turbulence interact to predict front-end success, such that agility results in a higher front-end success when technology turbulence is high.

4.4 Methodology

4.4.1 Data Collection and Sample

The data were obtained via a survey among R&D managers in a large industrial firm. The focal company has a reputation for being innovative and invests 5.5% of its revenues in R&D (almost twice the industry average). In total, 178 R&D unit leaders participated in the survey (89% response rate). The informants possessed job titles such as R&D group/unit leader or product manager and had responsibility regarding all front-end activities and NPD tasks of their unit. Eliminating cases with missing values left 162 useable observations. 9 % of the surveyed R&D managers were in their positions for less than one year, 33% between 1 and 3 years, 25% between 4 and 7 and 18% between 8 to 12 years. 15% of the R&D unit leaders were in their position for more than 12 years.

4.4.2 Measures

The constructs' measures stem from existing scales in the literature when available. We changed the item wording to better fit the survey context in some cases. Informants assessed all

items on a Likert-type scale (DeVellis, 2016; Hair et al., 2013) ranging from 1 ("does not apply at all") to 7 ("applies completely"). Only the culture used different anchors (from "not at all" to "to a large extent") because it assessed the extent to which employees shared the agile values.

Dependent variable. We measured an R&D unit's NPD success with three items reflecting the dimensions revenue and market share, profitability, and the NPD projects' market launch timing (Calantone et al., 2003; Salomo et al., 2007).

Mediators. Agility describes a unit's ability to respond and adapt to changing conditions (Kock & Gemünden, 2016; Meier & Kock, 2021a, 2021b) and was measured via three items taken from Kock and Gemünden (2016). We operationalized front-end success as a second-order construct using the two dimensions effectiveness and efficiency (Kock et al., 2015; Schrauder et al., 2018). Front-end effectiveness used five items reflecting the development portfolio's balance and the unit's ability to create a competitive advantage, to identify high market potential, and to secure future economic success via their predevelopment activities (Bertels et al., 2011; Ernst & Kohn, 2007; Ho & Tsai, 2011; Kock et al., 2015; Verworn et al., 2008). Front-end efficiency used three items based on Kock et al. (2015) and Ho and Tsai (2011).

Independent Variable. We relied on Meier and Kock's (2021a) developed original ARDO scale to measure the independent variable. ARDO is a second-order construct with the six first-order dimensions culture, customer integration, work method, cross-functional capabilities, and flat hierarchies. We measured every dimension with three items, except for culture, which used five items (Meier & Kock, 2021a).

Moderators. Market and technology turbulence refer to the extent and frequency of customer and technology-induced changes in the R&D unit's environment (Sethi & Iqbal, 2008). We operationalized both dimensions with three items from Sethi and Iqbal (2008).

Control Variables. We also account for other variables that might affect R&D units' agility, front-end success, or NPD success. First, we controlled for the size of the R&D unit measured as the number of unit members. Second, we accounted for the R&D unit's business unit affiliation. Third, we controlled for a unit's ideation strategy since it was found to be positively related to front-end success (Kock et al., 2015; Schrauder et al., 2018) and innovation success (Zhou et al., 2005). Ideation strategy refers to the extent to which an R&D unit's front-end

activities are supported by an overall framework, more specifically by clearly communicated search fields in which innovations are needed (Kock et al., 2015; Schrauder et al., 2018). Table 8 provides the descriptive statistics and correlations of all variables used in our study.

Table 8: Correlations (Research study C)

	Variables	M	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	NPD success	4.55	.99	1										
(2)	Agility	4.72	1.15	.16	1									
(3)	Front-end success	3.94	1.13	.28	.51	1								
(4)	Agile R&D units' organization	5.40	.64	.32	.49	.48	1							
(5)	Market turbulence	3.76	1.20	.01	-.04	-.02	.02	1						
(6)	Technological turbulence	3.34	1.15	.11	.34	.22	.24	.28	1					
(7)	Group size	15.19	23.18	-.08	-.14	.00	-.10	-.03	-.04	1				
(8)	Business Unit 1	.40	.49	-.05	-.06	-.06	-.03	-.10	.15	-.04	1			
(9)	Business Unit 2	.36	.48	.09	.01	-.08	-.00	.13	-.25	.10	-.60	1		
(10)	Business Unit 3	.21	.41	-.04	-.04	.11	-.07	.00	-.06	-.07	-.42	-.38	1	
(11)	Business Unit 4	.04	.19	-.01	.23	.12	.23	-.06	.36	.02	-.16	-.15	-.10	1
(12)	Ideation strategy	4.18	1.68	.05	.29	.47	.37	-.07	.15	.08	-.04	-.06	.06	.12

n = 162, M = mean, SD = standard deviation, all correlations above .16 are significant at the 5%-level.

Measurement Assessment. Principal component factor analysis (PCFA) revealed that all items loaded on the intended higher order construct. Results of the subsequent confirmatory factor analysis (CFA) showed that all standardized loadings exceeded the recommended cut-off value of .50 (DeVellis, 2016; Hair et al., 2013; Hinkin, 1995). In addition, we followed the criteria of Fornell and Larcker (1981) suggesting that Cronbach's alpha as well as composite reliability (CR) for each scale should be above the cut-off value of .70, while the average variance extracted (AVE) should exceed the cut-off value of .50. According to Hu and Bentler (1998), the overall measurement model containing all first-order as well as second-order constructs indicated an acceptable fit to data ($\chi2$ (716) = 1018.95; CFI = .901; RMSEA = .051; SRMR = .078). We also conducted Harman's single-factor test, as it is arguable that our results might be liable to common method variance. The one-factor CFA indicated an extremely poor fit ($\chi2$

(740) = 2601.04; CFI = .394; RMSEA = .125; SRMR = .119), suggesting a low threat of common method bias (Jarvis et al., 2003).

4.5 Results

4.5.1 Main Effects

We tested our research framework using structural equation modeling in STATA. Our analysis examines the interplay of two second-order constructs (ARDO, front-end success) and the four first-order constructs agility, NPD success, market and technology turbulence. Hence, we transformed the second-order constructs ARDO and front-end success to first-order constructs by calculating the means to their indicators and treating these values as indicators for the prior second-order constructs. This is a common procedure to reduce the complexity in research models containing second-order and first-order constructs (Hoegl & Gemuenden, 2001; Schrauder et al., 2018). The basic model with control variables but without interaction terms fits the data quite well ($\chi 2$ (121) = 183.43; CFI = .918; RMSEA = .056; SRMR = .062).

Figure 9 shows the results. Supporting H1, ARDO was positively related to agility (path coefficient γ = .53, p = .000). In line with H2, ARDO also positively related to front-end success (γ = .25, p = .021). The model also shows a positive relationship between agility and front-end success (γ = .46, p = .000), supporting H3. H4 suggested that front-end success contributes to NPD success, which our analysis also supports (γ = .64, p = .000). We found significant indirect effects between ARDO and front-end success (γ = .44, p = .001), and between agility on NPD success (γ = .27, p = .009). ARDO's indirect effect on NPD success was weakly significant (γ = .32, p = .077). Overall, the results support our model's premise that agility and front-end success mediate ARDO's relationship with NPD success. Regarding the control variables, we did not find a significant influence of group size or business unit affiliation. However, ideation strategy positively related to front-end success. We also ran a model without controls, coming to similar results.

4.5.2 Moderating Effects

To test Hypotheses 5a and b, we estimated a separate model including latent interactions following common procedures (Marsh et al., 2004). The resulting interaction terms were added to the basic SEM. The model testing the moderation effects of market turbulence showed an acceptable fit to data ($\chi 2$ (227) =318.31; CFI = .913; RMSEA = .050; SRMR = .064). The included direct effects of market turbulence were not significant, but the interaction term of market turbulence and agility was significantly related to front-end success (γ = .20, p = .033), supporting H5a. This finding suggests that the effect of agility on front-end success is stronger for increased turbulence in the R&D unit's market environment. We conducted the same procedure regarding the moderation effects of technological turbulence and this model also had a good fit ($\chi 2$ (227) =312.75; CFI = .916; RMSEA = .048; SRMR = .064). However, the interaction term with agility was not significantly related to front-end success. Therefore, we cannot support hypothesis 5b.

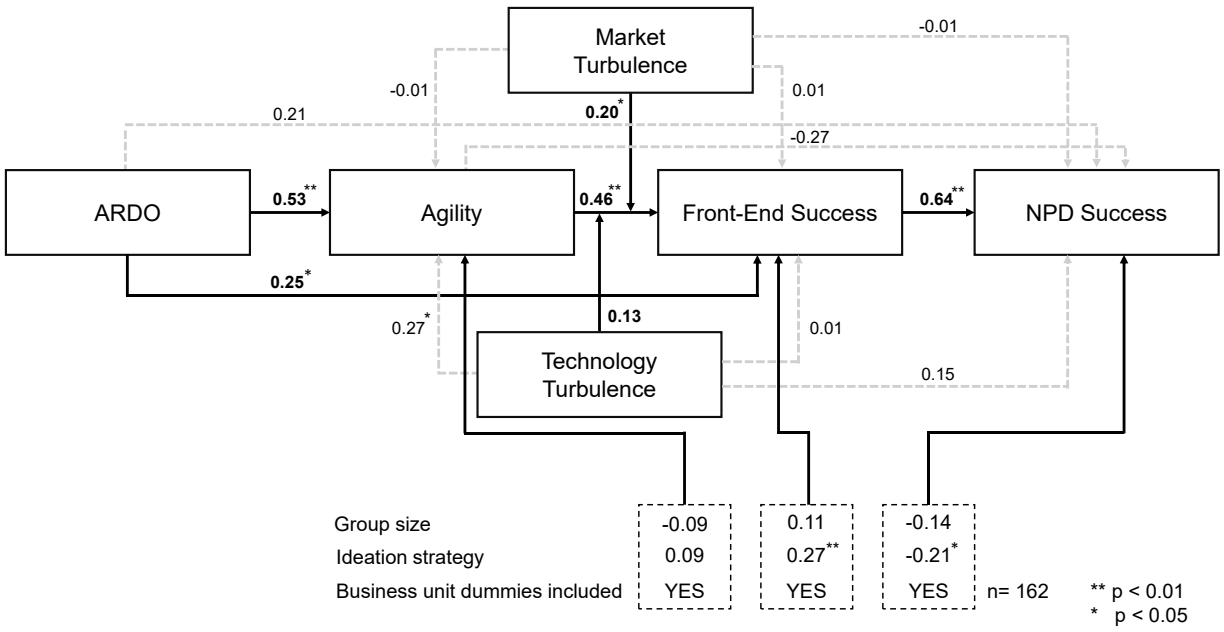

Figure 9: Results (Research study C)

4.6 Discussion

This study investigates the influence of agile R&D units' organization on innovation performance and provides deeper insights regarding the interplay of ARDO, agility, front-end success, and NPD success. In addition, we analyze the influence of two contextual factors, technology turbulence and market turbulence, on the relationship between agility and front-end success.

Results show that ARDO positively relates to an R&D unit's agility. Consequently, it can be regarded as an important means to cope with constantly changing business environments (Bennett & Lemoine, 2014; Saviotti & Pyka, 2004; Teece et al., 2016). Our results further show that agilely organized R&D units are, on average, more successful in their front end. As suggested by prior conceptual work (Meier & Kock, 2021b), ARDO thus contributes to the generation of innovative ideas, the selection of the most promising ones, and efficient and quick processing of these. In addition, our results support the positive relationship between front-end success and NPD success (Markham, 2013; Verworn, 2009), confirming our overall proposition that ARDO, through the mediating roles of agility and front-end success, positively relates to NPD success.

We further find that market turbulence strengthens the positive relationship between agility and front-end success. Hence, ARDO and the resulting agility are particularly favorable in a turbulent market environment. However, it is surprising that we could not find similar results regarding technology turbulence. A possible explanation could be that market- and technology-related uncertainty differ regarding the information basis. Especially in the front end of innovation, market information is often more speculative and based on estimations (Kim & Wilemon, 2002; Murphy & Kumar, 1997; Schoenherr & Wagner, 2016). Technological information is more tangible and merely based on comprehensive research and testing (Martinsuo & Poskela, 2011; Poskela & Martinsuo, 2009). Consequently, agility might be more favorable for front-end success when market turbulence prevails, as the information at hand is more intangible (Kim & Wilemon, 2002; Murphy & Kumar, 1997; Schoenherr & Wagner, 2016). However, our results also do not rule out the existence of a possible moderation effect as the likelihood of a type-II error is given and the .95 confidence interval of the moderation effect is rather large (-.10; .37).

4.7 Implications

4.7.1 Theoretical Implications

This study builds on agility research, innovation management, and organizational theory and contributes to these fields in several ways. First, our study advances research on the phenomenon of agilely organized R&D units (Meier & Kock, 2021a, 2021b), particularly concerning further quantitative analysis. By applying Meier and Kock's (2021a) ARDO measure, we empirically elucidate performance outcomes of the practically highly relevant phenomenon ARDO, such as increased NPD success. More specifically, by showing that the increased success in new product development results from ARDO's increased agility and front-end success, our results help better understand how agilely organized R&D units affect innovation performance, thus potentially showing why more and more firms in an industrial setting rely on agile R&D units (Meier & Kock, 2021a). In doing so, our study complements prior conceptual work by quantitatively showing that ARDO relates to effectiveness and efficiency in the early innovation phases and NPD (Meier & Kock, 2021b). Hence, the study also contributes to agility literature by counteracting extant research's attachment to the firm level (Gligor et al., 2015; Tallon & Pinsonneault, 2011), software development (Conboy, 2009; Tallon et al., 2019), and considering it only as increased adaptiveness instead as a way of working and organizational form (Bouwman et al., 2018). Moreover, our findings support ARDO as an important antecedent of agility, adding another important factor to this extensively discussed debate (Kock & Gemünden, 2016; Swafford et al., 2006a; Tallon et al., 2019).

Primarily, we comprehensively elucidate agility's relationship with innovation success by combining agility's neglected capability perspective (i.e., ARDO) (Meier & Kock, 2021a) and outcome perspective (i.e., increased adaptiveness) (Bouwman et al., 2018) with several innovation performance measures. The mediated research model shows that ARDO leads to increased agility, favoring front-end success and, ultimately, NPD success. The results show which structure, capabilities, and cultural traits are relevant to increase adaptability and responsiveness in product development and how this increased adaptiveness helps to better manage the early innovation stages, favoring performance in NPD. We thus advance prior work that investigated agility's influence on innovation performance from an outcome perspective. Specially, we complement the results of Shuradze et al. (2018) and Kester et al. (2014), who

showed positive relationships between increased adaptiveness and innovation success. Integrating ARDO and front-end success in one analysis, we provide deeper insights regarding the mechanisms of how agility leads to increased innovation performance and open the black box of agility's relationship with NPD success (Kester et al., 2014; Shuradze et al., 2018). Concerning the latter, our study empirically shows the positive relationship between agility and front-end success, thus complementing prior conceptual or qualitative work in the innovation management field (Beaumont et al., 2017; Cooper & Sommer, 2016, 2018; Gonzalez, 2014). Doing so also provides new insights regarding agility's performance outcomes (Gligor et al., 2015; Tallon et al., 2019) and front-end success's antecedents (Kock et al., 2015; Schrauder et al., 2018). We also found that ARDO positively relates to front-end success above and beyond its effect through increased agility, which adds to the debate on how to manage the front end (Haase & Laursen, 2018; Jörgensen et al., 2011; Kock et al., 2015; Schrauder et al., 2018; Schweitzer & Gabriel, 2012). Our results further complement the conceptual work of Gonzalez (2014) who proposed that agile project management's application (APM), i.e., agility's capability perspective, results in increased effectiveness and speed in the front end. Overall, our study's findings advance scarce research linking agility and the front end of innovation (Brock et al., 2020; Gonzalez, 2014) and provide new insights to the extensive discussion in innovation management literature on how to succeed in NPD (Liu et al., 2015; Markham, 2013; Patanakul et al., 2012; Sivasubramaniam et al., 2012).

In addition, by applying a contingency perspective, we also provide deeper insights regarding moderating factors of this relationship and thus advance extant contingency research in both fields (Ashrafi et al., 2019; Clauss et al., 2019; Kock et al., 2016; Schrauder et al., 2018; Tallon et al., 2019). We thus add to agility and front-end research by identifying contextual factors under which both factors' interplay is particularly beneficial. Specifically, we find that market turbulence interacts with agility to predict higher front-end success. This finding might not seem surprising as the concept of agility has been primarily developed to cope with uncertain and complex environments (Abrahamsson et al., 2009; Conforto & Amaral, 2010; Little, 2005; Strode et al., 2011), which also refers to innovation's front end (Eling & Herstatt, 2017; Schweitzer & Gabriel, 2012). While other research contexts observed agility's beneficial effect on performance in turbulent environments (Ashrafi et al., 2019; Clauss et al., 2019; Kock & Gemünden, 2016), regarding the front end, this relationship has only been theorized (Gonzalez, 2014). Hence, our study is the first to provide quantitative support of agility's positive relationship with front-end success in turbulent market environments, thus elucidating

boundary conditions of this interplay and overall enhancing our understanding of agility's relationship with innovation performance. However, our results imply that the moderation effect does not apply to technologically turbulence.

Finally, being our study's guiding theory to explain ARDO's positive effect on agility and innovation performance, we further contribute to dynamic capabilities theory (Eisenhardt & Martin, 2000; Teece et al., 1997; Teece, 2007; Teece et al., 2016). We show that ARDO facilitates adapting and innovating in turbulent environments, thus providing evidence that ARDO is a dynamic capability (Meier & Kock, 2021a, 2021b). Further, we support prior conceptual work's propositions with empirical data (Teece et al., 1997; Teece et al., 2016).

4.7.2 Managerial Implications

Our study's results might encourage managers to reorganize their R&D unit. Managers could use the elucidated benefits such as increased agility, front-end success, and NPD success to justify and enforce corresponding reorganizations (Meier & Kock, 2021a, 2021b). One R&D unit in the focal company, for example, started to reorganize its structure, implemented iterative approaches, and laid a specific focus on specific cultural facets to become agile. According to the unit manager, these changes were necessary to cope with the unit's constantly changing business environment, led to astonishing results, and encouraged other R&D units to follow this example, resulting in reorganizing the whole business unit.

In addition, our study also revealed boundary conditions when agile R&D units' setup is particularly beneficial since our results reveal that agility's ARDO-enabled positive effect on front-end success and consequently on NPD success is stronger in a more turbulent market environment. Nevertheless, for technologically turbulent environments, we could not find similar results. Hence, R&D managers should particularly consider agilely organized R&D units' setup when the market in which the unit operates is highly turbulent. In addition, the study sensitizes managers to pay more attention to the front end of innovation since our study's findings show the fuzzy front end's relevance for R&D units' NPD performance (Kock et al., 2015; Markham, 2013; Schrauder et al., 2018).

4.7.3 Limitations and Future Research

Like every study, our research is liable to limitations that need to be considered when interpreting the results, offering avenues for future research. First, even though we took great care to avoid common method bias and controlled for it, the results' complete non-impairment cannot be entirely guaranteed (Jarvis et al., 2003). In addition, even though its various business units operate in distinct markets and industries, our sample stems from one large industrial firm. Therefore, future research could investigate the relationship of ARDO and innovation performance via a multi-informant research design or by using objective performance measures to further elucidate ARDO's performance-relevance. In addition, the ARDO construct could also relate to softer or socio-cultural consequences.

Second, one could further question our cross-sectional study design, as there might be a time lag between an agile R&D unit's setup and the corresponding outcomes. Our research design could not consider time-lagged effects, which would require a longitudinal analysis. Last, the present study provides valuable insights regarding ARDO's consequences but fails to sharpen our understanding of organizational factors contributing to such R&D units' agile organization's setup with empirical evidence (Meier & Kock, 2021b).

Table 9: Appendix: Survey items (Research study C)

Construct	Item	Loading
Agile R&D Units´ Organization (2nd order construct) (Meier & Kock, 2021a)		
Culture (Cronbach's Alpha = .83 ; AVE = .52 ; CR = .84)		
	Please estimate how strongly the following values are shared in your unit.	
	Courage to take self-responsibility and self-organization.	.67
	Commitment to achieve the agreed tasks and goals.	.66
	Respect among employees.	.72
	Mistakes are not seen as failures but rather as a learning opportunity.	.77
	Mistakes are altogether dealt with in an open manner.	.76
Customer Integration (Alpha = .90 ; AVE = .75 ; CR = .90)		
	During the development of new products and services in my unit …	
	… we involve customers in all development stages.	.89
	… we co-design products and services with our customers.	.87
	… we often gather customers' opinion on prototypes.	.85
Autonomy (Alpha = .76 ; AVE = .55 ; CR = .78)		
	In my unit employees …	
	… are strongly encouraged to make their own decisions.	.78
	… have the opportunity to select different ways to do their tasks.	.81
	… make their own decisions without detailed management influence.	.62
Work Method (Alpha = .75 ; AVE = .50 ; CR = .75)		
	In my unit …	
	… we regularly present working interim results (e.g. prototypes, minimum viable products, ...).	.63
	… the workflows are characterized by iterative planning and execution cycles.	.70
	… the completed work cycle is reflected and findings are derived from it.	.78
Cross-functional Capabilities (Alpha = .75 ; AVE = .62 ; CR = .83)		
	In my unit …	
	… the employees can support each other professionally and compensate each other in case of failures.	.69
	… the employees are able to get familiar with related areas and to take over tasks.	.88
	… the employees are able to understand the tasks of areas outside their field of expertise (e.g. purchasing, controlling, sales etc.)	.61
Flat Hierarchies (Alpha = .77 ; AVE = .55 ; CR = .78)		
	My unit is characterized by flat structures and short information paths.	.66
	In my unit, decisions are made on a professionally appropriate hierarchical level.	.89
	In my unit, the communication is open, i.e. we share information and appreciate discussions and different opinions.	.65

Front-end Success (2nd order construct) (adapted from Bertels et al., 2011; Ernst & Kohn, 2007; Ho & Tsai, 2011; Kock et al., 2015; Verworn et al., 2008)	
Front-end Effectiveness (Alpha = .85 ; AVE = .55 ; CR = .86)	
With studies prior to the PEP, we create a sustainable competitive advantage.	.76
When new products and/or technologies are introduced, we assume the role of innovative leadership within our sphere of activity as compared to our competitors.	.79
Our current ongoing predevelopment activities help us to identify the topics with high market potential.	.76
Our current idea and concept pipeline secures our future economic success.	.76
Our development portfolio has a good balance between the further development of existing products and novel products.	.61
Front-end Efficiency (Alpha = .90 ; AVE = .76 ; CR = .91)	
Resources are provided quickly for the development of preliminary projects and concept studies.	.81
New ideas are quickly advanced to preliminary projects and concept studies.	.96
Preliminary projects and concept studies are quickly and efficiently concluded.	.85
NPD-Success (Alpha = .74 ; AVE = .51 ; CR = .75) (adapted from Calantone et al., 2003; Salomo et al., 2007)	
All of our NPD platform and variant projects achieve their objectives regarding ...	
… revenue and market share.	.85
… profitability (DB4, ROI).	.71
… customer satisfaction.	.55
Agility (Alpha = .79 ; AVE = .68 ; CR = .86) (Kock & Gemünden, 2016)	
In my unit, we are able to quickly react to ...	
… new technical challenges.	.98
… changed customer needs.	.71
… market changes with new business models.	.77
Market Turbulence (Alpha = .83 ; AVE = .64 ; CR = .84) (Sethi & Iqbal, 2008)	
In our market, it is difficult to predict how our customers' wants and needs will develop.	.87
Customer preferences frequently change in our market.	.71
Market developments in our industry branch are fundamentally difficult to predict.	.81
Technological Turbulence (Alpha = .77 ; AVE = .56 ; CR = .79) (Sethi & Iqbal, 2008)	
The technologies in our product segment are constantly changing.	.79
Technological breakthroughs are commonplace in our product segment.	.87
Major technological developments in our product segment are a rarity.	.55
Ideation Strategy (Schrauder et al., 2018)	
Concrete search fields have been defined and communicated for our unit within which innovative ideas are needed.	

Model fit $\chi^2[716] = 1019$; comparative fit index [CFI] = .901; root mean square error of approximation [RMSEA] = .051; standardized root mean square residual [SRMR] = .078
AVE = average variance extracted; CR = composite reliability.

5 Research Study D: What About the People? Agile Project Organization and Team Member Dedication

Abstract:

Extant research exhaustively investigated agility's performance outcomes, but studies on its consequences for the individual employee are scarce. Particularly agility's influence on employee dedication remains unexplored, although dedicated employees highly affect a firm's success. In addition, previous research rarely elucidates contingencies of agility's consequences for the individual. This study addresses these shortcomings and investigates how an agile project organization—conceptualized with the five dimensions culture, customer integration, work method, autonomy, and cross-functional capabilities—relates to individual project team members' dedication. In addition, we explore how individual perceptions and project-specific and organizational characteristics benefit or mitigate this relationship. We test our hypotheses on a triple-informant sample of 286 project team members nested in 70 projects in the context of physical product development. The study contributes to the literature by quantitatively showing agility's positive relationship with employee dedication for the first time. It also identifies boundary conditions of this relationship: a structured implementation approach, employee involvement, a clear ideation strategy, and entrepreneurial orientation.

Classification with respect to this dissertation:

- *Method:* Quantitative: Random effects regressions
- *Data*: R&D projects survey data (n = 286 project employees nested in 70 projects)
- *Study contributing to overall research question*: 3

Publication and conference:

Meier, A., & Kock, A. (2022). What About the People? Agile Project Organization and Team Member Dedication. Under review.

An earlier version of this paper has been accepted for presentation at the European Academy of Management 2022 Conference, Winterthur/Zurich, Switzerland.

5.1 Introduction

Agility becomes increasingly relevant in practice (Hobbs & Petit, 2017; Sithambaram et al., 2021), leading to similarly high scholarly interest (Christofi et al., 2021; Tallon et al., 2019). However, the majority of studies focus on agility's methods (Abrahamsson et al., 2009; Conforto et al., 2014; Conforto & Amaral, 2010; Copola Azenha et al., 2021) or influence on performance (Gemino et al., 2021; Gligor et al., 2015; Kaufmann et al., 2020; Serrador & Pinto, 2015; Sheffield & Lemétayer, 2013; Tallon et al., 2019; Tam et al., 2020). Very few studies consider the human aspects of agility (Burga et al., 2021; Drury-Grogan, 2021), for example, recent studies on team empowerment (Malik et al., 2021) or psychological safety (Hennel & Rosenkranz, 2021). In particular, research on agility's consequences for individual employees is scarce, as shown in a recent literature review (Christofi et al., 2021). This lack surprises because the Agile Manifesto (Beck et al., 2001) stresses individuals' high relevance and agility is highly employee-centric, strongly relying on empowered and open-minded employees (Grass et al., 2020; Hennel & Rosenkranz, 2021; Lee & Xia, 2010; Lu & Ramamurthy, 2011; Sithambaram et al., 2021; Yusuf et al., 1999).

Only McHugh et al. (2011) qualitatively investigated how agile approaches contribute to motivation in IT project teams, while other work analyses agile approaches' relationship with employee satisfaction (Gupta et al., 2019; Tripp et al., 2016) and developers' reduced exhaustion (Venkatesh et al., 2020). Notably, Benlian (2021) investigated how agile methods affect software developers' well-being while considering this relationship's deeper mechanisms and potential adverse effects. Despite their value, these studies leave essential research gaps. First, all studies focus on software development, leaving some authors to recommend investigating other contexts, such as physical new product development (NPD), where agility increasingly gains relevance (Conforto et al., 2014; Cooper, 2016).

Second, all studies focus on how specific agile methods (e.g., iterative working or certain coding techniques) affect individuals (Benlian, 2021; Tripp et al., 2016; Venkatesh et al., 2020). While these aspects are highly relevant, prior research suggests that agility is a multidimensional concept (Meier & Kock, 2021a, 2021b; Sarker et al., 2009), consisting of diverse factors such as cross-functional team composition (Bottani, 2010; Hennel & Rosenkranz, 2021; Lee & Xia, 2010; Malik et al., 2021), customer proximity (Conforto et al., 2016; Recker et al., 2017; Sheffield & Lemétayer, 2013), the project team's empowerment (Grass et al., 2020; Hennel & Rosenkranz, 2021; Lee & Xia, 2010; Malik et al., 2021), and a

change-embracing culture (Gonzalez, 2014; Madi et al., 2011). Applying this holistic view would show how project teams need to structure, organize, and which processes they need to possess to gain agility (Meier & Kock, 2021a, 2021b), thus thoroughly conceptualizing an agile project organization.

Third, previous research only regarded job satisfaction and general well-being as individual outcomes (Benlian, 2021; Gupta et al., 2019; Tripp et al., 2016). But it would be fascinating to know how and under which conditions agility affects employees' dedication since experience from practice and evidence from the literature suggest that dedicated employees willing to go the extra mile for the firm ultimately boost company success (Fletcher et al., 2008; Lee & Miller, 1999; van Scotter & Motowidlo, 1996). Dedication is the extent to which a firm's employees are proud and enthusiastic about their job and perceive it as significant, inspiring, and challenging (Salanova et al., 2005). It manifests through increased self-discipline and commitment, among other things, via working extra hours, investing additional energy, own initiatives, and resilience during challenging tasks (Conway, 1999; Grant, 2008; van Scotter & Motowidlo, 1996). Dedication can be triggered, for example, through autonomy, task significance and variety, and positive feedback (Grant, 2008; Maden-Eyiusta, 2016). The construct is highly relevant for practice and research (Hurtz & Donovan, 2000) because it is a crucial antecedent to employee's pro-active behavior and general performance (Fletcher et al., 2008; Hurtz & Donovan, 2000; Maden-Eyiusta, 2016; van Scotter & Motowidlo, 1996), and thus also overall project success (Malik et al., 2021). However, even though agility and employee dedication are individually well-researched, no study so far has investigated their relationship and, thus, supported agility advocates' claim that this work approach increases employee dedication (Rigby et al., 2016).

In sum, no previous study investigated an agile project organization's influence on project team member dedication, let alone in the context of physical product development. This research gap is important, considering employees decisive role for agility's successful implementation (Hobbs & Petit, 2017; Rigby et al., 2016). We thus formulate our first research question:

How does an agile project organization (APO) affect individual team members' dedication?

In addition, investigating this relationship's contingency factors would allow us to identify boundary conditions on different hierarchical levels and from various perspectives, thus

deepening our understanding of agility's consequences (Sousa & Voss, 2008). However, except for Benlian (2021), previous studies did not investigate contingencies of agility's effects on the individual employee. Such an analysis could consider personal, project-specific, or organizational contingencies that companies could leverage to increase employee dedication further. Thus, our second research question is:

What are contingency factors of the relationship between APO and individual team members' dedication?

We apply Meier and Kock's (2021a, 2021b) conceptualization of agile R&D unit's organization, which takes a capability perspective on agility and transfer it to the project level. Consequently, we regard APO as a second-order construct capturing a project team's cultural, structural, and process-based resources to increase its adaptiveness toward changing environments (Meier & Kock, 2021a). Building on self-determination theory (Coccia, 2019b; Gagné & Deci, 2005; Ryan & Deci, 2000), we expect APO to be highly correlated to each team member's dedication since APO addresses self-determination theory's threefold concept of autonomy, relatedness, and competence (Coccia, 2019b; Gagné & Deci, 2005). Moreover, we investigate how individual perceptions and project-specific characteristics, which prior literature identified as agility-supporting or -hindering (Burga et al., 2021; Chen et al., 2016; Hobbs & Petit, 2017; Meier & Kock, 2021b; Sithambaram et al., 2021) affect this relationship. Specifically, we investigate the following contingency factors: (1) fear of agility, (2) clear career paths, (3) team members' involvement, (4) APO's structured setup, (5) management's clear ideation strategy and (6) the entrepreneurial orientation of the higher-level organizational unit, in which the projects are nested. We test our hypotheses on a triple-informant sample of 286 team members nested in 70 projects in the context of physical product development.

This study contributes to the literature by advancing scarce research on agility's influence on the individual employee (Christofi et al., 2021; Gupta et al., 2019; Tripp et al., 2016). First, our study is the first to provide empirical evidence on agility's effect on employee dedication (Fletcher et al., 2008; Hurtz & Donovan, 2000; Maden-Eyiusta, 2016; van Scotter & Motowidlo, 1996). We complement prior quantitative studies on agility's effect on employee satisfaction (Tripp et al., 2016) and well-being (Benlian, 2021) with a new aspect. Second, our study contributes to understanding individual and organizational contingencies affecting this relationship. Third, our measure for APO contributes to agility research by providing a holistic,

multidimensional view of project agility. Our results question prior studies that measure agile project management one-dimensionally (Mishra et al., 2017; Serrador & Pinto, 2015; Sheffield & Lemétayer, 2013).

5.2 Theoretical Framework

5.2.1 Agility's Influence on the Individual Employee

Studies investigating agility's effect on individual employees are scarce, and insights often evolved incidentally (Christofi et al., 2021). For example, the interview data of Cooper and Sommer (2016) suggested that scrum's implementation leads to increased employee motivation and satisfaction. Rigby et al. (2016) and Dyba and Dingsoyr (2009) provide similar fractional insights. Yusuf et al. (1999) also argued employees' vital role for agility, which a later study supported empirically (Bottani, 2010). Agility's human aspects have been mainly addressed in the team context (Burga et al., 2021). For instance, studies have investigated how agile practices influence psychological empowerment (Malik et al., 2021), psychological safety (Hennel & Rosenkranz, 2021), but also interruptions in development teams (Wiesche, 2021).

However, only a few studies explicitly investigate how agility affects individuals, particularly their emotional perception, attitude, and attachment to the daily work in an agile project setting (Benlian, 2021; McHugh et al., 2011; Tripp et al., 2016). In an exploratory approach, McHugh et al. (2011) investigated how three agile practices (iteration planning, daily stand-ups and, retrospectives) influence employee motivation. While they found various motivating elements such as work's variety, employees' involvement and empowerment, new career opportunities, or the better visibility of task's progression, it also became apparent that methods like scrum can also demotivate employees (McHugh et al., 2011). For example, daily stand-ups can cause stress and pressure for team members since they shall provide a new achievement and report on their performance every day. Moreover, the high number of meetings or handling so many fragmented tasks can demotivate employees (McHugh et al., 2011).

Regarding quantitative analyses, Tripp et al. (2016) surveyed software-development professionals on how agile methods' usage, which they divide into agile project management

practices (e.g., iterative delivery, retrospectives, burndown charts etc.) and agile software development practices (e.g., continuous integration, unit testing, pair programming etc.), relate to employee satisfaction. While they found significant effects for the former, they could not find similar results for the latter and did not investigate contingency factors (Tripp et al., 2016). The same applies to Gupta et al. (2019), who used a similar research design and arrived at the same results, but in addition, elucidated HR systems' mediating role in the relationship between agile project management and employee satisfaction (Gupta et al., 2019). Moreover, agile software development practices reduce developers' work exhaustion (Venkatesh et al., 2020). These examples show that research on agility's consequences on the individual employee is scarce and that additional analyses, especially from a contingency perspective, are needed to better understand how and under which constraints agility influences the individual employee (Sousa & Voss, 2008). Benlian's (2021) study takes the first step in this direction and elucidates that agile methods positively affect software developers' well-being through the mediating effects of an increased challenge appraisal and work engagement. Contrary, the study also shows employee well-being's negative affection in the presence of threat appraisal and resulting resource depletion. In addition, the results show that these effects depend on employees' IT mindfulness (Benlian, 2021). Nevertheless, this study does not elucidate how and under which contingencies a holistic, agile project organization affects the individual employee, particularly in agility's new disciplines such as physical product development (Cooper & Sommer, 2016).

5.2.2 The Five Dimensions of an Agile Project Organization

Before investigating APO's relationship with employee dedication, we must conceptualize the construct. We rely on Meier and Kock (2021a, 2021b), who already conceptualized agile R&D unit's organization from a capability perspective, thus showing which structure, processes, capabilities, and culture an R&D unit shall possess to become agile (Meier & Kock, 2021a, 2021b). Since our research also aims to holistically conceptualize an agile project organization—instead of individual aspects like methods (Mishra et al., 2017)—we transfer Meier and Kock's (2021a) scale to our study's context and thus from the unit to the project level. We omit the original sixth dimension (flat hierarchies) because projects in our sample only have two hierarchical layers (i.e., the project team and the project manager/product owner). Consequently, we conceptualize APO as a second-order construct, capturing an R&D unit's culture, structure, and processes with five dimensions: (1) culture, (2) customer integration, (3)

autonomy, (4) iterative work method, and (5) cross-functional capabilities (Meier & Kock, 2021a, 2021b).

(1) In agilely organized projects, the commonly called agile values (Madi et al., 2011) characterize the prevailing culture (Meier & Kock, 2021a, 2021b). Values include openness regarding tasks and project status, the sole focus on the goals, mutual respect, commitment, and courage (Gonzalez, 2014; Madi et al., 2011; Meier & Kock, 2021a, 2021b). In addition, a specific openness to deal with failures exists, fostering a climate of psychological safety (Hennel & Rosenkranz, 2021; Meier & Kock, 2021b). (2) APO also implies an extremely pronounced customer integration (Meier & Kock, 2021a, 2021b), as satisfying the customer is one of agility's primary objectives (Gunasekaran, 1998). (3) Increased autonomy (Lee & Xia, 2010; Malik et al., 2021; Meier & Kock, 2021a, 2021b; Sithambaram et al., 2021) ensures appropriate employees make change-responding decisions quickly (Meier & Kock, 2021b; Yusuf et al., 1999). (4) APO's work method is iterative, feedback-driven work in sprints (Meier & Kock, 2021a, 2021b). Every iteration results in a product increment to present to the customer. Iterative approaches allow objectives' constant adjustment and continuous learning (Cooper & Sommer, 2016, 2018; Meier & Kock, 2021b; Rigby et al., 2016; Sithambaram et al., 2021). (5) Cross-functionality is the final dimension of agility and consequently of APO (Hennel & Rosenkranz, 2021; Lee & Xia, 2010; Meier & Kock, 2021a, 2021b; Yusuf et al., 1999), as it contributes to shorter development cycles and increased innovation success (Bunduchi, 2009; Stettina & Hörz, 2015). Additionally, team members possess in-depth expert knowledge in their field of expertise and a widespread general understanding in related areas, often referred to as T-Shapedness (Hansen, 2001; Meier & Kock, 2021a, 2021b). All these dimensions collectively describe APO.

5.3 Hypotheses

Figure 10 shows the study's research framework. Based on self-determination theory (Coccia, 2019b; Ryan & Deci, 2000), we argue that APO addresses crucial aspects of autonomy, competence, and relatedness, which according to self-determination theory, facilitate employee's intrinsic motivation, well-being, personal development (Ryan & Deci, 2000), and dedication (Grant, 2008; Malik et al., 2021). Thus, we hypothesize that APO positively relates to each project team member's dedication. We further suggest that personal perceptions,

project-specific and organizational characteristics, which prior research identified as highly associated with agility (Chen et al., 2016; Hobbs & Petit, 2017; Meier & Kock, 2021b; Sithambaram et al., 2021), also serve these individual's needs and strengthen this relationship (Ryan & Deci, 2000). More precisely, we argue that each team member's perception of career paths' clarity, APO's structured setup, employee involvement, a clear ideation strategy, and entrepreneurial orientation of the project's larger organizational unit positively moderate APO's effect on the team member dedication. In addition, we argue that team members' fear of agility negatively moderates the effect. We now argue for the hypotheses in more detail.

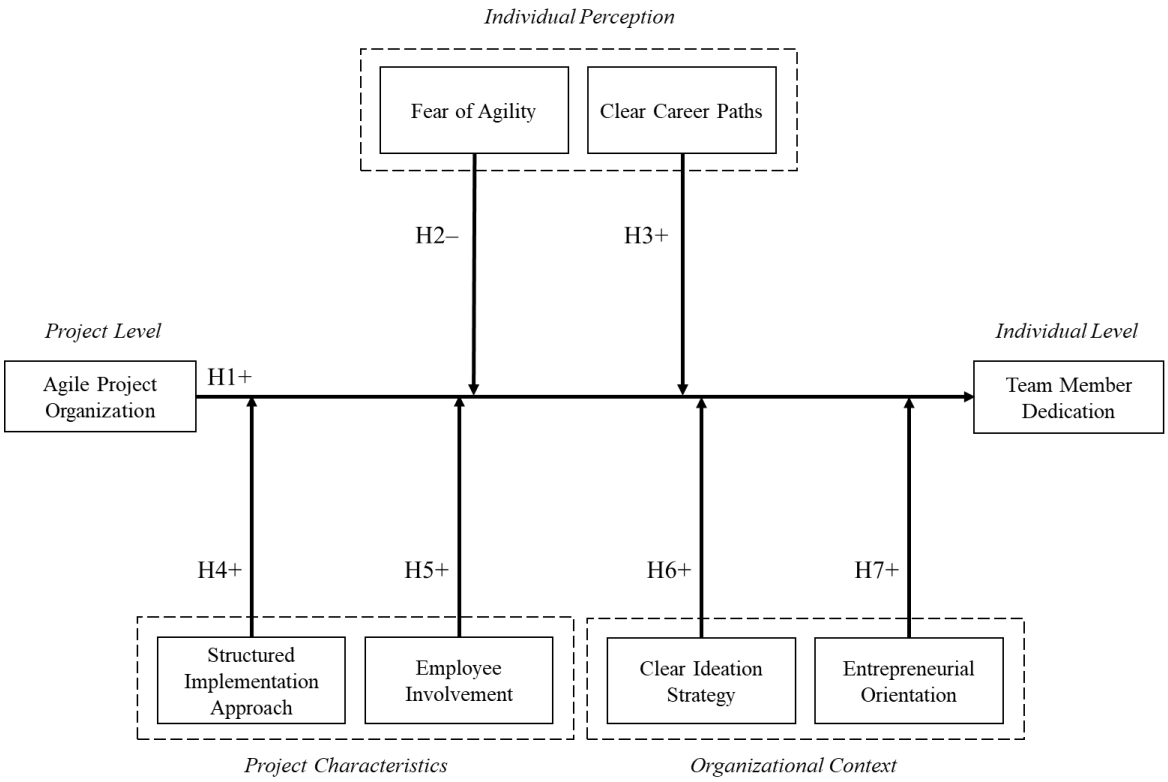

Figure 10: Conceptual framework (Research study D)

5.3.1 Agile Project Organization and Employee Dedication

APO represents a project's cultural, structural, and process-related resources, which enable the project to cope with changes more easily (Meier & Kock, 2021b) but which we also expect to favor individual team members' dedication. Since dedication refers to the extent to which the employees are proud and enthusiastic about their job (Salanova et al., 2005), it closely connects to intrinsic motivation, well-being, and personal development, which can be discussed in light

of self-determination theory (Coccia, 2019b; Ryan & Deci, 2000). Following Ryan and Deci (2000), this threefoldness evolves if employees simultaneously perceive autonomy, competence, and relatedness in their work environment, all of which APO likely contributes to.

With autonomy being one of agility's key aspects (Copola Azenha et al., 2021; Lee & Xia, 2010; Yusuf et al., 1999), employees perceive the individual's empowerment and the higher degree of freedom as pleasant and thus a motivating aspect in itself (Malik et al., 2021; McHugh et al., 2011). Since empowerment implies that employees can make proactive decisions, the thus-implied trust of their management provides them with a feeling of competence (Yusuf et al., 1999). Moreover, the increased autonomy also leads to a higher liability for the product and toward management, thus favoring the employees' relatedness to their work (Burga et al., 2021). Agile team members often develop personal ownership regarding the product, which ultimately leads to increased relatedness and dedication as they want their product to succeed (Cooper & Sommer, 2016; Ryan & Deci, 2000).

APO's extreme customer focus (Meier & Kock, 2021a, 2021b) further increases this aspect. Contrary to traditional development approaches, in which a sample product was delivered to the customer only at predefined points during a project and the team members thus only saw the customer once or twice, if at all (Cooper & Sommer, 2016), agile approaches rely on a constant customer contact (Cooper, 2016; Copola Azenha et al., 2021; Sithambaram et al., 2021). The team delivers a working prototype every one to four weeks and receives direct and unvarnished feedback (Cooper & Sommer, 2016; Meier & Kock, 2021b). This close interaction makes the employees highly dedicated to presenting a superior product on every sprint and satisfying the customer, which is considered agility's primary objective (Gunasekaran, 1998), thus ultimately favoring employees' relatedness to their work (Meier & Kock, 2021b). This products' continuous delivery might make employees perceive their job as positively challenging and full of purpose since they see their work's results and how it affects the customer after each sprint (McHugh et al., 2011). In addition, agility also satisfies employees' other psychological needs, such as the need for novelty (Cram & Newell, 2016).

While agility's application in our study's context of physical NPD is relatively new itself (Cooper & Sommer, 2016), the explorative and experimental approaches further affect employees' dedication as they allow them to constantly try out and learn new things, thus further providing them with a feeling of competence (Ryan & Deci, 2000). Agility also

addresses employees' need for individuality in terms of creative behaviors (Cram & Newell, 2016) and a supportive culture (Madi et al., 2011; Meier & Kock, 2021b; Sithambaram et al., 2021; Tam et al., 2020), which further supports the simultaneous presence of autonomy, relatedness, and competence (Coccia, 2019b).

Agile values foster an environment where team members respect each other for their individual skills and characteristics (Meier & Kock, 2021b). Moreover, mutual trust and openness are encouraged (Madi et al., 2011; McHugh et al., 2011; Meier & Kock, 2021b), and team members deal with mistakes in an open manner, providing a climate of psychological safety (Hennel & Rosenkranz, 2021; Meier & Kock, 2021b), and a sense of unity (McHugh et al., 2011; Meier & Kock, 2021b), subsequently favoring relatedness, competence, and finally increased dedication (Ryan & Deci, 2000; van Scotter & Motowidlo, 1996). This aspect is closely related to the mutual support among employees owing to their T-shapedness and cross-functional capabilities (Hansen, 2001; Meier & Kock, 2021b; Yusuf et al., 1999). However, also the collaboration with other departments holds motivational and inspiring aspects. On the one hand, a friendly but competitive climate could evolve to outperform the other department, while on the other hand, such collaborations foster diversity and new perspectives (Carlgren et al., 2016).

In summary, all of APO's dimensions address aspects of autonomy, relatedness and competence, which self-determination theory relates to motivation, well-being, self-development (Coccia, 2019b; Ryan & Deci, 2000), overall fostering each team member's dedication (Salanova et al., 2005). Therefore, we suggest that team members in projects characterized by an APO have higher dedication:

Hypothesis 1: APO positively relates to project team member dedication.

5.3.2 The Moderating Influence of Employee's Fear of Agility

Fear of agility refers to an employee's negative perception of the concept due to established routines or potential disadvantages of such a way of working (Meier & Kock, 2021b). While agility enthuses many employees (McHugh et al., 2011; Rigby et al., 2016), it provides challenges for others (McHugh et al., 2011; Meier & Kock, 2021b). These challenges may interfere with team members' need for autonomy, competence, and relatedness and thus reduce APO's positive effect on their dedication (Gagné & Deci, 2005; Ryan & Deci, 2000). For some

employees, shifting to agile methods is problematic because the agility's principles and values interfere with old habits and routines (Chen et al., 2016). Agility's transparency can lead to peer pressure for some employees since they need to report their performance constantly, which may cause stress and discomfort. In addition, the number of meetings (daily stand-ups, retrospectives, sprint plannings and reviews) and the variety of fragmented tasks can further demoralize employees (McHugh et al., 2011; Meier & Kock, 2021b). Some team members also perceive the constant and close collaboration with the team as a limitation of their privacy (Meier & Kock, 2021b). In the long run, these aspects can lead to employees' reserved attitude toward agility or even fear of the concept, which decreases their relatedness with their job and work environment (Coccia, 2019b; Meier & Kock, 2021b). These employees may refuse to apply the new methods or even try sabotaging implementation activities (Boehm & Turner, 2005; Meier & Kock, 2021b). Seeing their colleagues' outperforming them might make agility-aversive employees feel less competent. Being told how to work and which methods to apply in a transition to agile work might harm their autonomy (McHugh et al., 2011; Meier & Kock, 2021b).

We argue that if employees possess a fear of agility, they might be less dedicated since their fear of agility interferes with self-determination theory's threefold concept of autonomy, relatedness, and competence (Ryan & Deci, 2000). Moreover, they could intentionally perform low to make agility appear unfavorable, consequently possessing decreased dedication (Meier & Kock, 2021b). We thus hypothesize that APO's original positive effect on each team member's dedication reverses if the individual team member manifests a fear toward agility.

Hypothesis 2: A fear of agility negatively moderates the relationship between APO and each project team member's dedication.

5.3.3 The Moderating Influence of Clear Career Paths

Clear career paths describe employees' clarity on developing, assessing, and pursuing their career prospects in an agile setting (Meier & Kock, 2021b), which we argue strengthens APO's positive effect on employee dedication. Human resource (HR) systems often interfere with agility in large organizations, as the concept is challenging to align with established HR processes. It is not uncommon that HR departments hinder employees' positive attitude toward

agility and their resulting participation in agile teams rather than supporting it (Boehm & Turner, 2005; Meier & Kock, 2021b). This situation is problematic since prior work found that employees' support is key to developing organizational agility (Crocitto & Youssef, 2003; Meier & Kock, 2021b). Role descriptions are a significant issue because agile teams' required skills and experience differ from traditional positions (Boehm & Turner, 2005; Burga et al., 2021; Hobbs & Petit, 2017; Meier & Kock, 2021b). These issues also affect employees' career paths, a vital motivational factor (Crocitto & Youssef, 2003; McHugh et al., 2011). For instance, if career paths are not clearly defined and employees do not know how to achieve their next career step, they may perceive the agile setting as inferior, harming their job-relatedness (McHugh et al., 2011; Meier & Kock, 2021b). Moreover, unclear career paths, role descriptions, and skill requirements might make employees feel less competent and autonomous because they either do not know which skills are required or how they can achieve their goals.

Consequently, clear career paths address various aspects of self-determination theory's concurrent feeling of autonomy, relatedness, and competence to foster employees' motivation and dedication (Ryan & Deci, 2000; Salanova et al., 2005). Therefore, we argue that APO's positive effect on the individual team member's dedication is even higher if employees perceive their career paths as clear and know their development opportunities in an agile setting.

Hypothesis 3: Clear career paths positively moderate the relationship between APO and each project team member's dedication.

5.3.4 The Moderating Influence of a Structured Implementation Approach

Following prior work stressing a proper implementation approach's relevance for successful agile project management (Sithambaram et al., 2021), we investigate how such a structured implementation approach, which refers to various coordinated steps and practices for an agile organization's successfully setup (Meier & Kock, 2021b), also affects team members' dedication. The implementation approach's best practices firstly highlight the need for adjacent departments' involvement right from the start since it ensures the agilely organized project's compatibility with the rest of the organization (Meier & Kock, 2021b). Agile teams' ways of working are often hard to align with the linear development approaches of non-agile teams or departments. In addition, also cultural differences could arise (Chen et al., 2016; Meier & Kock,

2021b; Rigby et al., 2016; Sithambaram et al., 2021). This incompatibility can negatively affect firm performance (Rigby et al., 2016) and employees' relatedness and thus dedication since it fosters inner-firm conflicts and additional alignment efforts, increasing unnecessary workload (Meier & Kock, 2021b). Moreover, incompatible interfaces to other departments might increase stress and workload for the employees and make them feel incompetent and less autonomous because they need to constantly align with the non-agile parts of the organization (Meier & Kock, 2021b).

Besides involving adjacent departments in the transition activities, a step-by-step introduction with fixed deadlines is considered beneficial (Meier & Kock, 2021b; Sithambaram et al., 2021). This approach supports transparency, a vital motivational aspect of agility, and fosters the commitment to the change activities (Cooper & Sommer, 2016; McHugh et al., 2011). Additionally, this transparency helps employees plan how to organize to provide their input needed for the change activities.

Moreover, starting with pilot teams is helpful since it ensures that occurring problems do not blog all the firm's running projects and if these projects succeed, they foster employees' conviction as well as their desire to also work in an agile project (Chen et al., 2016; Hobbs & Petit, 2017; Meier & Kock, 2021b; Rigby et al., 2016; Sithambaram et al., 2021). The structured implementation approach also includes a supporting expert transition team to support the employees (Hobbs & Petit, 2017; Meier & Kock, 2021b). In combination with additional coaching, this ensures that all employees possess the required competencies (Chen et al., 2016; Sithambaram et al., 2021) and contributes to employee dedication (Ryan & Deci, 2000; Salanova et al., 2005).

Hypothesis 4: A structured implementation approach positively moderates the relationship between APO and each project team member's dedication.

5.3.5 The Moderating Influence of Employee Involvement

Employee involvement refers to employees' positive attitude, initiatives, and participation in APO's setup (Meier & Kock, 2021b), which we also expect to affect team members dedication. The basis for this involvement is that employees start to understand and experience agility's benefits for their daily work activities (Burga et al., 2021; Meier & Kock, 2021b; Rigby et al.,

2016). Once they do, they actively participate in corresponding organizational changes and are a vital source for their further progression (Crocitto & Youssef, 2003; Meier & Kock, 2021b; Rigby et al., 2016). Sometimes, employees start applying agile methods on their own (Hobbs & Petit, 2017; Meier & Kock, 2021b). Such pilots often spread their knowledge and enthusiasm to other individuals and teams, thus initiating organizational change in the entire organization (Meier & Kock, 2021b; Rigby et al., 2016). No matter which of these scenarios lead to employees' involvement, we argue that it increases their autonomy, relatedness, and competence (Ryan & Deci, 2000). First, active involvement in the change allows them to create their working environment and suggest ideas, strengthening their autonomy. Second, the personal buy-in and responsibility for results foster employees' relatedness to the transition activities. Finally, when they are informed early on about what skills an agile organization depends on and when they can determine, at least to a certain extent, how the new work organization looks, employees will feel increased competence to succeed (Coccia, 2019b; Ryan & Deci, 2000).

Consequently, we suggest that APO's effect on team member dedication is stronger when employee involvement is high. We thus posit:

Hypothesis 5: Employees' involvement positively moderates the relationship between APO and each project team member's dedication.

5.3.6 The Moderating Influence of a Clear Ideation Strategy

To investigate contingencies within the project's larger strategic context, we focused on the project-sponsoring R&D unit's ideation strategy since prior work in the field suggests overall firm strategies' high relevance for agile project management's execution (Sithambaram et al., 2021). Arguing that the larger organizational unit's strategy also affects the projects nested within the unit, we assume that a clear ideation strategy further strengthens APO's positive effect on team members' dedication because it also addresses self-determination theory's threefold concept of autonomy, competence, and relatedness (Ryan & Deci, 2000). Ideation strategy refers to the extent to which an R&D unit's idea generation and processing activities align with the R&D unit's innovation strategy (Kock et al., 2015). This clarity can mean defining concrete search fields for ideas (Salomo et al., 2008) and implies that the R&D unit

possesses an overall innovation strategy, which benefits innovation performance but also the employees (Kock et al., 2015; Schrauder et al., 2018). A clear innovation strategy elucidates an R&D unit's overall objectives so that employees understand the bigger picture of what's going on (Kock et al., 2015). This clarity increases their relatedness with the unit because they might identify with the unit's future course, see a purpose, and feel pride in what they are doing (Salanova et al., 2005).

Moreover, the clearly defined search fields provide focus and guidance regarding which ideas are needed (Kock et al., 2015). These areas of interest often result from customer needs, market trends, or arising technologies relevant for the firm in the future (Salomo et al., 2008). This confinement fosters employees' competence since it provides a narrower field to innovate autonomously. Without these guardrails, the number of potential search fields might overwhelm and frustrate employees, reducing their feeling of competence. In addition, this approach also prevents employees from developing many irrelevant ideas, which may negatively influence their sense of competence, relatedness, and autonomy. With predefined search fields, employees perceive their tasks as manageable, conduct them faster with less effort, and the immediate partial successes keep them dedicated (Kock et al., 2015; Ryan & Deci, 2000; Salanova et al., 2005).

Concluding, we argue that while APO favors team member dedication, this relationship is stronger when a clear ideation strategy provides orientation to team members.

Hypothesis 6: A clear ideation strategy positively moderates the relationship between APO and each project team member's dedication.

5.3.7 The Moderating Influence of an Entrepreneurial Orientation

R&D units with a strong entrepreneurial orientation ambitiously pursue innovation, aggressively enter new markets, and accept risk in their innovation endeavors (Anderson et al., 2015). We see entrepreneurial orientation as a behavioral construct and investigate how managers pursue strategic decisions and innovative actions in the project's larger organizational context (Anderson et al., 2015). We argue that APO more strongly leads to dedicated employees when the larger organizational R&D unit possesses a well-pronounced entrepreneurial orientation. The corresponding innovativeness, proactiveness and risk-taking (Anderson et al.,

2015) harmonizes well with APO's dimensions and likewise address employees' sense of autonomy, competence, and relatedness to foster dedication (Ryan & Deci, 2000; Salanova et al., 2005).

If R&D managers urge the projects to introduce many promising innovations, the teams need to rely more strongly on active customer involvement and experimental approaches (Schweitzer et al., 2018), which serve employees' psychological need for novelty (Cram & Newell, 2016). Put differently, a larger organizational unit's orientation toward generating innovation encourages employees' autonomy and relatedness to proactively deal with risk (Anderson et al., 2015; Covin & Slevin, 1989). Entrepreneurial orientation generates an organizational context that allows or even forces the agilely organized project to conduct those activities and possess those cultural traits, favoring innovative behavior and the team members' dedication. In addition, the constant need for innovativeness and proactiveness fosters a motivational and challenging climate, supporting employees' relatedness. Moreover, APO relies on a culture based on courage, autonomy, and openness to try out new things, which provides employees with a feeling of competence to achieve what management expects (Coccia, 2019b; Madi et al., 2011; Meier & Kock, 2021b).

We expect APO's behavior to interact with such a climate in the project's larger organizational context, fostering the individual team member's dedication by increasing autonomy, relatedness, and competence (Ryan & Deci, 2000):

Hypothesis 7: An entrepreneurial orientation positively moderates the relationship between APO and each project team member's dedication.

5.4 Method

5.4.1 Data Collection and Sample

We obtained the data to test our hypotheses in a large industrial firm via a survey among R&D project team members, their project managers, and overarching R&D units' managers. The company has a reputation for being highly innovative and invested 5.5% of its revenues in R&D

(almost twice the industry average). In total, 110 project managers and 485 team members participated in the survey, which we could match to 104 projects (response rate 85%). We contacted the informants based on a list of the company's ongoing or recently concluded innovation projects provided by the firm's central innovation department. While both informants' online questionnaires evaluated the agile project organization's extent in the teams' innovation endeavors, the team members also reported on their general dedication, their potential fear of agility, and how clear they perceive the career paths in the agile setting. The project managers also reported on APO's setup and how the employees perceived and assisted this organization's setup. We matched the projects to the responses of 178 managers (response rate 91%) of R&D units, in which the projects were running, getting information on the units' innovation strategy and climate. The unit of analysis is the individual project team member nested in the R&D project. The final sample with complete information from each of the three types of informants (team member, project management, R&D unit manager) comprised 286 team members nested in 70 R&D projects.

5.4.2 Measures

The constructs' measures stemmed from existing scales in literature when available. We changed the item wording to better fit the survey context in some cases. We applied multi-item scales for each construct (Hair et al., 2013), and informants assessed all items on a Likert scale (DeVellis, 2016) ranging from 1 ("does not apply at all") to 7 ("applies completely"). Only APO's culture scale used different anchors (from 1 = "not at all" to 7 = "to a large extent").

Dependent variable. Project team members assessed their dedication with three items of the well-established scale by Salanova et al. (2005). The items evaluated to which extent the team members perceive their job as (1) full of meaning and purpose, (2) inspiring, and (3) challenging (Salanova et al., 2005).

Independent Variable. We relied on Meier and Kock's (2021a) measure for the agile R&D unit's organization and adapted it from the unit to the project level. Thus, we measured APO as a second-order construct using the sub-dimensions culture, customer integration, iterative work method, and cross-functional capabilities (Meier & Kock, 2021a). Both the project team

members and the project managers assessed the APO measure. We calculated APO's extent as the mean of the project manager's and the team's rating.

Moderators. Since most of the identified potential contingencies have not been quantitatively assessed previously, we developed several own scales. We measured fear of agility with three items based on Meier and Kock's (2021b) interview findings. The same applies to clear career paths. The team members assessed both scales. The structured implementation approach describes various steps and best practices supporting APO's successful setup (Meier & Kock, 2021b). We developed five items to cover common best practices for agility's implementation based on Meier and Kock's (2021b) findings and additional qualitative work (Chen et al., 2016; Hobbs & Petit, 2017). Likewise, we developed three items to evaluate employee involvement. The project managers assessed these scales as they have a good overview of APO's setup and how the employees reacted, for example, if they endorsed the changes and participated in it (Meier & Kock, 2021b). To assess the project's organizational context, we relied on three items to evaluate the clarity of the R&D unit's ideation strategy (Kock et al., 2015; Schrauder et al., 2018). To measure the entrepreneurial orientation of the larger organizational unit in which the projects are nested, we used the established scale by Covin and Slevin (1989). However, in line with Anderson et al. (2015), the performed factor analysis proposed a two-dimensional second-order operationalization instead of the original three-dimensional one. Thus, three items captured the units' entrepreneurial behavior while two items assessed management's behavior toward risks (Anderson et al., 2015). The R&D managers served as the informants for these scales.

Control Variables. We also account for other variables that might affect employees' dedication in product development projects. First, we controlled for the individual's innovativeness with three items (De Jong et al., 2015; Scott & Bruce, 1994). Owing to the ability to experiment on new ideas in a self-determined manner, which APO provides (Meier & Kock, 2021a, 2021b), employees with an entrepreneurial mindset might be more dedicated right away. Second, we controlled for various personal team member characteristics such as gender, tenure, functional background, and experience in agile methods. Third, the project manager informed on the team's proximity. It was measured with three items (Hoegl & Proserpio, 2004). Moreover, we controlled for the group size, business unit affiliation and the market's turbulence in which the project operates. The R&D managers assessed turbulence using three items from Sethi and Iqbal

(2008) because they had a good overview of the market environment. Table 10 provides the descriptive statistics and correlations of the used variables.

Table 10: Correlations (Research study D)

	Variables	M	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	Team member dedication	5.63	1.04	1.00									
(2)	Innovativeness	5.46	.95	0.41	1.00								
(3)	Team member proximity	4.94	1.61	0.10	0.00	1.00							
(4)	Market turbulence	3.55	1.02	0.05	0.08	0.19	1.00						
(5)	Agile project organization	5.16	.51	0.20	0.09	0.23	0.38	1.00					
(6)	Fear of agility	2.12	1.21	-0.23	-0.20	-0.12	-0.06	-0.11	1.00				
(7)	Clear career paths	3.82	1.39	0.38	0.12	0.11	0.02	0.24	-0.09	1.00			
(8)	Structured implementation approach	4.30	1.33	-0.02	0.02	0.19	0.33	0.39	-0.02	0.08	1.00		
(9)	Employee involvement	4.54	1.45	0.02	0.04	0.16	0.21	0.42	-0.23	0.05	0.36	1.00	
(10)	Clear ideation strategy	5.05	1.49	0.08	0.05	0.35	0.13	0.38	-0.20	0.07	0.26	0.52	1.00
(11)	Entrepreneurial orientation	4.83	.87	0.08	0.03	0.25	0.17	0.12	-0.24	0.02	0.36	0.44	0.42

n = 286, M = mean, SD = standard deviation, all correlations above .12 are significant at the 5%-level.

Measurement Assessment. To assess all scales' validity, we applied confirmatory factor analysis (CFA) on each informant's full sample since using different sample compositions is recommended when validating measures and enhances the assessment's validity (DeVellis, 2016; Hinkin, 1998). All standardized loadings exceeded the recommended cut-off value of .50 (DeVellis, 2016; Hair et al., 2013). In addition, we followed further criteria by Fornell and Larcker (1981), suggesting that Cronbach's alpha and composite reliability (CR) should be above a cut-off value of .70, while the average variance extracted (AVE) should exceed a cut-off value of .50 (Fornell & Larcker, 1981). Moreover, we assured all measurement models' fit following the criteria of Hu and Bentler (1998). As the project managers' sample size was too small, we could not perform a CFA and instead relied on principal component factor analysis (PCFA), ensuring that all items loaded on their intended construct (DeVellis, 2016; Hinkin, 1995). The appendix shows the scales' validation statistics. Although the three-informant approach limits common method bias, we also conducted Harman's single-factor test. The one-factor CFA indicated an extremely poor fit ($\chi 2$ (1484) = 5948.09; CFI = .194; RMSEA = .146; SRMR = .142), suggesting a low threat of common method bias (Jarvis et al., 2003). Since we

calculated the mean over a group of informants for our independent variable APO, we followed LeBreton and Senter (2008) and calculated the average score intra-class correlation coefficients (ICC(2)). The intra-class agreement among project manager and team members on APO is moderate to strong (ICC(2) = .64), and the between-group variance is significantly larger than the within-group variance ($F= 2.80$, $p < 0.000$). Thus, the data justify aggregation to group mean values for further analyses (LeBreton & Senter, 2008).

5.5 Results

We tested our hypotheses with random effects regressions using the project as the grouping variable, allowing us to consider individual- and project-level effects simultaneously (Hair et al., 2013). Model 1 in Table 11 shows the control variables' direct effects on each team member's dedication. As expected, the individual innovativeness of each team member is positively related to their dedication (unstandardized coefficient $b = 0.45$; $p = 0.00$). Supporting H1, Model 2 confirms APO's positive relationship with team members' individual dedication ($b = 0.47$; $p = 0.00$). The subsequent models test the interaction effects. Model 3 shows that APO's and fear of agility's interaction effect is insignificant ($b = 0.06$; $p = 0.54$), indicating that we cannot confirm H2. The same applies to clear career paths' positive moderation effect as proposed in H3 (Model 4; $b = -0.08$; $p = 0.34$), suggesting that both individual-level factors might not affect employee dedication in an APO setting. However, on the project-level and supporting H4, Model 5 depicts a positive interaction between a structured implementation approach and APO to predict each team member's dedication ($b = 0.22$; $p = 0.01$). In addition, also employee involvement positively moderates APO's effect on dedication (Model 6; $b = 0.23$; $p = 0.01$), supporting H5. H6 suggested that APO leads to even more dedicated employees if the project's larger R&D unit provides a clear ideation strategy. Model 7 confirms this hypothesis by showing a significant and positive interaction effect ($b = 0.45$; $p = 0.00$). The same applies to H7, which we tested in the final Model 8. APO's positive effect on employee dedication is stronger when the R&D unit, which contains the project, has a strong entrepreneurial orientation. The interaction effect is positive ($b = 0.47$; $p = 0.00$).

Table 11: Regression results (Research study D)

	Team Member Dedication															
	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)	
Controls																
Innovativeness	0.45**	[0.00]	0.43**	[0.00]	0.41**	[0.00]	0.40**	[0.00]	0.43**	[0.00]	0.45**	[0.00]	0.43**	[0.00]	0.43**	[0.00]
Team Member Proximity	0.05	[0.18]	0.04	[0.35]	0.03	[0.54]	0.04	[0.31]	0.05	[0.22]	0.03	[0.41]	0.05	[0.18]	0.07+	[0.07]
Market Turbulence	0.00	[0.98]	-0.02	[0.78]	-0.01	[0.89]	0.00	[0.96]	-0.02	[0.84]	-0.08	[0.31]	-0.05	[0.55]	-0.04	[0.63]
Functional Background (5 Dummies)	yes		yes		yes		yes		yes		yes		yes		yes	
Gender (2 Dummies)	yes		yes		yes		yes		yes		yes		yes		yes	
Tenure (5 Dummies)	yes		yes		yes		yes		yes		yes		yes		yes	
Experience in agile methods (2 Dummies)	yes		yes		yes		yes		yes		yes		yes		yes	
Group size (4 Dummies)	yes		yes		yes		yes		yes		yes		yes		yes	
Business Unit (7 Dummies)	yes		yes		yes		yes		yes		yes		yes		yes	
H1: Agile Project Organization (APO)			0.47**	[0.00]	0.48**	[0.00]	0.31*	[0.02]	0.51**	[0.00]	0.48**	[0.00]	0.34*	[0.03]	0.27+	[0.07]
Moderators																
Fear of Agility					-0.12*	[0.02]										
H2: APO x Fear of Agility					0.06	[0.54]										
Clear Career Paths							0.22**	[0.00]								
H3: APO x Clear Career Paths							-0.08	[0.31]								
Structured Implementation Approach (SIA)									-0.09+	[0.06]						
H4: APO x SIA									0.22*	[0.01]						
Employee Involvement (EI)											-0.11+	[0.06]				
H5: APO x EI											0.23*	[0.01]				
Clear Ideation Strategy (CIS)													-0.10	[0.27]		
H6: APO x CIS													0.45**	[0.00]		
Entrepreneurial Orientation (EO)															-0.24+	[0.06]
H7: APO x EO															0.77**	[0.00]
Constant	3.02**	[0.00]	3.19**	[0.00]	3.05**	[0.00]	3.28**	[0.00]	3.19**	[0.00]	3.70**	[0.00]	3.38**	[0.00]	3.84**	[0.00]
R^2 (within)	0.21		0.21		0.22		0.30		0.21		0.22		0.21		0.21	
R^2 (overall)	0.23		0.26		0.28		0.34		0.29		0.30		0.29		0.31	
R^2 (between)	0.32		0.36		0.42		0.40		0.44		0.40		0.38		0.54	

Random effects GLS regression; N (projects) = 70; n (team members) = 286; unstandardized regression coefficients are reported; interaction variables were mean-centered.
+ p < 0.10; ∗p < 0.05; ∗ ∗p < 0.01; p-value in brackets.

5.6 Discussion

Extant literature exhaustively investigated agility's influence on firm performance (Gligor et al., 2015; Tallon et al., 2019). Conversely, even though studies helped to understand that human aspects favor this increased performance (Hennel & Rosenkranz, 2021; Malik et al., 2021), the consequences of agility on the individual employee remain relatively unexplored (Benlian, 2021; Tripp et al., 2016). This study investigates an agile project organization's influence on a project team member's dedication. In addition, we examine how personal traits, project-specific factors, and organizational factors moderate this relationship.

The results confirm agility advocates' claim that employees are more dedicated in agilely organized projects (Rigby et al., 2016), on average. This finding shows that agility provides not only increased adaptability and superior performance (Gligor et al., 2015; Hallgren & Olhager, 2009) but also employee benefits, thus further enriching the discussion on agility's role for organizational success (Cram & Newell, 2016).

Regarding contingency factors, results align with prior work stressing organizational boundary conditions' relevance for agile project management (Burga et al., 2021; Sithambaram et al., 2021) and show that a clear ideation strategy (Kock et al., 2015) and the larger organizational unit's entrepreneurial orientation (Anderson et al., 2015) further strengthen APO's relationship with employee dedication. This suggests that agility, with its experimental approaches and less bureaucracy, which some executives even perceive as anarchy, still requires a certain amount of strategic guidance and an entrepreneurial culture to keep the employees dedicated (Rigby et al., 2016; Rigby et al., 2018).

Concerning contingencies on the project level, we focused on factors that prior literature identified as beneficial for agility's successful implementation (Chen et al., 2016; Meier & Kock, 2021b; Sithambaram et al., 2021). Results suggest that a structured implementation approach and employees' involvement contribute to a higher employee dedication when combined with APO, thus further favoring their deployment (Meier & Kock, 2021b).

However, our research could not identify contextual factors on the individual level which strengthen or weaken APO's effect on team members' dedication (Chen et al., 2016; Hobbs &

Petit, 2017; Meier & Kock, 2021b; Sithambaram et al., 2021). Even though prior research considers the stress caused by agility, which might favor fearing the concept (Meier & Kock, 2021b) as a demotivating factor for agile team members (McHugh et al., 2011), our results could not confirm an interaction effect between APO and fear of agility with regards to employee dedication. The same applies to clearly defined career paths, which McHugh et al. (2011) also identified as a motivational aspect for employees. This suggests that both factors might be relevant for APO's setup but do not necessarily affect employees' dedication once they take the established agile organization for granted (Meier & Kock, 2021b). However, our results also do not rule out a possible moderation effect's existence because a type-type-II error is likely, and the 95% confidence intervals of the moderation effects are rather large.

5.7 Implications

5.7.1 Theoretical Implications

This study contributes to the agility literature by advancing scarce research regarding the concept's influence on the individual employee (Benlian, 2021; McHugh et al., 2011; Tripp et al., 2016). First, this research is the first to quantitatively link agility to an increased employee dedication, thus providing empirical evidence of prior conceptual work (Rigby et al., 2016) and adding another aspect to how agility affects individuals in organizations (Benlian, 2021; Tripp et al., 2016). Our results link agility to dedicated employees, a key antecedent to firm performance (Fletcher et al., 2008; Lee & Miller, 1999; van Scotter & Motowidlo, 1996). We thus provide new insights on the mechanisms of how agility facilitates firm and project performance (Gemino et al., 2021; Gligor et al., 2015; Hennel & Rosenkranz, 2021; Kaufmann et al., 2020; Malik et al., 2021; Serrador & Pinto, 2015; Sheffield & Lemétayer, 2013; Tallon et al., 2019; Tam et al., 2020).

Second, our study advances contingency research regarding agility's effect on the individual employee by elucidating new contingency factors and boundary conditions, thus increasing the understanding under which conditions the concept benefits employees (Benlian, 2021; Sousa & Voss, 2008). We accordingly provide insights on how personal, project-specific, and the larger organizational context affect employees' dedication in an agile environment. By showing

that a structured implementation approach, consisting of various best practices, and employees' involvement strengthen agility's influence on employee dedication, we not only for the first time quantify these aspects investigated by prior qualitative research but also corroborate this work's assumptions that the factors indeed strongly connect to agility (Chen et al., 2016; Hobbs & Petit, 2017; Meier & Kock, 2021b; Sithambaram et al., 2021). Our multi-informant research design facilitates this, advancing prior studies' single-informant approach (Tripp et al., 2016). While we could not find interaction effects for employees' fear of agility or clear career paths, the results show that both aspects relate to employee dedication directly. Our results thus provide empirical evidence of their relevance for employees' emotional engagement in an agile working environment, hence advancing prior qualitative work (McHugh et al., 2011).

Third, our study is original since it measures agility's manifestation in product development projects via a multidimensional measure, which approaches agility from a capability perspective (i.e., how to organize to be agile) instead of from the more prominent outcome view (i.e., an increased adaptiveness) (Bouwman et al., 2018; Meier & Kock, 2021a, 2021b). By now, extant studies solely applied one-dimensional measures in this respect (Gemino et al., 2021; Mishra et al., 2017; Serrador & Pinto, 2015; Sheffield & Lemétayer, 2013; Tripp et al., 2016). However, experience from practice and extant literature shows that agility is a multidimensional concept (Bottani, 2010; Lee & Xia, 2010; Meier & Kock, 2021a, 2021b; Sarker et al., 2009; Yusuf et al., 1999). Our study thus questions extant measures and provides a valid multidimensional scale to thoroughly measure agility's neglected capability perspective in project teams and thus transfer the insights of Meier and Kock (2021a) to the project level. Our study's results hence not only show which aspects are relevant for agility's application in project management but also elucidate which aspects of agility lead to dedicated employees.

5.7.2 Managerial Implications

Our study provides managers with valuable insights for setting up agilely organized projects and how to increase their employees' dedication within these. Our APO construct's multiple dimensions serve as a starting point regarding which aspects to consider when implementing an agile project organization. Moreover, our measurement model facilitates evaluating a project team's agility level and benchmarking different teams and thus tracking a firm's progress along the way to an agile firm (Meier & Kock, 2021a, 2021b). In addition, our results assure managers

that APO's successful setup will not only make their projects more adaptive but also increase their employees' dedication, hence providing another supportive argument for such organizational changes. With respect to this, managers should particularly consider the evaluated contingencies. Following a structured approach when setting up APO will not only favor a successful implementation owing to the assured best practices (Chen et al., 2016; Hobbs & Petit, 2017; Meier & Kock, 2021b) but will also result in more dedicated project team members. The same applies to their involvement, which shows managers the importance of getting employees' support, for example, by making them understand agility's benefits (Meier & Kock, 2021a, 2021b; Rigby et al., 2018). On a higher strategic level, our results endorse the need for a clear ideation strategy and encourage managers to more innovative and risk-orientated behavior because it favors employee dedication and eventually the unit's overall success (Anderson et al., 2015; Kock et al., 2015; van Scotter & Motowidlo, 1996). Moreover, our results might relieve managers' concerns that if employees have a negative perception or even fear of agility, they might be less dedicated (Meier & Kock, 2021b).

5.7.3 Limitations and Future Research

Like in every study, our research's limitations offer avenues for future research. First, the sample stems from only one large industrial firm, even though its business units operate in distinct markets. Our study cannot show differences in APO's effect on employee dedication across firms, industries, and other contexts. Second, our analysis's correlation-based methods prevent us from making reliable direct causal interpretations of our findings, even though our multi-informant study design and additional statistical tests mitigate some endogeneity-concerns, for example, common-method bias.

Nevertheless, our study is the first to link agility to employee dedication and hopefully encourages more research on the concept's effect on the individual employee, particularly from a contingency perspective. Future research could detect other personal traits, as well as project-specific and organizational characteristics that influence employees' dedication in an agile setting. Since we only found empirical evidence for amplifying factors, future research could set out to specifically investigate constraints.

Table 12: Appendix A - Confirmatory factor analysis of the second-order APO construct (Research study D)

Construct	Item	Loading
Agile Project Organization (2nd order construct) (adapted from Meier & Kock, 2021a)		
Culture (Cronbach's Alpha = .88 ; AVE = .51 ; CR = .88)		
	Please estimate how strongly the following values are shared in your project.	
	Openness regarding tasks, priorities, and project status.	.71
	Courage to take self-responsibility and self-organization.	.75
	Commitment to achieve the agreed tasks and goals.	.75
	Respect between employees.	.68
	Focus on the currently agreed tasks and goals.	.69
	Mistakes are not seen as failures but rather as learning opportunities.	.72
	Mistakes are dealt with openly.	.71
Customer Integration (Alpha = .89 ; AVE = .70 ; CR = .90)		
	During the development of new products and services in my project …	
	… we involve customers in all development stages.	.91
	… we co-design products and services with our customers.	.94
	… we often gather customers' opinions on prototypes.	.84
	… customers join our product development team temporarily, e.g., to test new products and services.	.63
Autonomy (Alpha = .86 ; AVE = .62 ; CR = .87)		
	In my project, employees …	
	… are strongly encouraged to make their own decisions.	.83
	… have the opportunity to select different ways to do their tasks.	.82
	... make their own decisions without detailed management influence.	.74
	… determine how tasks are done as a team.	.75
Work Method (Alpha = .84 ; AVE = .56 ; CR = .83)		
	In my project …	
	… we regularly present working interim results (e.g., prototypes, minimum viable products, ...).	.64
	… the workflows are characterized by iterative planning and execution cycles.	.75
	… goals are continuously adjusted during the course of the project based on gained knowledge.	.74
	… the completed work cycle is reflected, and findings are derived from it.	.83
Cross-functional Capabilities (Alpha = .75 ; AVE = .53 ; CR = .76)		
	In my project …	
	… the employees can support each other professionally and compensate another in case of failures.	.76
	… the employees are able to get familiar with related areas and taking over tasks.	.84
	… the employees are able to understand the tasks of the areas outside their field of expertise (e.g., purchasing, controlling, sales, etc.).	.55

Model fit $\chi^2[202] = 633$; comparative fit index [CFI] = .938; root mean square error of approximation [RMSEA] = .062; standardized root mean square residual [SRMR] = .055; AVE = average variance extracted; CR = composite reliability.

Table 13: Appendix B - Confirmatory factor analysis of the first-order team member constructs (Research study D)

Construct	Item	Loading
Team Member Dedication (Cronbach's Alpha = .85 ; AVE = .67 ; CR = .86) (Salanova et al., 2005)		
	I find the work that I do full of meaning and purpose.	.79
	My job inspires me.	.92
	I find my job challenging.	.74
Clear Career Paths (Alpha = .80 ; AVE = .58 ; CR = .81)		
	I know my development opportunities in an agile environment.	.76
	HR has clearly defined career paths for agile roles.	.69
	I am confident of achieving my career goals in an agile environment.	.83
Fear of Agility (Alpha = .83 ; AVE = .65 ; CR = .84)		
	The high transparency of agile working is a problem for me.	.86
	I perceive my privacy limited by the permanent close collaboration in the agile team.	.87
	The transition to an agile way of working is a problem for me because it stands in a strong contradiction to my previous way of working.	.67
Innovativeness (Alpha = .82 ; AVE = .62 ; CR = .83) (De Jong et al., 2015; Scott & Bruce, 1994)		
	I generate creative ideas.	.77
	I identify new technologies and/or product ideas.	.82
	I promote and champion ideas to others.	.76

Model fit $\chi^2[48] = 110$; comparative fit index [CFI] = .973; root mean square error of approximation [RMSEA] = .054; standardized root mean square residual [SRMR] = .054. AVE = average variance extracted; CR = composite reliability.

Table 14: Appendix C - Exploratory factor analysis of the first-order project manager constructs (Research study D)

Construct/Items	EI	SIA	TMP
Employee Involvement (Cronbach's Alpha = .92)			
The employees in this project …			
… accept the agile way of working well.	**.94**	-.08	.03
… participate actively in the implementation of agile work methods in our organization.	**.95**	.04	-.05
… take proactive actions to establish the agile way of working in our organization.	**.92**	-.02	.01
Structured Implementation Approach (Alpha = .85)			
Please evaluate to which degree the following aspects have been taken into consideration with respect to the latest work method changes.			
Involvement of other departments (e.g. HR).	.14	**.61**	.08
Step by step introduction with fixed deadlines.	.04	**.72**	.07
Initial application in a pilot team.	-.17	**.89**	-.01
Implementation of a supporting expert/transition team.	.05	**.83**	-.05
Transfer of competences and know-how by coaching.	.01	**.84**	-.05

Team Member Proximity (Alpha = .82) (Hoegl & Proserpio, 2004)			
Most members of my team work directly in the vicinity, so that a quick, direct contact is possible without much effort.	-.02	-.03	**.86**
Team members are located too far from one another to move the project along expeditiously.	-.04	-.03	**.89**
It is at times problematic to get the team members together in one place for spontaneous meetings (e.g. for discussions and decisions).	.05	.04	**.84**

Principle-component factor analysis with promax rotation; Eigenvalues 1 > were considered. n = 101;
EI = Employee Involvement, SIA = Structured Implementation approach, TMP = Team Member Proximity

Table 15: Appendix D - Confirmatory factor analysis of the R&D manager constructs (Research study D)

Construct	Item	Loading
Entrepreneurial Orientation (2nd order construct) (Anderson et al., 2015; Covin & Slevin, 1989)		
Entrepreneurial Behaviors (Cronbach's Alpha = .75 ; AVE = .53 ; CR = .77)		
In general, in my unit we favor ...		
	... a strong emphasis on tried and true products or services. -- ... a strong emphasis on R&D, technological leadership, and innovations.	.58
In dealing with competitors, my unit ...		
	... typically responds to actions which competitors initiate. -- ... typically initiates actions to which competitors respond.	.76
In dealing with competitors, my unit ...		
	... is seldom the first business to introduce new products/services, administrative techniques, operating technologies, etc. -- ... is very often the first business to introduce new products/services, administrative techniques, operating technologies, etc.	.82
Managerial Attitude toward Risk (Alpha = .77 ; AVE = .63 ; CR = .77)		
When confronted with decision-making situations involving uncertainty, my unit ...		
	... typically adopts a cautious posture. -- ... typically adopts a bold, aggressive posture.	.79
In general, my unit has a strong proclivity for ...		
	... low-risk projects (with predictable and moderate rates of return). -- ... high-risk projects (with chances for very high returns).	.79
Clear Ideation Strategy (Alpha = .84 ; AVE = .64 ; CR = .84) (Kock et al., 2015; Schrauder et al., 2018)		
	Based on the innovation strategy, our unit offers a framework for generating ideas.	.75
	Concrete search fields have been defined and communicated for our unit, within which innovative ideas are needed.	.84
	Our unit processes innovation needs in a structured way and contributes them to our development activities.	.82
Market Turbulence (Alpha = .82 ; AVE = .62 ; CR = .83) (Sethi & Iqbal, 2008)		
	In our market, it is difficult to predict how our customers' wants and needs will develop.	.89
	Customer preferences change frequently in our market.	.68
	Market developments in our industry branch are fundamentally difficult to predict.	.77

Model fit $\chi^2[39] = 51$; comparative fit index [CFI] = .984; root mean square error of approximation [RMSEA] = .043; standardized root mean square residual [SRMR] = .053. AVE = average variance extracted; CR = composite reliability.

6 Overall Discussion

Located at the interface of agility research, R&D and innovation management literature, and organizational theory, this dissertation for the first time investigates agilely organized R&D units in physical product development. The present work elucidates this practically highly relevant phenomenon's characteristics and consequences for the organizational unit and the individual employee in four separate research studies. While the first study develops a holistic conceptual framework for agile R&D units' organization (ARDO) in a qualitative-explorative approach, the subsequent studies validate and advance the proposed framework with quantitative analyses. Besides their individual contributions, the research studies' alignment also provides superordinate implications. Chapter 6.1 addresses the overarching implications for research, while Chapter 6.2 provides an overview of the present work's contributions to practice. Chapter 6.3 finally shows avenues for future research on ARDO and agility based on this dissertation's insights.

6.1 Implications for Theory

Extant literature by now has neglected agile R&D units and their organization, including the relevant structure, processes, and culture. This dissertation provides three major implications for research on the phenomenon of ARDO, along with several overall advancements of extant agility, R&D and innovation management, and organizational theory literature.

First, the present work for the first time elucidates what holistically constitutes ARDO. Study A develops a comprehensive conceptual framework for agilely organized R&D units, revealing their characteristics, antecedents, and consequences. The framework proposes that six dimensions characterize ARDO: a culture of agile values and failure tolerance, customer integration, autonomy, an iterative work method, cross-functional capabilities, and flat hierarchies. Study B builds on these propositions and empirically validates study A's holistic ARDO conceptualization. Consequently, the study finally answers this dissertation's first overall research question of what ARDO constitutes by applying a holistic perspective. In doing so, this dissertation also develops a novel multidimensional scale to measure ARDO and thus facilitates future research on this academically neglected but practically relevant phenomenon of agilely organized R&D. Since ARDO's conceptualization addresses which structure,

processes, capabilities, and culture an R&D unit needs to be agile, it also addresses shortcomings in extant agility literature and hence advances agility research in general. On the one hand, ARDO explicitly focuses on the R&D unit level and thus follows extant research's call to counteract agility's strong firm focus and more extensively investigate the concept's micro-levels and underlying processes (Christofi et al., 2021; Dabić et al., 2021). On the other hand, this dissertation follows agility scholars call to detach the concept from its strong software development focus and hence investigate its application in other development contexts, such as physical product development in traditional mechanical engineering firms (Conforto et al., 2014; Cooper & Sommer, 2016). Finally and most critically, conceptualizing ARDO also means conceptualizing agility's neglected capability perspective (Bouwman et al., 2018; Cooper & Sommer, 2016). While initial studies already apply this, compared to the more prominent outcome perspective, less prominent view on the concept, they solely address certain aspects such as the methods or autonomy (Bianchi et al., 2020; Sheffield & Lemétayer, 2013; Vijayasarathy & Turk, 2012). Thus, these works fail to conceptualize agility holistically (Lee & Xia, 2010; Sarker et al., 2009), which ARDO does. In addition, this dissertation answers extant research's call to develop a novel multidimensional measure to assess agility thoroughly, thus finally elucidating which factors complementarily facilitate increased adaptability (Bianchi et al., 2020).

Second and based on ARDO's comprehensive operationalization, this dissertation sheds light on ARDO's organizational consequences and thus on the performance outcomes of agilely organized R&D units. The results of research study A's qualitative-explorative approach suggest that ARDO leads to increased adaptiveness and the unit's ability to quickly respond to changes of any kind. This increased responsiveness, in turn, favors more downstream outcomes such as NPD success, effectiveness, efficiency, uncertainty reduction, and customer satisfaction. Building on these propositions, study C empirically corroborates that ARDO indeed leads to increased agility, mediating ARDO's effect on front-end and NPD performance. Thus, both studies help better understand the phenomenon of agile R&D units, particularly how they relate to performance. Moreover, the results show what engineering firms can expect when setting up agile R&D units or, put more forward, why more and more manufacturing firms already rely on agile R&D units. In general, the dissertation's results shed more light on the interplay between agility, organizational theory, and innovation management (Cai et al., 2019; Kester et al., 2014; Kock & Gemünden, 2016). On the one hand, they help better understand the interplay of agility and innovation performance and elucidate the mechanisms at play by

showing the empirical relationships between ARDO, increased adaptability, front-end performance, and NPD success. The dissertation holistically elucidates how an agile organization favors adaptability and, in the long run, innovation performance. It thus provides empirical corroboration of prior conceptual work (Cooper & Sommer, 2016, 2018; Gonzalez, 2014; Rigby et al., 2016; Salvato & Laplume, 2020) and helps explain prior empirical studies linking increased agility to innovation success (Kester et al., 2014; Shuradze et al., 2018). On the other hand, the present work particularly shows how agility can help manage the front end of innovation, whose uncertain and complex setting seems to be just right for the concept's application (Eling & Herstatt, 2017; Gonzalez, 2014; Kim & Wilemon, 2002). Even though their relationship is evident, research linking agility and the front end of innovation is scarce and primarily qualitative, anecdotal, outcome-focused, and neglects physical product development (Brock et al., 2020; Gonzalez, 2014; Hoonsopon & Puriwat, 2019). By, for the first time, empirically linking both agility's outcome and capability perspective to increased efficiency and effectiveness in the front end, the present work further connects both research streams (Christofi et al., 2021; Eling & Herstatt, 2017; Tallon et al., 2019). In sum, the dissertation overall also contributes to the everlasting discussion of how to achieve superior innovation success (Acur et al., 2012; Brown & Eisenhardt, 1995; Calantone et al., 2003; Marzi et al., 2020; Patanakul et al., 2012; Sivasubramaniam et al., 2012).

Third, this dissertation provides a better understanding of ARDO by showing how an R&D unit's agile organization affects the unit's employees themselves and thus elucidates ARDO's individual consequences. Besides revealing ARDO's organizational and performance outcomes, study A's results imply that besides increased performance, ARDO also favors employee welfare due to a better work-life balance and increased motivation, appreciation, and personal development's support. Study D empirically supports and advances these assumptions by showing how and under which contingencies ARDO's transfer to the project level, an agile project organization (APO), favors employee dedication. In addition, study B's ARDO conceptualization shows that cultural values and individual traits, such as an open and change-embracing mindset, courage, commitment, or respect, are an agile organization's essential components (Madi et al., 2011). Moreover, ARDO's setup highly relies on employees' involvement and their executives' servant leadership style. The dissertation detaches agility research from its strong method and performance focus and consequently advances scarce agility research on the individual level and the concept's human aspects (Gupta et al., 2019; McHugh et al., 2011; Tripp et al., 2016).

In addition, this dissertation advances extant agility research in general by introducing new antecedents and consequences of the concept as well as new in-depth insights on already addressed aspects by literature, hence generally expanding literature's understanding of the phenomenon. For instance, the present work identifies a structured implementation approach consisting of various new best practices such as clear role descriptions, all relevant departments' involvement, and incompatible employees' transfer as a new enabler. Furthermore, this dissertation's results reveal several new barriers such as agility's misapplication, unclear career paths, and employees' fear of change. The research studies also revealed new consequences of the concept, such as uncertainty reduction, customer satisfaction, and employee dedication. This dissertation adds to extant agility research by applying a system perspective on the concept, thus advancing prior work in the field which only focuses on the concept's elements, enablers, barriers, or outcomes (Boehm & Turner, 2005; Cai et al., 2019; Denning, 2016; Gligor et al., 2015; Shuradze et al., 2018). By also simultaneously considering agility's neglected capability perspective and the more prominent outcome perspective (Bouwman et al., 2018), this work thus finally provides a holistic and comprehensive conceptualization of agility in R&D and innovation management, which is already present in other research fields such as information systems (Conboy, 2009), operations management (Yusuf et al., 1999), and project management (Conforto et al., 2016).

This work further adds to agility's better understanding since it strongly advances extant contingency research on the concept (Ashrafi et al., 2019; Cai et al., 2019; Clauss et al., 2019; Tallon et al., 2019). Considering contingencies is vital when studying a scientific phenomenon (Sousa & Voss, 2008) since it provides deeper insights regarding boundary conditions at play (Busse et al., 2017; Whetten, 1989). For instance, the dissertation provides evidence that agility particularly increases front-end success when market turbulence is high. This contingency might not seem surprising since the concept of agility and the corresponding methods explicitly address coping with uncertain and complex environments (Abrahamsson et al., 2009; Conforto & Amaral, 2010; Little, 2005; Strode et al., 2011). However, this dissertation provides empirical evidence for agility's advantage when innovating in turbulent market environments, which research claims (Cooper, 2016; Gonzalez, 2014; Rigby et al., 2016) but not yet thoroughly corroborates with empirical data. The dissertation's analyses even advance these insights by explicitly elucidating under which kind of turbulence, namely market turbulence, agility enhances front-end success. Surprisingly, according to the data, agility's positive effect on front-end success does not depend on technological turbulence. In addition, the dissertation

advances extant contingency research on the concept by showing which project-related and organizational factors influence the concept's effect on employee dedication (Ashrafi et al., 2019; Cai et al., 2019; Clauss et al., 2019; Tallon et al., 2019). The present work thus adds to agility research by showing these factors' relatedness with the concept and introducing a new set of contingency factors. According to study D's results, employee involvement, a structured implementation approach, entrepreneurial orientation, and a clear ideation strategy increase agility's advantages and thus are potential boundary conditions when studying agility.

This dissertation evolved at the interface of R&D and innovation management, agility research, and organizational theory and thus also contributes to the latter in general and particularly to dynamic capabilities (Eisenhardt & Martin, 2000; Teece et al., 1997; Teece, 2007; Teece et al., 2016) and self-determination theory (Coccia, 2019b; Gagné & Deci, 2005; Ryan & Deci, 2000). Firms constantly face increased turbulence and competition in their business environment (Bennett & Lemoine, 2014). Hence, practice and academia introduced various concepts to deal with these challenges (Christofi et al., 2021). The most popular ones are, among others, organizational ambidexterity (Gibson & Birkinshaw, 2004; Hill & Birkinshaw, 2012), strategic flexibility (Christofi et al., 2021; Dai et al., 2018), organizational learning (Flores et al., 2012), and resilience (Lengnick-Hall et al., 2011; Richtnér & Löfsten, 2014; Richtnér & Sodergren, 2008), whereas the agility concept is similar in nature. In line with these concepts, also ARDO is a new means to increase a firm's adaptiveness and resilience. Thus, this dissertation adds another relevant concept to the everlasting debate in organizational theory on how firms can address today's volatile and fuzzy business world (Bennett & Lemoine, 2014; Gibson & Birkinshaw, 2004; Khanagha et al., 2018).

Moreover, although dynamic capabilities theory is already among the most applied theoretical lenses in extant agility research (Tallon et al., 2019), this dissertation even tightens its link with agility. While the present work's first research study suggests that ARDO is a dynamic capability based on both concepts' high similarities (Teece et al., 1997; Teece et al., 2016), dynamic capabilities theory serves as the theoretical foundation for study B's scale development. In addition, study C applies this theoretical lens to explain ARDO's relationship with increased adaptiveness and front-end and NPD success. In doing so, this dissertation transfers dynamic capabilities theory to the context of agile R&D and shows that the six ARDO dimensions, which can be related to dynamic capabilities' sensing, seizing, and transforming activities, indeed represent a higher-order construct, i.e., a dynamic capability (Teece et al.,

2016). Moreover, considering that dynamic capabilities favor organizational agility (Teece et al., 2016), the dissertation shows that the dynamic capability ARDO indeed relates to increased adaptiveness and innovativeness. Consequently, this dissertation firstly advances dynamic capabilities theory by ARDO's identification as such a competence, secondly by corroborating Teece et al.'s (2016) conceptual propositions empirically, and, finally, by a dynamic capability's, i.e., ARDO, operationalization (Teece et al., 1997). This new scale allows future quantitative research on dynamic capabilities in R&D, e.g., empirically investigating antecedents and outcomes.

Finally, this dissertation also contributes to self-determination theory (Coccia, 2019b; Gagné & Deci, 2005; Ryan & Deci, 2000), this work's second theoretical lens. In the course of ARDO's conceptualization, study B relies on self-determination theory, particularly when elucidating autonomy's high relevance for ARDO. Study D uses self-determination theory's threefold concept of autonomy, relatedness, and competence to explain APO's positive influence on employee dedication and several moderating effects (Coccia, 2019b; Ryan & Deci, 2000). In doing so, this dissertation contributes to self-determination theory by transferring it to the context of agile R&D and thus further links the theory to the agility concept (Malik et al., 2021). More specifically, this work shows that the threefold basis of intrinsic motivation and well-being (Coccia, 2019b; Ryan & Deci, 2000) also applies to ARDO and APO. The dissertation's results empirically corroborate the theory's propositions that the complementarity of autonomy, relatedness, and competence indeed facilitates increased employee dedication and performance (Coccia, 2019b; Ryan & Deci, 2000).

6.2 Implications for Practice

For the first time, this dissertation investigates the practically highly relevant phenomenon of agile R&D units' organization and thus offers various implications for practice. In sum, it provides a guideline for managers on implementing an agile organization in their R&D unit and shows in which contexts agilely organized R&D units are particularly beneficial.

First, the empirically corroborated conceptualization of ARDO as a six-dimensional phenomenon shows managers which facets constitute an agilely organized R&D unit. It thus provides an important starting point for R&D managers regarding which aspects to consider

when setting up an agile organization. The results imply that an agile organization also relies on various other dimensions besides an iterative work method like Scrum, with which agility is often solely associated (Hobbs & Petit, 2017). For instance, an agile organization also requires integrating the customer into all development activities as much as possible and T-shaped employees, who possess in-depth knowledge in their field of expertise and a good general understanding of related tasks. Managers should thus consider the latter aspect when staffing their R&D unit to support inter-firm and inter-unit collaborations (Hansen, 2001; Lee & Xia, 2010; Sarker et al., 2009). In addition, managers need to grant autonomy to their employees, keep the organizational structure as flat as possible, and foster a supportive culture for agility. Besides cultivating failure tolerance and a climate of psychological safety in which mistakes are not perceived as negative but rather as a learning opportunity, managers should foster the agile values, such as respect, commitment, focus, courage, and openness among the unit members (Madi et al., 2011; Nienaber et al., 2015).

Second, the expert interviews with practitioners revealed that we need to approach an agile organization from a holistic system perspective and that ARDO relies on various antecedents, which managers can leverage to support the transition toward such an organizational form. These include top management support, success stories, a servant leadership style, and a structured implementation approach consisting of several aligned steps and best practices to support ARDO's setup. Finally, managers shall provide the needed resources and involve the employees to support the transition process. In addition, the practitioners stressed typical pitfalls that managers should consider in the transition activities, such as the classic HR systems, the executive staff, agility's misapplication, employees' fear of change, and the missing internal and external incompatibility (Boehm & Turner, 2005; Chen et al., 2016; McHugh et al., 2011).

Third, the developed ARDO measurement scale is an essential contribution for practice since it allows holistically assessing an R&D unit's agile organization. Consequently, it allows managers to measure an R&D units' agility level and thus to track the units' agile transition. The measurement scale's distinct dimensions help managers evaluate which of the unit's characteristics hold potential for improvement. Based on the dimensions' individual score, managers can then focus on weaknesses, e.g., the unit's lacking customer integration or if they need to provide the unit with more autonomy (Lee & Xia, 2010; Sarker et al., 2009).

Fourth, this dissertation relates agile R&D units' organization to increased adaptiveness during product development and enhanced front-end and NPD success. Thus, it shows that the transition toward an agile organization holds high potential for performance improvements of the unit and consequently that an agile transition indeed pays off. This empirical support helps managers promote, initiate, and conduct the agile transition.

Fifth, besides sole performance benefits, ARDO favors employee welfare, particularly employee dedication, thus implicating further arguments for ARDO's setup. This dissertation's results introduce APO as a new means for managers to foster their employees' well-being and address lacking dedication since APO's higher degree of autonomy and individual liability for product success foster each unit member's individual dedication. Additionally, managers should consider contingency factors of ARDO's positive effect on employee dedication to strengthen this effect. These contingencies inter alia include following a structured implementation approach and involving the employees in the transition activities. In addition, the larger organizational unit shall provide a clear ideation strategy and possess an entrepreneurial orientation based on an innovation-driven and risk-taking attitude and behaviors (Anderson et al., 2015; Kock et al., 2015).

Last, this dissertation shows in which contexts agile R&D units' setup is particularly beneficial. Since they favor increased adaptiveness and success in the front end of innovation, agilely organized R&D units are favorable when ideas are fuzzy, the problem is highly complex, solutions are unknown, and development tasks are explorative (Gonzalez, 2014). In addition, this dissertation's results show that agility is particularly beneficial in the early innovation phases if the market in which the R&D unit operates is highly turbulent and thus elucidates another favorable setting for ARDO.

6.3 Avenues for Future Research

Even though agility is a well-researched phenomenon in the information systems and operations management fields (Potdar et al., 2017; Tallon et al., 2019), agility research in R&D and innovation management, particularly concerning quantitative studies, is scarcer but rising (Del Giudice et al., 2021; Kester et al., 2014; Kock & Gemünden, 2016). Addressing this neglect,

this dissertation provides future research with several foundations and avenues to further link both fields, whose close relationship is beyond dispute (Gonzalez, 2014; Rigby et al., 2016).

Primarily, this work offers an empirically validated measurement scale for ARDO, which facilitates more research on the phenomenon of agilely organized R&D units. Simultaneously, it finally thoroughly operationalizes agility`s neglected capability perspective (Bouwman et al., 2018; Cooper & Sommer, 2016). The scale could thus serve future research to investigate new antecedents and consequences of ARDO and agility's capability perspective, which not only advances empirical research on organizational agility in R&D and innovation management (Cai et al., 2019; Kock & Gemünden, 2016) but also in agility's more established research fields (Potdar et al., 2017; Tallon et al., 2019). Since the scale's items do not contain agility-specific terms and practices, it allows a broader research approach. Scholars can thus apply the measure to R&D units and development contexts that do not explicitly apply the agility concept but still display agile characteristics to some extent. This dissertation already related ARDO to established performance measures in R&D and innovation management literature, such as an increased front-end and NPD success. Nevertheless, future studies could use more objective and monetary performance measures to further elucidate ARDO's positive effect on development performance and thus empirically support agility advocates' claim on the concept's performance-relevance with objective data (Cooper & Sommer, 2016; Rigby et al., 2016).

Concerning this avenue for research and while this dissertation already applied a multilevel research design, future studies could also focus on applying a longitudinal research design, e.g., by investigating agile R&D units and their performance at several points in time. Doing so would advance this work's static perspective on ARDO and could elucidate how it evolves over time, e.g., if specific characteristics or antecedents become more (or less) relevant the longer the units' agile organization exists. In addition, this approach would allow elucidating causal relationships between ARDO and innovation performance. Observing performance measures at later points in time would rule out time-lapsed effects and how the agile organization of an R&D unit influences innovation performance in the long run.

A popular discussion in R&D and innovation management is whether specific development approaches or organizational forms favor incremental or radical innovations (Coccia, 2017; Verworn et al., 2008). On the one hand, one could argue that agility's iterative approaches and

incremental development methods might favor incremental innovations and products' constant enhancement (Cooper & Sommer, 2016). On the other hand, agility favors risky and uncertain developments, fostering radical innovations (Beaumont et al., 2017; Cooper & Sommer, 2018; Gligor et al., 2015; Gonzalez, 2014; Rigby et al., 2016). I thus call for future studies to investigate whether ARDO and thus the capability to be agile favors incremental or radical innovations' development or even both? In line with this and while this work has already investigated a large set of contingency factors, I encourage more of such investigations to better understand under which conditions an agile organization and the resulting increased adaptiveness facilitate success or employee dedication. Clarifying this could help better understand in which contexts applying the concept could be particularly beneficial (Gligor et al., 2015).

In addition, future research should enhance the generalizability of this work by investigating the phenomenon of agile R&D units in other firms and industry contexts (Conforto et al., 2014). For instance, an interesting context could be the pharma industry, where R&D also plays a major role but with different development processes, costs, and durations (Bruni & Verona, 2009). It would be interesting to know if ARDO speeds up these processes, if it shows identical or other characteristics in this context, or if it is even unsuitable in this setting.

This dissertation also addressed the shortcoming that extant agility studies primarily focus on (firm) performance outcomes (Gligor et al., 2015; Tallon et al., 2019) and that investigations regarding the concept's effect on the individual are scarce (Christofi et al., 2021; Grass et al., 2020; McHugh et al., 2011). This neglect particularly refers to quantitative studies (Benlian, 2021; Tripp et al., 2016). In doing so, this work hopefully triggers more research on agility's human aspects and its consequences on the individual employee to see whether the increased performance holds disadvantages for the staff (McHugh et al., 2011) or, as the results suggest, an agile organization is a win-win situation for the firm and the employees (Rigby et al., 2016).

Even though both field's relationship is plausible (Brock et al., 2020; Gonzalez, 2014), this work is among the few that connects the two research streams agility and the early innovation phase, also known as the front end of innovation (Brock et al., 2020; Gonzalez, 2014; Hoonsopon & Puriwat, 2019). In the fuzzy front end, ideas and product concepts are ill-defined, need to be developed in an explorative and iterative manner, and high complexity and uncertainty persist (Eling & Herstatt, 2017; Kim & Wilemon, 2002), all of which could be

addressed by the agile ways of working (Cooper & Sommer, 2016; Gonzalez, 2014; Teece et al., 2016). Future studies should thus further link both fields and conduct more agility research located in the front end, particularly of quantitative nature. For instance, research could investigate the interplay of several R&D units cooperating in the front end, firstly in a qualitative-explorative approach (Corbin & Strauss, 1990; Gioia et al., 2013) and then corroborate these findings with empirical data, e.g., to provide managers with insights on how to manage and steer multiple R&D units working on highly innovative products. Concerning this question, it would be interesting to apply a strategic management perspective on the phenomenon and investigate how ARDO's quick adaption to different strategies depending on the environmental challenges at hand aligns with the firm's overall long-term strategy. For instance, if it is still possible to coordinate the units along such strategies or if their more short-term orientation makes the units diverge time by time from the corporate strategy.

Finally, this dissertation evolved in close collaboration with academia and practice and provides firms with insights on how to increase adaptiveness in R&D. On the one hand, extant studies linking agility and innovation management build on anecdotal evidence but provide firms with specific recommendations on how to organize to be agile (Rigby et al., 2016; Rigby et al., 2018; Schatz & Abdelshafi, 2005). Contrary, other scholarly work possesses high methodological rigor, e.g., by in-depth statistical analysis, but fail to translate these insights into practical recommendations (Cai et al., 2019; Kester et al., 2014). By considering both facets, this dissertation hopefully encourages future research on agility, particularly of quantitative nature, to provide more practice-orientated recommendations to help organizations be more adaptive in the future.

7 References

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Declaration of Authorship

The dissertation is provided by me with a list of all sources used. I declare that I have written the thesis on my own - apart from the help explicitly mentioned in it.

The thesis has not been published anywhere else nor presented to any other examination board.

Die Dissertation ist von mir mit einem Verzeichnis aller benutzten Quellen versehen. Ich erkläre, dass ich die Arbeit – abgesehen von den in ihr ausdrücklich genannten Hilfen – selbstständig verfasst habe.

Die Arbeit wurde bisher weder einer anderen Prüfungsbehörde vorgelegt noch veröffentlicht.

Andre Meier

_____ _____

(Place/Ort) (Date/Datum)

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